EFFECTIVENESS OF PROCESS STAGE MODEL ON SELECT LEARNING OUTCOMES IN MATHEMATICS AMONG SECONDARY SCHOOL STUDENTS

Thesis
Submitted for the Degree of
DOCTOR OF PHILOSOPHY IN EDUCATION

By

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2024

DECLARATION

I, **Radhika T.**, hereby declare that the thesis entitled "EFFECTIVENESS OF PROCESS STAGE MODEL ON SELECT LEARNING OUTCOMES IN MATHEMATICS AMONG SECONDARY SCHOOL STUDENTS" is based on the original work done by me under the guidance of **Dr. Niranjana K.P.,** Assistant Professor, Farook Training College and has not been included in any other thesis submitted previously for the award of any degree. The contents of the thesis are undergone plagiarism check using iThenticate software at C.H.M.K. Library, University of Calicut, and the similarity index found within the permissible limit. I also declare that the thesis is free from AI generated contents.

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Radhika T.

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ABSTRACT

Mathematics is a profound and fascinating domain, intricately connecting the threads of logic, patterns, and the very essence of the universe. Mathematics education is crucial globally due to it's connection to artificial intelligence, machine learning, data science, climate modelling, infrastructure development, and other scientific issues. The importance and contribution of Mathematics to the world is uncountable as it continues to play a crucial role in our day-to-day existence and will continue to influence future generations. In spite of the importance of mathematics education, the students express a variety of unfavourable attitude towards mathematics which includes fear of mathematics, lack of interest in mathematics, negative attitude as well as naive beliefs related to Mathematics. To strengthen Mathematics education, research should focus on a holistic approach which emphasizes both cognitive and affective outcomes in learning to make Mathematics learning enjoyable and meaningful. This includes the use of a variety of strategies by teachers, emphasizing that mathematical skills can be enhanced through practice and effort, and that making mistakes is a natural and valuable part of the learning journey. If the teacher designs a suitable instructional strategy for the learning of Mathematics, the students' beliefs, interest, motivation to learn Mathematics and to select Mathematics for higher education can be nurtured. Thus, the investigator decided to find out the effectiveness of a value based approach in Mathematics to enhance cognitive and affective outcomes of learning Mathematics. Hence, the study aims to find out the effectiveness of Process Stage Model to enhance learning outcomes in Mathematics such as Achievement in Mathematics, Logical Reasoning, Achievement Motivation in Mathematics, and Mathematical Beliefs and to reduce Mathematics Anxiety among secondary school students. The findings of the study indicated that the Process Stage Model is effective for enhancing Achievement in Mathematics, Logical Reasoning, Achievement Motivation in Mathematics, and Mathematical Beliefs of secondary school students. Results also indicated that the Process Stage Model is effective for reducing Mathematics Anxiety of secondary school students.

Key words

Effectiveness, Process Stage Model, Learning Outcomes in Mathematics, Secondary School Students

സംഗ്രഹം

യുക്തിയുടെയും പാറ്റേണുകളുടെയും പ്രപഞ്ചത്തിന്റെ സത്തയുടെയും ഇഴകളെ സങ്കീർണ്ണമായി ബന്ധിപ്പിക്കുന്ന അഗാധവും ആകർഷകവുമായ ഒരു മേഖലയാണ് ഗണിതശാസ്ത്രം. ആർട്ടിഫിഷ്യൽ ഇന്റലിജൻസ്, മെഷീൻ ലേണിംഗ്, ഡാറ്റാ സയൻസ്, ക്ലൈമറ്റ് മോഡലിംഗ്, ഇൻഫ്രാസ്ട്രക്ചർ ഡെവലപ്മെന്റ്, മറ്റ് ശാസ്ത്രീയ പ്രശ്നങ്ങൾ എന്നിവയുമായുള്ള ബന്ധം കാരണം ഗണിതശാസ്ത്ര വിദ്യാഭ്യാസം ആഗോളതലത്തിൽ നിർണായകമാണ്. ലോകത്തിന് ഗണിതത്തിന്റെ പ്രാധാന്യവും സംഭാവനയും എണ്ണമറ്റതാണ്, അത് നമ്മുടെ ദൈനംദിന അസ്തിത്വത്തിൽ നിർണായക പങ്ക് വഹിക്കുകയും ഭാവി തലമുറകളെ സ്വാധീനിക്കുകയും ചെയ്യും. ഗണിതവിദ്യാഭ്യാസത്തിന് ഇത്രയേറെ പ്രാധാന്യം ഉണ്ടായിരുന്നിട്ടും, ഗണിതത്തെക്കുറിച്ചുള്ള ഭയം, ഗണിതത്തോടുള്ള താൽപ്പര്യക്കുറവ്, നിഷേധാത്മക മനോഭാവം, ഗണിതവുമായി ബന്ധപ്പെട്ട ദുർബല വിശ്വാസങ്ങൾ എന്നിവകൊണ്ട് ഗണിതശാസ്ത്രത്തോട് വിദ്യാർത്ഥികൾ പലതരത്തിൽ പ്രതികൂല മനോഭാവം പ്രകടിപ്പിക്കുന്നു. ഗണിതശാസ്ത്രം ആസ്വാദ്യകരവും അർത്ഥപൂർണ്ണവുമാക്കുന്നതിന് പഠനത്തിലെ വൈജ്ഞാനികവും വൈകാരികവുമായ നേട്ടങ്ങളെ ഉൾച്ചേർത്ത് സമഗ്രമായ സമീപനത്തിനാണ് ഗവേഷണം ഊന്നൽ നൽകേണ്ടത്. ഇത് ഗണിതപഠനത്തെ ശക്തിപ്പെടുത്തുകയും മെച്ചപ്പെടുത്തുകയും ചെയ്യും. വൈവിധ്യമാർന്ന പഠന തന്ത്രങ്ങൾ ഉപയോഗിക്കുക, പരിശീലനത്തിലൂടെ കഴിവുകൾ മെച്ചപ്പെടുത്താമെന്ന് ബോധ്യപ്പെടുത്തുക, തെറ്റുകൾ വരുത്തുന്നത് പഠന യാത്രയുടെ സ്വാഭാവികവും മൂല്യവത്തുമായ ഭാഗമാണെന്നും ഊന്നിപ്പറയുക എന്നിവ ഇതിൽ ഉൾപ്പെടുന്നു. പഠനപ്രക്രിയയ്ക്ക് അനുയോജ്യവും പര്യാപ്തവുമായ ബോധന തന്ത്രം അധ്യാപകൻ രൂപകല്പന ചെയ്താൽ, വിദ്യാർത്ഥികളുടെ വിശ്വാസങ്ങൾ, ഗണിതശാസ്ത്രം പഠിക്കാനുള്ള താൽപ്പര്യം, ഉന്നതപഠനത്തിന് ഗണിതശാസ്ത്രം തിരഞ്ഞെടുക്കാനുമുള്ള പ്രചോദനം എന്നിവ പരിപോഷിപ്പിക്കാനാകും. ഇക്കാരണത്താൽ ഗണിതശാസ്ത്ര പഠനത്തിന്റെ വൈജ്ഞാനികവും വൈകാരികവുമായ ഫലങ്ങൾ വർദ്ധിപ്പിക്കുന്നതിന് ഗണിതത്തിൽ മൂല്യാധിഷ്ഠിത സമീപനത്തിന്റെ ഫലപ്രാപ്തി കണ്ടെത്താൻ ഗവേഷക തീരുമാനിച്ചു. ആയതിനാൽ, സെക്കൻഡറി സ്കൂൾ വിദ്യാർത്ഥികളിൽ ഗണിതശാസ്ത്ര പഠനത്തിലെ നേട്ടങ്ങൾ, യുക്തിചിന്ത, ഗണിതപരമായ അഭിപ്രേരണ ഗണിതശാസ്ത്ര ധാരണകൾ എന്നിവ മെച്ചപ്പെടുത്തുന്നതിലും, ഗണിത ഉത്കണ്ഠ കുറയ്ക്കുന്നതിലും പ്രക്രിയ ഘട്ട മാതൃകയുടെ ഫലപ്രാപ്തി കണ്ടെത്താൻ പഠനം ലക്ഷ്യമിടുന്നു. സെക്കണ്ടറി സ്കൂൾ വിദ്യാർത്ഥികളുടെ ഗണിതശാസ്ത്ര പഠനത്തിലെ നേട്ടങ്ങൾ, യുക്തിചിന്ത, ഗണിതപരമായ അഭിപ്രേരണ, ഗണിതശാസ്ത്ര ധാരണകൾ എന്നിവ വർദ്ധിപ്പിക്കുന്നതിനും സെക്കൻഡറി സ്കൂൾ വിദ്യാർത്ഥികളുടെ ഗണിതശാസ്ത്ര ഉത്കണ്ഠ കുറയ്ക്കുന്നതിനും പ്രക്രിയഘട്ട മാതൃക ഫലപ്രദമാണെന്ന് ഗവേഷണ കണ്ടെത്തലുകൾ സൂചിപ്പിക്കുന്നു.

പ്രധാന വാക്കുകൾ: ഫലപ്രാപ്തി, പ്രക്രിയഘട്ട മാതൃക, ഗണിതത്തിലെ പഠനഫലങ്ങൾ, സെക്കൻഡറി സ്കൂൾ വിദ്യാർത്ഥികൾ

Chapter I

INTRODUCTION

- Need and Significance of the Study
- Statement of the Problem
- Definition of Key Terms
- Variables
- Objectives
- Hypotheses
- Design of the Study
- Scope of the Study
- Delimitations of the Study
- Organization of the Report

Education is at the forefront of our global endeavors and is frequently considered as the cornerstone of human growth and societal development. From ancient Greek academies to contemporary internet classrooms, history is provided with examples of how education can change lives. Education can uplift people, fill the gap between socio-economic classes, and unlock the doors to a better life we never thought possible. In its purest form, education serves as a mechanism for transfer of knowledge as well as for social and personal development. Education enables people to acquire knowledge and abilities and nurtures the moral principles that define their personality. Education enables individuals to take an active role in the social web. In a world where things are changing so quickly, the value of education should be emphasized as it is the engine of technical innovation, social growth, and economic competitiveness. In the modern world, there is a greater focus on the need for an educational system that equips students with the skills they need to meet the challenges.

Report of Education Commission (1964-66) emphasized that “the destiny of India is being shaped in its classroom” (Ministry of Education, Government of India, 1996). Hence, school education is a fundamental aspect of a comprehensive education system that provides students with opportunities to learn and grow. Education is a structured approach that entails the continuous process of acquiring knowledge, skills, and values throughout a person's life. Ultimately, school education is an essential component which enables students for comprehensive development and exposes them to a variety of subjects. School education plays a crucial role in enhancing the overall learning experience and prepares them for higher education and the workforce. The purpose of various academic disciplines in school is to give students a comprehensive education that helps to understand the world around them and prepare them for the future. Each subject provides students with knowledge, skills, and abilities in areas that help them to succeed in their career and life pursuits.

Mathematics is an important subject in the school curriculum at every stage of education as it develops the logical and analytical thinking of individuals. Also, it plays a crucial role in developing thinking skills, promoting STEM careers, and enhancing cognitive development and brain function (Yadav, 2019). Mathematical expression and problem-solving are universal across disciplines and cultures and it acts as a common language which offers a platform for cooperation and communication between people and nations (Waller & Flood, 2016). Critical thinking abilities like reasoning, logic, and problem-solving are developed through learning mathematics which are crucial in many other disciplines like science, engineering, and economics (Su et al., 2016). Research indicates that young children's comprehension of mathematical terminology is positively associated with their mathematical skills (Kung et al., 2019; Purpura, 2016). Students who study mathematics gain analytical abilities that support them in making defensible decisions based on facts and data which are essential in today's world where data is abundant and decision-making is essential (Rasheva-Yordanova et al., 2018). The ability to comprehend reading material for students' academic development is a strong indicator of their skills in mathematics (Mckee, 2012). Analytical skills is fundamentally connected to mathematics, as it is a cognitive ability that aids students in understanding mathematical concepts and problem solving effectively (Garcia-Madruga et al., 2014) Mathematics provides a foundation for many other fields, develops critical skills (Firdaus et al., 2015), helps in decision-making and personal finance management, problem-solving (Krulik & Rudnick, 1985) and is a universal language that fosters communication and cooperation across different cultures and countries. One of the main aims of implementing mathematics education is to enable students to use mathematics in real-life situations (Wijaya et al., 2015). Thus, mathematics serves as the cornerstone upon which other subjects are built and it is an essential resource for comprehending difficult ideas and phenomena. Mathematics is regarded as the queen of science (Burton, 2003). The importance and contribution of mathematics to the world is uncountable because it continues to play a crucial role in our day-to-day existence and will continue to influence future generations.

However, students express unfavorable attitudes regarding mathematics and majority of them believe that mathematics is extremely a tough subject (Fritz et al., 2019). Students' dissatisfaction is one of the primary reasons they do not pursue mathematics as a subject in their tertiary level of education (Brown et al., 2008). Society has faced significant challenges in mathematics education due to children's low mathematical performance and inclination to avoid mathematics. Various factors, including students' attitudes, interests, and instructional techniques, play a role in diminishing academic performance and developing lack of enthusiasm for learning mathematics as well as students' perceptions on their engagement with the subject (Jumadi & Kanash, 2013). Mujtaba et al. (2014) highlighted the need for a country to increase the mathematical skills and proficiency of its students. Mathematics requires students to use logical reasoning and apply complex problem solving skills which can be challenging. The discipline would become unfeasible, as mathematics relies on solving well-established concrete concepts and explaining the rationale that supports them (Altintas & Ilgun, 2017).

The development of mathematical competencies is influenced by the learning process, which affects the learning outcomes. The measurable knowledge, abilities, skills, or values that students are capable of expressing upon completion of the module in mathematics are referred to as mathematics learning outcomes (Quality Enhancement Committee, Texas University, 2014). Of all the learning outcomes in the context of mathematics, cognitive learning outcomes is the utmost significance. The integration of affective learning needs into teaching and learning of mathematics catalyzes students to engage in the learning process. This integration recognizes that the acquisition of knowledge in subjects like mathematics is not solely dependent on cognitive outcomes, but also on affective outcomes. The National Council of Teachers of Mathematics (NCTM, 1989) strongly advocates for the incorporation of affective factors along with cognitive factors in mathematics education. In support of this, Freeman et al. (2014) asserts that the implementation of active learning methods enhanced students academic as well as non-academic performance and increased engagement in mathematics courses, surpassing the effectiveness of traditional lecture method. Various studies demonstrated that different teaching methods including flipped classrooms (Freeman et al., 2014), cooperative learning (Slavin, 1996), inquiry-based learning (Nieveen & Folmer, 2013), differentiated instruction (Tomlison,2014), real-world connections (Wijaya et al., 2015), positive feedback (Corpus & Lepper, 2007), active learning (Freeman et al., 2014) enhances the cognitive and affective learning outcomes in mathematics.

National Curriculum Framework for School Education (NCFSE, 2023 & NCERT, 2023) emphasizes that mathematics education is crucial globally due to its connection to artificial intelligence, machine learning, data science, climate modelling, infrastructure development, and other scientific issues. To strengthen mathematics education, educators and teachers have to use a variety of strategies that enhance both cognitive and affective factors. Teachers can encourage the active participation of children through group problem-solving, hands-on activities, and interactive lessons that allow them to engage with the material. Demir et al. (2022) indicated that social anxiety and participation styles have an impact on active participation, which significantly affects academic achievement. Providing opportunities for students to learn at their own pace by using differentiated instructions and adaptive learning tools can help them to learn by catering to individual needs (Bender, 2012). Supporting students' emotional well-being by creating a positive and supporting learning environment, providing opportunities to talk about emotions, and using social-emotional learning techniques are some of the teaching strategies that educators can help to strengthen mathematics education and improve students' cognitive and affective factors, leading to improved academic performance and success in future endeavors (Ni et al., 2018).

Need and Significance of the Study

Schooling is a legal right of every child and every subject is important for students. Mathematics education plays a crucial role in schools by helping individuals to grow mentally, emotionally, physically as well fosters creativity and accountability (Niss, 1996). Along with acquiring theoretical knowledge, mathematics education enables an individual to put the theory into practice. Therefore, learning mathematics is mandatory for the fullest development of a child's personality in today's ever changing society. True learning of mathematics enables the students to acquire the basic and essential knowledge, abilities, interests, skills, and proper attitude in life. In addition to that, Kuboja and Ngussa (2015) pointed out that affective learning is frequently compared to cognitive learning, the later being linked to the process of synthesis, evaluation and understanding of knowledge or information and the practical use of the knowledge acquired. Hence, the learners require both cognitive and practical experiences in their mathematics education, to become productive 21st century citizens.

Research studies indicated that several factors affect students' mathematics learning such as cognitive factors (Swanson, 2004), individual factors (Pajares, 2015; Ashcraft & Krause, 2007), instruction factors (Hiebert & Grouws, 2007), environmental factors (Hill et al., 2005), and teaching methods (National Research Council, 2001). Thus, implementation of effective teaching strategy and personalized learning approach may increase motivation and engagement of students which helps to enhance their academic performance ultimately. Personalized learning is a solution for adapting education to the needs of the individual and their previous experiences

(Lee et al., 2018; Miliband, 2006). Therefore, by recognising the interplay of these multifaceted factors, educators can tailor their instructional approaches and provide students with the necessary tools and assistance required for success in their mathematical endeavors.

In general, most of the students think that they are not clever enough to learn mathematics (Lay & Davadas, 2018). Methods of teaching mathematics have an important role in resolving this misunderstanding (Kunwar et al., 2022). Lack of teachers' ability to link the new mathematical concepts and previously learned mathematical concepts, negative feelings towards mathematics, mathematics anxiety, school management system, and lack of regular assessment system of school are the main causes of difficulties in learning mathematics (Acharya, 2017). Teachers' instructional approaches, rules, teaching methods, teachers' affective support, and attitude toward mathematics have an important role in creating a negative attitude in students towards mathematics (Lay & Davadas, 2018). Many researchers pointed out that the attitude towards mathematics is an important factor that can influence students' achievement (Mensah & Kurancie, 2013; Lay & Davadas, 2018). To be brief, in order to overcome these challenges students need to have access to quality resources, a positive attitude towards learning, good mentoring, practical and interactive teaching methods that engage them in learning process.

Research studies also indicated that the teaching methods have significant influence on cognitive and affective learning outcomes in teaching and learning of mathematics (Hui & Muhmud, 2023). Lessani et al. (2017) emphasized that students are more successful in academics when systematic problem-solving methods are incorporated into discovery learning. The choice of teaching methods in mathematics education can significantly influence student's affective factors, including their attitudes, motivation, interest, and emotional well-being (Sugano & Mamilo, 2021). Thus, employing effective and inclusive teaching strategies, educators can create a positive learning environment that fosters love for mathematics and supports students in their mathematical journey.

The affective factors related to students' achievement in mathematics are academic self- concepts, confidence in their ability to learn mathematics, mathematics anxiety, test anxiety, perceptions of the usefulness of mathematics, motivation, self esteem and locus of control (House, 1995). Alrabai (2016) reported that EFL instructors have the power to affect students' affective factors by strengthening their sense of autonomy and self-worth, lowering anxiety, encouraging positive attitude towards learning and raising their motivation. According to Gonpot et al. (2014), attitude and motivation are positively impacted by the perceived utility of mathematics. The study conducted by Mujtaba et al. (2014) revealed that both high achieving and low achieving students perceive mathematics as dull, irrelevant and boring subject and this can significantly impact their motivation and engagement level. In addition to that, the lack of motivation makes learning mathematics challenging for students as well as to focus and learn mathematical concepts effectively (Gafoor & Kurukkan, 2015).

Gomez-Chacon (2000) revealed that a negative attitude towards mathematics is also a source of challenge in mathematics learning. Mathematics achievements are often low due to a lack of interest in the subject and studies indicate that a student's level of interest plays a crucial role in their success or difficulties in learning mathematics (Singh et al., 2002). Many research studies have pointed out a widespread trend of poor performance in mathematics is closely connected to students' disinterest in the subject (Mbugua et al., 2012; Sa'ad et al., 2014; Mazana et al., 2020; Ndume et al., 2020). Issues such as dull teaching methods, the broad scope of the subject, and limited practice opportunities also contribute to students' lack of enthusiasm for mathematics (Shoaib & Saeed, 2016). Overcoming these obstacles requires educational improvements to make learning more captivating. Acknowledging the rewarding students for their progress can increase their confidence and interest in mathematics (Peteors et al., 2020). Creating a positive and enjoyable learning atmosphere has been proven to significantly improve students' interest in mathematics and boost their performance (Mazana et al., 2019). Therefore, to meet students' needs, their thirst for mathematics, motivating and engaging students to learn mathematics, and to develop a positive and strong attitude towards mathematics, an effective model which encompasses the mathematical beliefs and values must be applied in the classroom.

National Council of Teachers of Mathematics (NCTM, 1989), encourages mathematics educators to incorporate affective factors along with cognitive factors in mathematics teaching and learning. According to the study conducted by Faruq and Hidayati (2022) mathematical beliefs have a positive relationship with cognitive aspects of the mathematical learning outcome, but have a positive and negative relationship with affective aspects. Results of the study also indicated that mathematical beliefs have a positive correlation with conceptual understanding, achievement, and problem-solving. But they have a positive correlation with the affective aspect- motivation, negative correlation with maths- anxiety. The affective cognitive consistency theory (Rosenberg, 1956) examines the relationship between attitudes and beliefs. According to Rosenberg (1956) students possess a set of beliefs or attitudes about various objects or events and these beliefs or attitudes generate certain emotions in them. Students strive to keep consistency between their beliefs and emotions and beliefs and attitudes and any type of inconsistency between these feelings causes discomfort or dissonance, which motivates the person to reduce or eliminate the inconsistency (Rosenberg, 1956). Thus, mathematical beliefs about the ability to learn mathematics can impact students' academic performance. Norman (1975) emphazised the importance of assessing both the affective and cognitive components of attitude in identifying those whose verbal attitude reports have consequences for their behavior.

According to Bandura (1994) students' success in school and future mathematical endeavours are greatly influenced by their mathematical beliefs which include their attitudes, self-efficacy, and mindset. Papanastasiou (2000) explored the effects of the school environment on students' attitudes and beliefs in mathematics learning and reported that the students' beliefs about their own abilities and the nature of mathematics can also impact their performance. Lefevre et al. (2010) reported that the positive beliefs about mathematics predicted better mathematics performance in later grades. Boaler and Dweck (2016) explained how promoting the development of positive mathematical beliefs, such as a growth mindset and a sense of belonging, can increase mathematics achievement. Hence, it is essential to use approaches and models in teaching and learning process to improve the mathematical beliefs as well as other affective learning outcomes of the students which in turn helps in enhancing both the cognitive and affective outcomes of mathematics.

Active learning (Vale & Barbosa, 2023) and reflective thinking (Kablan & Günen, 2021) are important components in making mathematics education effective. Active learning involves students actively participating in the classroom through group projects, problem-solving, presenting ideas, and trusting their positive beliefs about the subject. Engaging students through active learning methods also involves encouraging them to think critically, discuss ideas, explore concepts, and create new knowledge, which significantly improves their learning experiences (Freeman et al., 2014; Abdulla & Yang, 2018; Theobald et al., 2020). By actively engaging in the learning process and reflecting on their progress and achievement, students can develop a deeper understanding of mathematics concepts and build important skills that will serve them throughout their academic life and professional lives (Davis, 2012). Reflective thinking skill is one of the prominent and higher-order thinking skills in a constructivist understanding environment. Reflective thinking involves thinking deeply about what has been learned and how it has been learned. This includes analyzing the learning process, evaluating the effectiveness of different strategies, and making connections between different concepts and ideas. Saracoglu and Kahyaglu (2021) emphasized that the learning and study approaches of students' are a significant predictor of reflective thinking skills and also exist a positive relationship between reflective thinking skills and problem-solving. Toraman et al.

(2020) also reported that mathematics achievement and reflective thinking towards problem-solving have a strong positive correlation.

Reflective thinking can help students to identify areas where they need to improve and develop strategies for overcoming challenges. Reflective thinking is active learning, that create a more engaged and effective mathematics education experience for students. According to Dewey (1933) reflective thinking is an active, persistent, and careful consideration of beliefs or supposed knowledge, and the further conclusions to which that knowledge leads. Reflective practice is a part of learning and it helps in growth and development of an individual. By connecting mathematical ideas to real-life situations, students can see the relevance of the concept and the significance of what they are learning. Mathematics education (Freudenthal, 1991) focuses on giving students a deeper understanding and relevance of mathematics by linking mathematical ideas to actual situations.

Cooperative learning philosophy emphasizes group work in solving mathematical problems as a key component of mathematics education (Klang et al., 2021). When students discuss potential solutions, exchange viewpoints, and work together in small groups they can tackle the complexity of the problem (Yackel et al., 1991). Students who collaborate can communicate more effectively and are exposed to a variety of approaches to problem-solving (Barrows, 1986). By encouraging students to investigate and apply mathematical concepts in real-world contexts, students develop an intuitive and better understanding of mathematical concepts. Providing students with opportunities to engage with cognitive factors such as problem solving, logical reasoning, critical thinking, achievement and affective factors such as interest, beliefs, anxiety, motivation, attitude, etc. is essential to make mathematics education effective at the secondary stage of education.

Enhancing mathematics education during the secondary stage can have significant benefits for enhancing students' mathematical abilities, academic success and future career opportunities. According to Nolting (2007), students' mathematics performance is as much related to students' beliefs and attitudes as their mathematics knowledge. Suthar et al. (2010) found that there is a significant relationship between students' beliefs about the importance of mathematics and beliefs about one's ability in mathematics. Basically, values are the inner realities of individuals, and these are reflected through beliefs, habits, behaviors, expectations, and relationships. The base of affective aspects of learning is the analysis of human experience and values are formed when a student experiences the processes in stages (Dewey, 1939), either as individual or as a group. By connecting learning to real-world situations and experiences, students develop a deeper understanding of the significance of mathematical values and beliefs. Hence, along with the formation of beliefs and values in a subject, it is possible to enhance cognitive and affective outcomes.

In the view of McLeod (1992) beliefs, attitudes, and emotions are seen as categories of affect, which influences affective outcomes of mathematics education. Goldin (2002) emphasized that a meta affective context and individualized beliefs are constructed as a result of inculcation of values and beliefs that evoke personal emotions which helps in forming affective pathways that encode cognitive information. To enhance motivation for challenging tasks and improve success expectations, teachers can design their lessons related to real life by incorporating values and beliefs directly in the learning process and can offer variety methods for students to demonstrate their understanding (Blumenfeld et al., 1992). Learning goals are encouraged when scaffolding and support are available, efforts and improvements are acknowledged when mistakes are viewed as opportunities for learning, students can revise their work, evaluations emphasize learning, individual competition is minimized, and students are grouped by topic, interest, and choice rather than performance (Blumenfeld et al., 1992). Freudenthal (1991) emphasized the importance of engaging students with mathematics and applying it effectively to connect mathematical concepts with everyday life, thereby transforming abstract ideas into concreate realities. Since the mathematical knowledge originates from real-life contexts, the inferences, assumptions, and applications of this knowledge are closely linked to practical situations (Eli, 2009; Gainsburg, 2008).

National Curriculum Framework (NCF) (2005) and National Education Policy (NEP) (2020) have recommended the adoption of pedagogical approaches and teaching methods in school education that encourage students to reflect on the subject matter, enabling them to build their own understanding (Ministry of Human Resource and Development, Government of India, 2020). National Curriculum Framework for School Education (NCFSE) (2023) pointed out that the process of making decisions rooted in rational analysis, creativity, and solid comprehension of the world exemplifies the exercise of autonomy. This reflects an individual's ability to encourage in rational reasoning, critical thinking, and possess a comprehensive understanding of various subjects, enabling them to perceive and enhance their surroundings (NCERT, 2023). Thus, in educational context, it is essential to nurture independent thinkers who are curious, embrace of new ideas, and develop their own perspectives and beliefs at secondary stage (NCF, 2023). National Education Policy (2020) pointed out that the use of strategies that combine STEM fields (science, technology, engineering, and mathematics) with the humanities and arts have often demonstrated beneficial learning outcomes, such as greater creativity and invention, critical thinking, and increased ability to think more abstractly, solve problems, work in teams, communicate effectively, learn more deeply and become proficient in a variety of subject areas, develop moral and social consciousness, etc. aside from involvement and enjoyment in the process of learning (Ministry of Human Resource and Development, Government of India, 2020). Hence, research should be strengthened and enhanced by using holistic approach to education which emphasizes both on cognitive and affective outcomes in learning inorder to make the learning of mathematics enjoyable and meaningful. National Council of Educational Research and Training (NCERT) (2023) in NCFSE highlighted that the mathematics education curriculum aims to develop students' foundational skills in number theory, mathematical thinking, and problem-solving while also fostering joy, curiosity, and appreciation for mathematical concepts, by addressing the prevalent fear of mathematics.

Thus, the investigator believes that a teaching model by incorporating values and beliefs will enhance students' beliefs, interest, and motivation to learn mathematics thereby increasing the propensity to choose mathematics at a higher level of education by enhancing both the cognitive and affective outcomes in learning. By reviewing the related literature it is evident that a model of teaching for enhancing selected cognitive learning outcomes such as achievement in mathematics, and logical reasoning as well as affective learning outcomes such as mathematics anxiety, achievement motivation in mathematics and mathematical beliefs of secondary school students were not adopted. Hence, a systematically developed model of teaching would be helpful to a great extent to the learners, teachers, teacher educators, and educational institutions to enrich mathematics education and to enhance performance and achievement in mathematics as well logical reasoning. It would also helps in reducing negative factors mainly mathematics anxiety, and enhancing mathematical beliefs and mathematics achievement motivation among the learners. Therefore, the main aim of the study is to find out the effectiveness of Process Stage Model on Learning Outcomes in Mathematics such as Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs among secondary school students. Hence, the research questions framed for the study are;

1. What is the level of Mathematical Beliefs of secondary school students?
2. Does the Process Stage Model enhances the Achievement in Mathematics of secondary school students?
3. Does the Process Stage Model enhances Logical Reasoning of secondary school students?
4. Does the Process Stage Model reduces Mathematics Anxiety of secondary school students?

5. Does the Process Stage Model enhances Achievement Motivation in Mathematics of secondary school students?

6. Does the Process Stage Model helps in developing Mathematical Beliefs of secondary school students?

Statement of the Problem

National Education Policy (2020) visualizes that India's future leadership in disciplines such as artificial intelligence, machine learning, and data science will rely heavily on mathematical skills and reasoning. Thus, mathematics and computing thinking will be given more priority throughout the school years by using a variety of innovative approaches, strategies and techniques that make mathematical thinking more fun and interesting (Ministry of Human Resource and Development, Government of India, 2020). Across the various stages of school education, mathematics has the ability to develop problem solving skills, logical reasoning, creativity and objectivity. Hence, it is essential to use innovative pedagogies that make learning of mathematics at the secondary stage of education enjoyable and meaningful by connecting mathematics with day-to-day living and engaging students in reflective learning. Therefore, the investigator decided to use a model of teaching which incorporates values and beliefs developed through processes as stages which is based on reflective and active learning principles for enhancing both cognitive and affective learning outcomes in mathematics. The use of such innovative pedagogies will be helpful in making learning of mathematics enjoyable and a lifelong passion by understanding fundamental concepts of mathematics connecting with the real world. Thus, the present study is entitled as "EFFECTIVENESS OF PROCESS STAGE MODEL

ON SELECT LEARNING OUTCOMES IN MATHEMATICS AMONG SECONDARY SCHOOL STUDENTS”

Definition of Key Terms

The key term used for stating the problem are explained under this section.

Effectiveness

Effectiveness is the extent to which something has been successful in bringing about a desired output (Gager, 2022).

For the present study, effectiveness means the extent to which the Process Stage Model is successful to produce desired cognitive and affective outcomes in mathematics.

Process Stage Model

The Process Stage Model, in this study, refers to an instructional strategy that incorporates a value-based approach to plan instruction in Mathematics for improving learning outcomes through the process in stages advocated by Dewey (1939) such as interact with the environment, reflective thinking on the meaning of interaction, based on the reflective thought formulate values or beliefs and based on reflective thinking apply the formulated values to a new situation.

Learning Outcomes in Mathematics

Learning outcomes are measurable statements that initially articulate what students should know, be able to do, or value as a result of taking a course or completing a programme (Jenkins & Unwin, 2001).

In the study, learning outcomes refer to measurable cognitive learning outcomes in mathematics such as achievement in mathematics and logical reasoning and affective learning outcomes such as mathematics anxiety, achievement motivation in mathematics, and mathematical beliefs of secondary school students as measured by using Achievement Test in Mathematics, Logical Reasoning Test, Mathematics Anxiety Scale, Scale on Achievement Motivation in Mathematics and Mathematics Beliefs Inventory prepared and standardized by the investigator.

Secondary School Students

The term secondary school students refers to those students studying at secondary stage of education i.e., VIII, IX, and X standards, in the secondary schools of Kerala state.

In the present study secondary school students refer to those students studying in VIII standard of Kerala state who follow Kerala state syllabus.

Variables

The main aim of the study is to find out the effectiveness of the Process Stage Model on select Learning Outcomes in Mathematics among secondary school students. The independent and dependent variables adopted in the study are;

Independent Variables

The independent variables in the study are two types of Instructional Strategies

a) Process Stage Model as Instructional Strategy for Experimental Group

b) Constructivist Model as Instructional Strategy for Control Group

Dependent Variables

The dependent variables in the study are select Cognitive and Affective Learning Outcomes in Mathematics.

Cognitive Learning Outcomes

Achievement in Mathematics

Logical Reasoning

Affective Learning Outcomes

Mathematics Anxiety

Achievement Motivation in Mathematics

Mathematical Beliefs

Objectives

The objectives framed for the study are;

Major Objective

- To find out the effectiveness of the Process Stage Model on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs of secondary school students.

Specific Objectives

The specific objectives are

1. To analyze the level of Mathematical Beliefs of secondary school students.

2. To compare the mean scores of pre-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs for experimental and control groups of secondary school students.

3. To compare the mean scores of post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs for experimental and control groups of secondary school students.

4. To compare the mean scores of pre-test and post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs for experimental group of secondary school students.

5. To compare the mean scores of pre-test and post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs for control group of secondary school students.

6. To compare the mean scores of gain scores on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs for experimental and control groups of secondary school students.

Hypotheses

The hypotheses framed for the study are;

1. Secondary school students are having moderate level of Mathematical Beliefs

2. There exists no significant difference in the mean scores of pre-test on Achievement in Mathematics for experimental and control groups of secondary school students.

3. There exists no significant difference in the mean scores of pre-test on Logical Reasoning for experimental and control groups of secondary school students.

4. There exists no significant difference in the mean scores of pre-test on Mathematics Anxiety for experimental and control groups of secondary school students.

5. There exists no significant difference in the mean scores of pre-test on Achievement Motivation in Mathematics for experimental and control groups of secondary school students.

6. There exists no significant difference in the mean scores of pre-test on Mathematical Beliefs for experimental and control groups of secondary school students.

7. There exists significant difference in the mean scores of post-test on Achievement in Mathematics for experimental and control groups of secondary school students.

8. There exists significant difference in the mean scores of post-test on Logical Reasoning for experimental and control groups of secondary school students.

9. There exists significant difference in the mean scores of Post-test on Mathematics Anxiety for experimental and control groups of secondary school students.

10. There exists significant difference in the mean scores of post-test on Achievement Motivation in Mathematics for experimental and control groups of secondary school students.

11. There exists significant difference in the mean scores of post-test on Mathematical Beliefs for experimental and control groups of secondary school students.

12. There exists significant difference in the mean scores of pre-test and post-test on Achievement in Mathematics for experimental group of secondary school students.

13. There exists significant difference in the mean scores of pre-test and post-test on Logical Reasoning for experimental group of secondary school students.

14. There exists significant difference in the mean scores of pre-test and post-test on Mathematics Anxiety for experimental group of secondary school students.

15. There exists significant difference in the mean scores of pre-test and post-test on Achievement Motivation in Mathematics for experimental group of secondary school students.

16. There exists significant difference in the mean scores of pre-test and post-test on Mathematical Beliefs for experimental group of secondary school students.

17. There exists significant difference in the mean scores of pre-test and post-test on Achievement in Mathematics for control group of secondary school students.

18. There exists significant difference in the mean scores of pre-test and post-test on Logical Reasoning for control group of secondary school students.

19. There exists significant difference in the mean scores of pre-test and post-test on Mathematics Anxiety for control group of secondary school students.

20. There exists significant difference in the mean scores of pre-test and post-test on Achievement Motivation in Mathematics for control group of secondary school students.

21. There exists significant difference in the mean scores of pre-test and post-test on Mathematical Beliefs for control group of secondary school students.

22. There exists significant difference in the mean scores of gain scores on Achievement in Mathematics for experimental and control groups of secondary school students.

23. There exists significant difference in the mean scores of gain scores on Logical Reasoning for experimental and control groups of secondary school students.

24. There exists significant difference in the mean scores of gain scores on Mathematics Anxiety for experimental and control groups of secondary school students.

25. There exists significant difference in the mean scores of gain scores on Achievement Motivation in Mathematics for experimental and control groups of secondary school students.

26. There exists significant difference in the mean scores of gain scores on Mathematical Beliefs for experimental and control groups of secondary school students.

27. The Process Stage Model is effective for enhancing Achievement in Mathematics of secondary school students.

28. The Process Stage Model is effective for enhancing Logical Reasoning of secondary school students.

29. The Process Stage Model is effective for reducing Mathematics Anxiety of secondary school students.

30. The Process Stage Model is effective for enhancing Achievement Motivation in Mathematics of secondary school students.

31. The Process Stage Model is effective for enhancing Mathematical Beliefs of secondary school students.

Design of the Study

Method

The study adopted multi-methodology by incorporating both survey and experimental method. The survey method was adopted to analyze the level of Mathematical Beliefs of secondary school students and experimental method was used to study the effectiveness of the Process Stage Model on select learning outcomes in mathematics such as Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs among secondary school students.

Design of Experimentation

In order to know the effectiveness of the Process Stage Model on select learning outcomes in mathematics such as Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, Mathematical Beliefs, the investigator required two groups of participants, one group who taught with the Process Stage Model, and another group with the Constructivist model. Two group pre-test post-test non-equivalent group design is selected for conducting the study. Intact class was used both in experimental and control groups. The design of the experimentation is;

$$G_1: O_1 \text{ x } O_2$$

$$G_2: O_3 \text{ c } O_4$$

Where,

G1 is the experimental group with pre-test O1 and post-test O2 and

G2 is the control group with pre-test O3 and post-test O4

Sample Selected for the Study

The population considered for the study is secondary school students studying in high schools of Kerala state who follow the Kerala state syllabus. A sample of 600 secondary school students studying in VIII standard was selected for the first phase during survey and for the experimentation, sample comprised of 62 secondary school students studying in VIII standard selected from two divisions of Higher Secondary School, Peringode in Palakkad district of Kerala state. Intact class was selected for both experimental and control groups which comprised of 31 students of VIII standard in both groups.

Instruments Used

The instruments used in the study are;

Lesson Transcript on Process Stage Model (Radhika & Niranjana, 2022)

Lesson Transcript on Process Stage Model was developed and validated by the investigator with the help of the supervising teacher. Process model is a value based approach and values or beliefs are cultivated as individuals or groups progress through a series of stages (Dewey, 1939) such as; interact with the environment, reflective thinking on the meaning of the interaction, based on the reflective thought, formulating values or beliefs, based on reflective thinking apply the formulated values to new situations.

Lesson Transcript on Constructivist Model

The investigator prepared Lesson Transcript on Constructivist Model that is existing in the secondary schools of Kerala state. Learning in constructivist contexts is characterized by active involvement, inquiry, problem- solving, and teamwork.

Achievement Test in Mathematics (Radhika & Niranjana, 2022)

Achievement Test in Mathematics was developed and standardized by the investigator with the help of the supervising teacher is used to measure the Achievement in Mathematics of experimental and control groups of secondary school students before and after the experimentation phase. The Achievement Test in Mathematics is constructed on the basis Revised Bloom's Taxonomy of educational objectives. The standardized Achievement Test in Mathematics consists of 30 multiple choice test items.

Logical Reasoning Test (Radhika & Niranjana, 2022)

To measure the Logical Reasoning of experimental and control groups of secondary school students before and after the experimentation, the investigator developed and standardized Logical Reasoning Test with the help of the supervising teacher. The standardized Logical Reasoning Test consists of 31 multiple choice test items on the bases of forms of logical reasoning such as inductive reasoning, analytical reasoning, deductive reasoning, and abstract reasoning.

Mathematics Anxiety Scale (Radhika & Niranjana, 2022)

To measure the Mathematics Anxiety of experimental and control groups of secondary school students before and after the experimentation, the investigator developed and standardized Mathematics Anxiety Scale with the help of the supervising teacher. The standardized Mathematics Anxiety Scale consists of 22 items about students Mathematics Anxiety with dimensions such as everyday life's math anxiety, learning mathematics anxiety, and test anxiety as suggested by Yanez-Marquina and Villardon-Gallego (2017).

Scale on Achievement Motivation in Mathematics (Radhika & Niranjana, 2022)

To measure the Achievement Motivation in Mathematics of experimental and control groups of secondary school students before and after the experimentation, the investigator developed and standardized Scale on Achievement Motivation in Mathematics with the help of the supervising teacher. The standardized Scale on Achievement Motivation in Mathematics consists of 42 items related to the dimensions such as academic motivation, need for achievement, academic challenge, work method, importance of marks, need to excel, meaningfulness of daily school tasks, attitude towards teacher, interpersonal relationship, participation in school activities, and social organisation as suggested by Deo and Mohan (1985).

Mathematical Beliefs Inventory (Radhika & Niranjana, 2022)

To measure the Mathematical Beliefs of experimental and control groups of secondary school students before and after the experimentation, the investigator developed and standardized Mathematical Beliefs Inventory with the help of the supervising teacher. The standardized Mathematical Beliefs Inventory consists of 34 statements related to beliefs about the nature of mathematics (Grouws et al., 1996; Zakaria & Musiran, 2010), beliefs about mathematics in daily life (Grouws et al., 1996), beliefs about mathematics teaching and learning (Op't Eynde & Decorte, 2002), and beliefs about competence in mathematics (Zakaria & Musiran, 2010).

Statistical Techniques Employed

The study made use of both descriptive and inferential statistics for the analysis of collected data. The following are the major statistical techniques used for the study.

Descriptive statistics

Mean, median, mode, standard deviation, skewness and kurtosis of each dependent variable, Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs were calculated to know the basic properties of the distribution. Descriptive statistics were used to summarize, organize and simplify data which helped the investigator to describe the nature of the dependent variable, such as Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Mathematics Achievement Motivation, and Mathematical Beliefs, for the selected sample.

Probability-Probability Plot (P-P Plot)

P-P plots of the distribution of scores of the dependent variables, Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs, of secondary school students were calculated to know whether the distribution of scores of dependent variable follows normality for the pre-test and post-test scores of experimental and control groups.

Pearson's Product Moment Coefficient of Correlation

Pearson's correlation was calculated to obtain the reliability of the scales, Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs. It is also used to calculate the correlation between mean scores of pre-test and post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs of experimental and control groups. Product moment correlation was calculated to assess how much of variation in the post-test scores can be explained by pre-test scores of experimental and control groups. Pearson's product moment correlation between the covariate (pre-test scores of Mathematical Beliefs) and the dependent variable (post-test scores of Mathematical Beliefs) is calculated for controlling the initial differences in Mathematical Beliefs. It also used to ensure whether the assumptions of ANCOVA are met.

Levene's Test for Equality of Variance

Levene's test was conducted to confirm the homogeneity of variance before testing the significance of the difference between the mean scores of pre-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs of experimental and control groups. Significance of the difference between the mean scores of post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs of experimental and control groups and to confirm the homogeneity of variance before testing the significance of the difference between the mean scores of two groups.

One Sample t test

One Sample *t* test was used to test the significance of difference between the mean value obtained for Mathematical Beliefs and the test value of Mathematical Beliefs Inventory to analyze the level of Mathematical Beliefs of secondary school students.

The Test of Significance of Difference Between Means of Large Independent Sample (t-Test)

Large independent sample *t*-test was conducted to compare mean scores of pre-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs for experimental and control groups. It also used to compare mean scores of post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs for experimental and control groups and to know the difference in the mean scores of gain scores on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs of secondary school students for experimental and control groups.

Test of Significance of Difference Between Mean of Large Dependent Sample (Paired Sample t-Test)

Paired sample *t*-test was conducted to compare pre-test and post-test mean scores on the dependent variables, Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs within the experimental and control groups.

Cohen's d

Cohen's *d* was used to find out the effectiveness of Process Stage Model through finding out the effect size of mean scores of post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs of the experimental and control groups, to find out the effectiveness of Process Stage Model. It also used to test the effect size of mean scores of pre-test and post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs of experimental group of secondary school students to find out the effectiveness of Process Stage Model.

Analysis of Covariance (ANCOVA)

Analysis of covariance is used to compare mean post-test scores of Mathematical Beliefs for experimental and control groups after controlling pre-test scores of Mathematical Beliefs.

Scope of the Study

The study was conducted to find out the effectiveness of Process Stage Model on the learning outcomes such as Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs among secondary school students. The model was prepared with the intention to transact all subjects in secondary class and specifically provide the provision for incorporation of mathematical values and beliefs. For the purpose of the study the investigator identified 25 values and 18 beliefs related to mathematics. The investigator designed the structure of the Process Stage Model by incorporating the identified mathematical values and beliefs required for secondary school students. The investigator developed and validated Lesson Transcripts on Process Stage Model. The researcher prepared thirty lesson transcripts on the chapter 'Identities' on Process Stage Model. Mathematics teachers who wish to experiment with innovations can use this model in their classrooms and guides them to prepare the new lesson transcripts for the whole content. The designed Process Stage Model can also be used for teaching mathematics in primary and higher secondary stages of education. But the mathematical values and situations selected might be according to the developmental stage of the selected student population.

The study was carried out in two phases such as survey phase and experimental phase. The survey was conducted on a sample of 600 secondary school students studying in VIII standard to analyze the mathematical beliefs. The experimental treatment involved a sample of 62 participants, evenly divided into experimental and control groups of secondary school students. It is important to note that although the number of participants varied across different phases, they were all selected from the same population, specifically eighth-standard secondary school students.

The study focuses on the dependent variables namely Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs. The background of each variable was analyzed with the theories related to them. The investigator developed and standardized instruments such as Achievement Test in Mathematics, Logical Reasoning Test, Mathematics Anxiety Scale, Scale on Achievement Motivation in Mathematics and Mathematical Beliefs Inventory with the help of supervising teacher. The same instruments were used to measure the dependent variable before and after the treatment for experimental and control groups of secondary school students.

Delimitations of the Study

The investigator has taken utmost care to make the study flawless, even though some delimitations of the study were identified by the investigator are described in this section. Effectiveness of the Process Stage Model is measured for selected cognitive outcomes such as Achievement in Mathematics, and Logical reasoning, as well as selected affective outcomes such as, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs of secondary school students. The other cognitive and affective outcomes such as problem solving ability, creativity, interest, attitude etc. are not considered.

The population of the study consists of secondary school students of Kerala state who follow Kerala state syllabus only. The secondary school students who follow other syllabus such as CBSE and ICSE syllabus were not considered. For conducting survey, the sample comprised 600 secondary school students of standard VIII studying in various schools of Trivandrum, Alappuzha, Palakkad, Kozhikode, Kannur and Kasargod districts of Kerala state. Among the 14 districts only 6 districts were considered during the survey. For conducting experimental study, two classes of secondary school students studying in standard VIII of same school in Palakkad District were selected as experimental and control groups. The sample were selected only from an aided school though there are government and unaided schools.

Another delimitation is that the experimental study is planned only for 30 days. The study is confined only to one chapter ‘Identities' of VIII standard Mathematics and other chapters are not considered. The study follows quasi-experimental design and certain factors like age, gender, socio economic status, and the home environment of students which may affect the experiment and their effects were not considered while conducting the experiment.

Organization of the Report

The study is systematically organized in five chapters namely, introduction, review related literature, methodology, analysis and interpretation, summary, findings and conclusions and implications, recommendations and suggestions. The detailed organization of the report is described below.

Chapter 1: Introduction

This chapter comprises general and brief introduction of the study, need and significance of the study, statement of the problem, definition of key terms, variables, objectives, hypotheses, design of the study, scope of the study, delimitations of the study and organization of the report.

Chapter 2: Review of Related Literature

This chapter deals with the theoretical overview of process stage model, mathematics achievement, logical reasoning, mathematics anxiety, achievement motivation and mathematical beliefs. It also includes studies related to mathematics achievement, logical reasoning, mathematics anxiety, achievement motivation and mathematical beliefs.

Chapter 3: Methodology

This chapter includes the detailed description of the variables, objectives, hypothesis, design of the study, sample, instruments used, data collection procedure, scoring and consolidation of data and statistical techniques used.

Chapter 4: Analysis and Interpretation

This chapter deals with the details of data analysis by using appropriate statistical techniques, interpretation of the results with relevant discussion.

Chapter 5: Summary, Findings and Conclusions

This chapter includes summary of the study such as study in retrospect, major findings of the study, tenability of hypothesis and conclusions of the study.

Chapter 6: Implications, Recommendations and Suggestions

This chapter includes the educational implications of the study, recommendations for improving the educational practices and suggestions for further research. At last, the report is followed by bibliography and appendices related to this study.

Chapter 2

REVIEW OF RELATED LITERATURE

- Theoretical Overview of the Process Stage Model and Dependent Variables
- Review of Related Studies on Instructional Strategy and Dependent Variables
- Conclusions

REVIEW OF RELATED LITERATURE

The present study aims to find out the effectiveness of the Process Stage Model on learning outcomes in Mathematics such as Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs among secondary school students. In this chapter, the investigator reviewed the available studies related to the variables Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs for getting an overview of these variables. This chapter is divided into two sections. The first section deals with the theoretical overview of the Process Stage Model and the variables such as Achievement in Mathematics, Logical Reasoning, Mathematical Beliefs, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs. The second section deals with the review of the empirical studies related to the instructional strategies and the variables, Achievement in Mathematics, Logical Reasoning, Mathematical Beliefs, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs. The various sections in this chapter are described under the following headings.

- **Theoretical Overview of the Process Stage Model and Dependent Variables**
- **Review of Related Studies on Instructional Strategy and Dependent Variables**

Theoretical Overview of the Process Stage Model and Dependent Variables

This section deals with the theoretical overview of the underlying theories of Process Stage Model and the dependent variables such as Achievement in Mathematics, Logical Reasoning, Mathematical Beliefs, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs. It also explains the available instruments for measuring the dependent variables used in the study. This section is described under the following sub sections.

- Theoretical Overview of Process Stage Model
- Theoretical Overview of Achievement in Mathematics
- Theoretical Overview of Logical Reasoning
- Theoretical Overview of Mathematics Anxiety
- Theoretical Overview of Achievement Motivation in Mathematics
- Theoretical Overview of Mathematical Beliefs

Theoretical Overview of Process Stage Model

This section deals with the theoretical background on which the Process Stage Model is developed such as theory of process stage, theory of valuation, experiential learning theory, reflective thinking model, and affective cognitive consistency theory and stages of value development.

Theory of Process Stage

Dewey (1938) a distinguished American philosopher, psychologist, and advocate of educational reform, underscored the significance of both experience and reflection within the context of learning process. In Dewey's (1939) pedagogical philosophy, the term "process stage" alludes to the dynamic and perpetual nature of learning and conceptualization of the "process stage" is intricately interrelated with his broader notions concerning experiential learning and application of scientific method within educational settings. Dewey (1938) firmly emphasized that the learning process goes through several stages and learning is not static, an isolated occurrence, but rather an ongoing and continuous process that entails interaction with the surrounding environment, problem solving, and reflection.

According to Dewey (1938), the learning process goes through several stages such as:

Experience (or Situational Phase). Experience phase is the starting point where learners encounter a situation or problem in their environment that involves direct interaction with the context or subject matter (Dewey, 1938).

Reflection (or Problematic Phase). After experiencing a situation, the learner engages in reflective thinking. They actively consider the problem at hand, analyze it, and identify possible solutions. Reflection is a crucial part of the learning process as it encourages critical thinking and the application of previous knowledge (Dewey, 1938).

Ideation (or Hypothesis Phase). Based on reflection, Learners generate ideas or hypotheses on how to address the problem as well as form theories or potential solutions, setting the stage for further exploration (Dewey, 1938).

Experimentation (or Testing Phase). In this phase, learners test their hypothesis through practical experimentation which involves actively trying out different approaches, observing outcomes, and collecting data (Dewey, 1938).

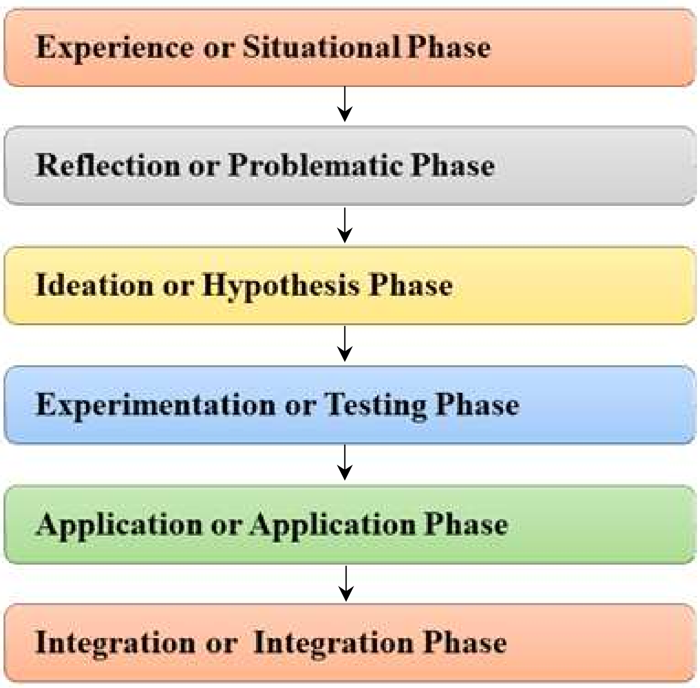
Application (or Application Phase). Learners apply the lessons learned from the experimentation phase to real life situations. This phase emphasizes the practical application of knowledge and skills in novel contexts (Dewey, 1938).

Integration (or Integration Phase). Finally, learners integrate their new experiences and knowledge into their existing understanding. This phase contributes to the ongoing development of one's knowledge and skills, setting the stage for future learning experiences (Dewey, 1938).

The diagrammatic representation of the learning process is presented in Figure 1.

Figure 1

Learning Process (Dewey, 1938)



Dewey (1939) in process stage theory emphasizes the cyclical and interconnected nature of learning, with each phase building upon the previous one. He advocates an educational approach that encourages active engagement, problem solving, and reflection to foster meaningful and lifelong learning and this approach aligns with the principles of experiential learning and inquiry based education.

Theory of Valuation

The theory of valuation of Dewey (1939) is based on the idea that value is not inherent in an object but instead arises from the relationship between the object and the individual experiencing it. He believes that value is dependent upon the experience of the individual and is constantly in a state of flux. Dewey (1939) proposes that the valuation of an object is determined by the factors of the immediate experience of the object, the context in which the object is experienced, the individual's needs and desires at the time of experience, the individual's past experience and knowledge that inform the current experience. Thus, the valuation process involves a continuous cycle of experience, reflection and action. The experiences and reflections of individuals on those experiences inform their actions and decision making process. The valuation theory of Dewey (1939) emphasizes the subjective nature of value and highlights the importance of considering individual perspectives and experiences when evaluating objects. Different dimensions of the valuation process are immediate or physical valuation, social valuation, reflective valuation, and critical valuation (Dewey, 1939) where immediate or physical valuation corresponds with fundamental and intuitive judgments , reflective valuation engages more complex thought processes, social valuation focuses on the impact of social factors and critical valuation stresses the necessity of examining and scrutinizing values.

Experiential Learning Theory

Experiential learning theory of (Dewey, 1938) emphasizes the importance of experience, action, and reflection in the learning process. The basic idea of this theory is that knowledge is gained through personal experience and that learning is an ongoing process that occurs throughout life. It also emphasizes the importance of reflection as a crucial part of the learning process and involves thinking about one's experiences, identifying what is learned, and how it can be applied in future situations. This process of reflection helps individuals to internalize their experiences and turn them into actionable knowledge (Dewey, 1938) .

According to Dewey (1916) educational process is considered as a continual reorganisation, reconstruction and transformation of experience. An educational experience is an experience in which individuals make a connection between what they do to things and what happens to them or others in consequences where the value of an experience lies in the perception of relationships or continuities among events. For example, an experience becomes an educational experience only, when a child touches a burning candle and the child experiences a burning sensation in the fingers as a result of touching the flames (Dewey, 1916).

Dewey's (1916) school of thought explained that the school is the place where we conduct the study of practicability and reflection through experience. Each person does not think about the other until there is a problem in the environment in which they interact. But only when one person experiences a problem in front of him/ her, he/she thinks about the solution to the problem and tries to overcome that unbalanced state of mind.Thus, learning is a process that stems from everyone's experiences. Dewey (1938) believes that educators want to recognize the relationship between experience and education and there exists a relation between the process of actual experience and education. He challenged teachers for providing learners with experiences that result in learning and growth, by believing that these experiences would somehow result in growth and creativity in learners' future experiences. According to Dewey (1938) education is as a social process, a process of growth and education is not a preparation for life; education is life itself. Experience is not simply a word, because it influences the formation of attitude, desire and purpose. When individuals have an experience, individuals act upon, do something and suffer or undergo the consequences and an ounce of experience is better than a ton of theory (Dewey, 1916).

An experience is capable of generating and carrying any amount of theory, but a theory apart from an experience cannot be definitely grasped even as theory (Dewey, 1938). It tends to become a mere verbal formula, a set of catchwords used to render thinking, or genuine theorizing. Dewey (1916) points out that interaction and continuity are the two important characteristics of effective teaching and learning, and also experience is the result of interaction between the student and the environment.

In experiential learning theory Kolb (1984) visualises learning as the process whereby knowledge is created through the transformation of experience and knowledge results from the combination of grasping and transforming experience. According to Kolb (1984), learning occurs in four stages such as concrete experience, reflective observation, abstract conceptualization, and active experimentation. The first phase of experiential learning theory of Kolb (1984) is concrete learning, where the learner faces a new experience or reinterprets an earlier one. This leads to reflective observation, where the learner engages in personal reflection on the experience. Following is the abstract conceptualization, where the learner creates new ideas or modifies existing ones based on insights from the reflection stage. The process concludes with active experimentation, where the learner implements these new ideas to assess any changes. This new experience then becomes the concrete starting point for the next cycle, and this entire process can occur in both short and extended periods (Kolb, 1984).

Reflective Thinking Model

According to Dewey (1916), reflective thinking is the active, continuous, and careful evaluation of beliefs or assumed knowledge, taking into account the evidence that supports them and the conclusions they may suggest. This form of thinking is integral to the critical thinking process, which involves analyzing and evaluating past events issues. Reflective thinking can vary from basic acceptance of a judgement to extensive inquiry into the issue raised. Dewey (1933) set out five states of thinking such as (1) suggestions in which the mind leaps forward to a possible solution, (2) an intellectualization of the difficulty or perplexity that has been felt into a problem to be solved, (3) the use of one suggestion after another as a leading idea, or hypothesis to initiate and guide observation and other operations in collection of factual material, (4) the mental elaboration of an idea, or supposition as an idea or supposition (reasoning, in the sense in which reasoning is a part, not the whole, of inference) and (5) testing the hypothesis by overt, or imaginative action.

In short the five steps described in Dewey's (1933) reflective thinking model are to define the problem, analyze the problem, establish criteria for solutions, generate possible solutions and select the best solution.

Dewey (1933) identifies three types of thought that are distinguished from reflection. First type is stream of consciousness which indicates uncontrolled coursing of ideas through our heads. Second is invention which is different from direct perception of objects and invention is briefly related to imagination. Though there is a difference between the imagination and severity of reflection, Dewey (1910) understands its significance within the reflection. Therefore, imagination is a subset of reflection and cannot be considered as equivalent. Third type is *belief* which characterises the type of thought as prejudgments, but not conclusions as a result of observing, collecting and examining evidence (Dewey, 1933).

Dewey's five steps of thinking are reduced into three by Bound et al. (1985) such as returning to experience, attending or connecting with feelings and finally, evaluating experience The three phases in the reflective process are presented in Figure 2.

Figure 2

Stages of Reflective Learning (Bound et al., 1985)

Returning to the Experience. The basis of learning is returning to experience which involves recalling or detailing salient events. A review of what happened to an individual and experience lived and experienced is needed for further study. The most important thing is to come back mentally and review what happened (Bound et al., 1985).

Connecting Emotions or Feelings. Two aspects of this phase are removing negative feelings that are being obstructed and using positive feelings. Positive feelings focus on learning experiences, which are subjected to reflection. When this happens, it creates awareness about the environment and recognizes the benefits gained from the experiences that have occurred. Since feelings are the part of return experience, learners focus on the feelings and emotions which are present and those feelings enhance reflection and learning (Bound et al., 1985).

Evaluating the Experience. In this stage the individual is involved in re-examining the experience using the original intent and existing knowledge and integrating it with new knowledge. This process will direct the learning process (Bound et al., 1985).

According to Boud et al., (1985) learning from reflection takes place when people recapture their experience, think about it, mull it over and evaluate it. The evaluation process includes re-examining experience in the light of intent and existing knowledge, and then integrating this new knowledge into conceptual framework. Boud et al. (1985) focuses especially on the experiences of adults and how they evaluate themselves in their professional practices. Thus, reflective inquiry model of Dewey (1933) is a problem-solving method which involves a process of active inquiry and reflection in which individuals continually question and evaluate their beliefs and values. It is a framework for understanding how individuals make value judgments and engage in reflective thinking and inquiry.

Affective Cognitive Consistency Theory

Affective Cognitive Consistency Theory (Rosenberg, 1956) posits that individuals have a tendency to strive for consistency between their attitudes, beliefs and behaviours. According to this theory, people are motivated to maintain harmony and coherence in their thoughts, feelings and actions. The theory suggests that when individuals experience cognitive inconsistencies, such as conflicts between their attitudes and behaviours and lead to a state of discomfort or cognitive dissonance. To alleviate this discomfort, individuals are motivated to reduce the inconsistency by either changing their attitudes, modifying their behaviours, or seeking out additional information to reconcile the discrepancies. Rosenberg (1956) emphasises the importance of examining the interplay between affective and cognitive elements in influencing behaviour and decision making process. It suggests that individuals strive for congruence between their emotions, thoughts, and actions, and seek to resolve any discrepancies that may arise. Affective learning is concerned with how learners feel while they are learning, as well as with how learning experiences are internalised and can guide the learner's attitudes, opinions, and behaviour in the future (Miller, 2005).

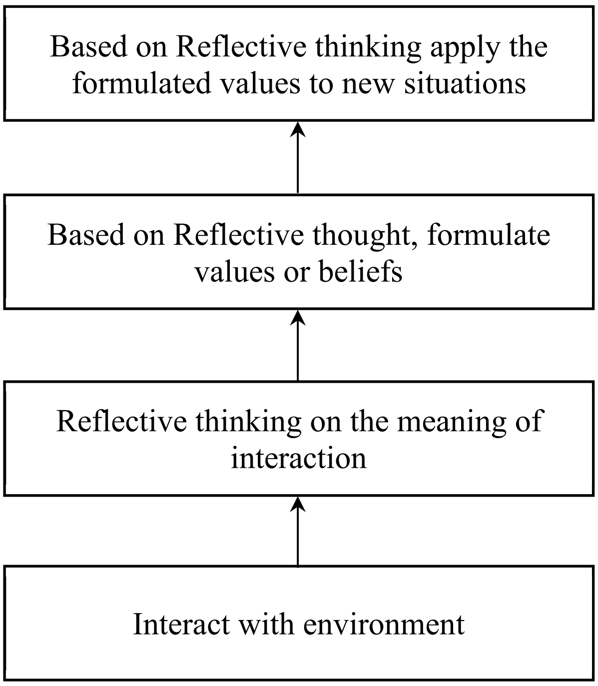
Stages of Value Development

Affective learning considers mainly two types of schools of thought. In the first school of thought, the content of affect such as values, ethics and morals are the source other than human experience. According to the above school of thought beliefs, or values are to be found in divine inspiration and the wisdom of the elders over the years. In education when beliefs are identified, they are inculcated in the learners, and they are made to observe. According to the second school of thought moral values and ethics should be derived from the analysis of human experience (Olatunji, 2013)

According to Olatunji (2013) there are two predominant perspectives on affective learning outcomes. The first perspective asserts that the essence of affect, including values, morals, and ethics, originates from external sources beyond human experience. Conversely, the second perspective argues that the essence of affect should primarily stem from an analysis of human experience itself. According to this perspective, which is rooted in the philosophy of pragmatism, values are cultivated as individuals or groups progress through a series of stages (Dewey, 1939) and the stages are presented in Figure 3.

Figure 3

Stages of Value Development



Interact with Environment. In this initial stage, individuals or group actively engage with their surroundings. This interaction is not passive; it involves encountering various situations, challenges, and opportunities. Through these experiences, individuals gather information and insights. The environment here includes not only the physical surroundings but also social, cultural and intellectual contexts. As individuals interact with these elements, they start to recognize patterns, problems, and possibilities that are meaningful to them (Dewey, 1939).

Reflective Thinking on the Meaning of the Interaction. After interacting with the environment, the next stage involves reflective thinking. Reflection is a critical process where individuals consider and analyse their experiences. They think about what happened, why it happened, and what it means. This stage is essential for deeper understanding and learning. Through reflection, individuals begin to see the underlying principles and values that can be drawn from their experiences. Dewey (1939) emphasized that reflection is not just about looking back but about critically evaluating one's experiences to derive meaning and understanding.

Based on the Reflective Thought, Formulate Values or Beliefs. Based on the insights gained from reflective thinking, individuals then begin to formulate values or beliefs. These values or beliefs are not imposed externally but are developed internally as a result of the reflective process. This stage is about making sense of experiences and determining what is important, right or valuable based on the insights gained. The values or beliefs formulated at this stage are informed by the individual's past experiences, reflective analysis, and personal or collective goals (Dewey, 1939).

Based on Reflective Thinking Apply the Formulated Values to New Situations. The final stage involves applying new formulated values or beliefs to new situations. This application is crucial because it tests and future refines the values or beliefs in a practical context. As individuals apply their values to new challenges, they learn whether these values hold true and are effective in guiding behaviour. This stage also opens the door for further interaction with the environment, leading to ongoing reflection and continued development of values. The cycle can repeat, with each new experience leading to more refined and mature values (Dewey, 1939)

Theoretical Overview of Achievement in Mathematics

Bloom (1956) categorized cognitive learning outcomes into different levels, ranging from simple knowledge acquisition to higher order thinking skills such as analysis, synthesis and evaluation and achieving higher levels of cognitive skills in the learning process which leads to deeper understanding and more complex thinking. Bloom's (1956), categorised cognitive learning outcomes into knowledge, comprehension. application, analysis, synthesis and evaluation. Krathwohl (1964) extends Bloom's taxonomy to affective domain, which includes learning outcomes related to attitudes, values and emotions. It highlights the significance of cognitive learning outcomes in shaping affective skills and attitudes (Bloom, 1956). Simpson (1972) developed a model specifically for the psychomotor domain, which includes several levels of skill development, from basic physical movement to more complex and skilled actions. Bloom's taxonomy (Bloom, 1956) was designed to help educators to set clear objectives for student learning and to assess the effectiveness of educational programmes. Each level presents a different type of cognitive process, from basic recall of information to higher-order thinking skills such as analysis, synthesis, and evaluation.

Cognitive learning outcomes refer to the knowledge, comprehension and application of concepts and theories, which influence the cognitive development of the learners (Chi et al., 1989; Mayer & Wittrock, 1996; Slavin, 1996; Anderson & Krathwohl, 2001). These outcomes focus on understanding the mental processes and behaviour that enhance learning, critical thinking and problem solving skills. The significance of cognitive learning outcomes is that they help to achieve higher levels of learning, including cognitive skills, affective skills and psychomotor skills (Bloom, 1956; Krathwohl et al., 1964; Simpson, 1972; Anderson & Krathwohl, 2001).

Revised Bloom's Taxonomy (Anderson & Krathwohl, 2001) offers a modern approach to understanding and categorising educational goals that reflects the dynamic nature of learning and the need for students to engage in higher order thinking skills to succeed in an increasingly complex world. By focussing on active processes and integrating different types of knowledge, the revised taxonomy provides a robust framework for educators to enhance teaching and learning (Anderson & Krathwohl, 2001). Revised Bloom’s Taxonomy categorised cognitive skills from nouns to verbs to emphasize active learning process. Evaluation is placed just below the highest level, ‘create’ which replaces synthesis. This reflects the view that creating something new requires all the other cognitive skills, including evaluation.

Anderson and Krathwohl (2001) reorganised and refined the original Bloom's taxonomy by introducing two dimensions: the cognitive dimension and knowledge dimension. The cognitive dimension represents the various types of cognitive processes or mental actions involved in learning. The revised taxonomy updates Bloom's original categories into a more dynamic model that emphasises the nature of cognitive engagement. The cognitive processes are:

Remembering. The cognitive process remembering involves retrieving, recognizing, and recalling relevant knowledge from long-term memory. It's the foundational level of cognition where information is accessed and recalled (Anderson & Krathwohl, 2001).

Understanding. The cognitive process understanding involves constructing meaning from instructional messages, including oral, written, and graphic communication. It includes interpreting, summarising, inferring, and explaining materials (Anderson & Krathwohl, 2001).

Applying. The cognitive process applying involves using learned materials in new and concrete situations. It includes implementing procedures, applying methods, and solving problems using acquired knowledge (Anderson & Krathwohl, 2001).

Analyzing. The cognitive process analyzing involves breaking information into parts and examining its structures. It includes identifying components, understanding relationships among parts, and recognizing underlying patterns (Anderson & Krathwohl, 2001).

Evaluating. The cognitive process evaluating involves making judgements based on criteria and standards. It includes assessing, critiquing, and making informed decisions or conclusions about the value, validity, or quality of information (Anderson & Krathwohl, 2001).

Creating. The cognitive process creating involves putting elements together to form a new, coherent whole. It includes generating new ideas, designing original products, or constructing new structures from existing knowledge (Anderson & Krathwohl, 2001).

The knowledge dimension categorises the types of knowledge that are targeted in learning outcomes. It describes the different kinds of knowledge that learners are expected to acquire and apply (Anderson & Krathwohl, 2001). The revised taxonomy organises knowledge into four categories:

Factual Knowledge. Basic elements that learners must know to be acquired with a discipline or to solve problems. It includes specific details, terminology, and basic concepts.

Conceptual Knowledge. Understanding the interrelationships among the basic elements within a larger structure. It includes knowledge of classifications, categories, principles, theories, models and frameworks.

Procedural Knowledge. Procedural knowledge refers to the methods and processes used to accomplish tasks. This includes knowledge of techniques, methods, and procedures for performing specific tasks or solving problems.

Metacognitive Knowledge. Metacognitive knowledge involves awareness and understanding of one's own cognitive processes. This includes knowledge about how to plan, monitor, and evaluate one's own learning and problem-solving processes.

The integration of the cognitive and knowledge dimensions in Revised Bloom's Taxonomy allows for a more comprehensive framework for designing educational objectives and assessments. This objective could involve students designing new theoretical modes based on their understanding of a subject's principles. By aligning specific cognitive processes with types of knowledge, educators can develop more targeted and effective learning experiences and assessments.

Cognitive learning outcomes are important in the development of individuals as they support the development of critical thinking and problem solving skills, which are essential for success in personal and professional life (Bailin et al., 1999; Sternberg & Grigorenko, 2003; Mayer, 2004; Facione, 2015). These outcomes are also relevant for educators and educational institutions as they help evaluate the effectiveness of teaching methods and strategies (Airasian, 1997; Black & Wiliam, 1998; Darling-Hammond, 2005; Hattie, 2009). Cognitive learning outcomes shape teacher preparation programs by guiding the curriculum, instructional strategies and assessments (Darling-Hammond & Baratz-Snowden, 2005). These outcomes play a vital role in evaluating teaching performance, as they serve the criteria for assessing the effectiveness of instructional practices.

Information processing theory (Atkinson & Shiffrin, 1968) explains that cognitive learning outcomes are influenced by attention, perception, memory processes and problem solving strategies. The theory emphasises the role of encoding, storage and retrieval processes in shaping cognitive learning outcomes. By focusing on cognitive learning outcomes, teacher preparation programmes can better equip educators to foster critical thinking, problem solving and deep understanding in their students, leading to improved learning outcomes (Afzal et al., 2023). Similarly, evaluating teaching performance against cognitive learning outcomes ensures that educators are effectively facilitating cognitive development in their classrooms (Yilmaz, 2011). The mental effort or capacity required to process information and perform cognitive tasks during learning is an important thing. Cognitive load theory (Sweller, 1988) explains that learners can only process a limited amount of information at a time, and therefore an optimal learning occurs when instructional materials are designed to minimise cognitive load.

Theoretical Overview of Logical Reasoning

According to Evans (1993), "reasoning is the central activity in intelligence thinking. It is the process by which knowledge is applied to achieve most of our goals" (p.561). Lannin et al. (2011) described reasoning as "an evolving process of conjecturing, generalising, investigating why, and developing and evaluating arguments" (p.13). Brodie (2010) acknowledged reasoning as "to understand mathematics is inductive reasoning, it is a cognitive process that uses specification formation or concepts, to use mathematical ideas and procedures flexibility, and to reconstruct once understood, but forgotten mathematical knowledge" (p.11).

One of the concepts that is most frequently used in educational settings is inductive reasoning. It is the cognitive process that uses specific information or isolated cases to infer general conclusions. (Adey & Csapo, 2012; Sternberg & Sternberg, 2012). This cognitive process is crucial for understanding science and using knowledge in new contexts (Csapo,1997). When complicated or new situations arise for which specialised subject knowledge is inapplicable, inductive reasoning assumes a more significant role. Based on observation, inductive procedures can be used to build fictitious rules, and these relational systems of problems can be described (Parret, 2015). Reasoning takes place in classrooms where teachers and researchers help students to enhance their mathematical understandings through problem solving activities (Wood et al., 2006). By developing and providing mathematical concepts through reasoning, students acquire new knowledge and develop an understanding of the links between logical and important mathematical ideas as opposed to simply memorising regular steps (Mata-Pereira & da Ponte, 2017).

Logical thinking is the one that is formed from the interaction of objects and is formed in individuals and has the ability to understand everything that surrounds us (Suarez et al, 2017). In order to come to a conclusion or make judgement based on provided information or premises, logical reasoning entails the act of playing sound arguments and deductive or inductive thinking. It is focussed on the standards and guidelines that define sound deduction and inference. In a broad sense, logical reasoning includes both informal and formal logic, which deals with daily debate and reasoning (Hurley, 2015). Formal reasoning is a field of mathematics and philosophy. Propositional logic, predicate logic, and modal logic are only a few examples of rigorous reasoning systems that are studied in formal logic, along with their characteristics and inference rules (Enderton, 2001). On the other side, informal logic investigates the patterns of reasoning present in common place conversation and arguments. It examines how individuals formulate and judge arguments, spot logical errors, and measure the reliability and power of reasoning. Informal logic places a strong emphasis on judging arguments according to their logical consistency, coherence and applicability of supporting data (Walton et al., 2008). Mathematics education research heavily relies on logical reasoning, which covers topics like problem solving techniques, proof methods and connection between logical and mathematical reasoning skills. It is thought that mathematical reasoning enables students to employ mathematics in their maths classes and in everyday life. In mathematics, the sole way to discover the truth is by reasoning rather than experiments or observation (Umay & Kaf, 2005). As a result, one of the most important abilities that needs to be developed is reasoning ability.

Cognitive Theory of Reasoning

According to the cognitive theory of reasoning, the human mind functions like a computer that continuously processes and encodes data (Neisser, 1967). In accordance with cognitive theory, a person's mind will consult previous schema when they are presented with stimuli in order to make sense of this information (Piaget, 1952). The cognitive process of forming conclusions from information is known as reasoning (Anderson, 1990). All arguments assert that one or more propositions give some justification for adopting a different proposition or conclusion. One important aspect of deduction is that conclusions are logically independent of the content of the propositions and are contained within the premises (Hilbert & Ackermann, 1928). Deductive arguments that assert that the premises provide absolute grounds for accepting the conclusion can be judged for their validity (Hilbert & Ackermann, 1928).

Theories of Deductive Reasoning

The mental model theory (Johnson- Laird, 1994) and mental logic theory (Braine & O' Brien, 1998) are two of the most important theories of logical reasoning. The mental model hypothesis states that individuals reason by creating models of the premises of logical puzzles. These models represent the premises of truth-contingencies. The circumstances that would determine whether a statement is true or false are known as the statement's truth contingencies. If they are in agreement with the first one, they can be integrated; otherwise, one of them needs to be discarded. When two premises can both be true at the same time they are consistent with one another. When they cannot both be true at the same time, they are inconsistent with one another (Braine, 1978). The final model is created by combining consistent premises and eliminating inconsistent ones. It can then be tested for consistency with the conclusion; if it is, the conclusion is accepted; if not, it is rejected as false (Schroyens et al., 2001). According to the mental logic hypothesis, humans draw logical conclusions in a manner that is similar to how we draw conclusions in formal logic (Schroyens et al., 2001).

According to the main proponents of mental logic, Braine and O'Brien (1998), people draw deductions by using inference schemas to combine premises and results. Each inference schema is a set of guidelines that specify what conclusions can be inferred from premises with a particular structure. For instance, according to the logic principle known as the modus ponens, we can infer the conclusion "q" from premises of the type "if p, then q" and "p". Another illustration is the disjunctive syllogism rule, which states that we can infer conclusions from premises of the type “p or q” and “not p”.

The two theories of deductive reasoning: mental logic and mental models differ in terms of the competency knowledge they rely on, the mental model they postulate, the mechanism they use, and the neuroanatomical predictions they make. According to mental logic theories (Henle, 1962; Braine, 1978; Rips,1994) reasoners possess a foundational competency knowledge of the inferential function of the language’s closed form, or logical terms such as “all”, “some”, “none”, “and” etc. To drive conclusions from premises, a technique of inference is applied to these representations. The basic premise of the assertion is that deductive reasoning is a rule- governed process that is specified over structural strings (Braine, 1978).

As contrast to this, the mental model theory (Johnson- Laird, 1983; Johnson-Laird & Byrne, 1991) proposes that reasoners have an underlying competence knowledge of meaning of the closed form, or logical terms, of the language such as “all”, “some”, “none”, “and” etc, and use this knowledge to construct and search for alternative scenarios. In contrast to the structural features of the propositional strings themselves, the structural properties of the world that the argument is about are preserved by the internal representation of arguments. The fundamental assertion is that spatial manipulation and search are necessary for deductive reasoning to occur (Johnson- Laird & Byrne, 1991). The dual mechanism theories distinguish between explicit, untrained, automatic processes and formal, deliberate, rule-based processes at every basic level. Dual mechanism theories come in a variety of flavours that differ in terms of the precise makeup and characteristics of these two systems.

Argumentative Theory

Argumentative theory of reasoning (Mercier & Sperber, 2011) challenges conventional notions of reasoning, which question accepted beliefs about reasoning, and asserts that the primary objective of reasoning is to persuade and convince others rather than to reach logical accuracy. According to Mercier & Sperber (2011), thinking evolved as a social and interactive skill to facilitate interaction and group engagement. It suggests that reasoning is not merely an independent and truth-seeking process but rather largely focused on creating convincing arguments to support one's beliefs and persuade others. The value of interaction in thinking is also emphasised by the argumentation theory (Mercier, 2016). It implies that the social environment in which reasoning occurs, such as conversation in groups, arguments in public forums, or other forms of discourse, plays a critical role in influencing and forming individuals' reasoning processes. Mercier and Sperber (2011) viewed reasoning as a group activity in which participants engage in arguments, refutations, and counter arguments in order to arrive at socially acceptable conclusions. Sfard (2008) explained the role of communication and argumentation in the development of mathematical thinking. It argues that mathematical thinking is not just a cognitive process but also involves communication and the use of mathematical discourse. Involving students in classroom activities using mathematical reasoning has some benefits, and it also provides insight into coefficient teaching strategies that support argumentative skills (Stylianides & Stylianides, 2013).

Some challenges to assessing mathematical reasoning have already been identified in the studies such as teacher knowledge (Clarke et al., 2012; Herbert et al., 2015; Loong et al., 2017) noticing of reasoning (Jacobs et al., 2010; Francisco & Maher, 2011; Llinares, 2013), students' difficulties in articulating their reasoning (Bragg et al., 2016); and planning for reasoning (Davidson et al., 2018). Effective teaching depends on teachers having a thorough comprehension of the material they are presenting (Darling-Hammond, 2000); therefore, in order to help students improve their reasoning, teachers must have a grasp of its complexities as well (Stylianides et al., 2013). As students progress through the mathematics curriculum, they encounter increasingly complex problems that require more sophisticated logical reasoning skills. Mathematics curricula from all over the world specify that in addition to fostering students' formal logical reasoning applied within mathematical tasks, mathematics education should foster reasoning that can be applied outside of the classroom which helps to develop 21st century skills (National Council of Teachers of Mathematics, 2009).

Measurement of Logical Reasoning

This section deals with the description of various instruments used to measure logical reasoning that are identified in reviewing the literature and related studies in logical reasoning.

Raven's Progressive Matrices or Raven's Matrices (Raven, 1965), is a non-verbal exam that is frequently used to assess abstract reasoning and general human intelligence. It is regarded as a non-verbal estimate of fluid intelligence, include 60 multiple-choice questions that are arranged in descending order of difficulty and the respondent is required to locate the element that completes a pattern in each test item (Raven, 1965). The test is named because many patterns are presented in a 6×6, 4×4, 3×3, or 2×2 matrix. Split half reliability coefficient of the Raven's Matrix is .91, and test retest reliability is .89. Construct Validity with Binet-Simon scale is .77.

Tobin and Capie (1981) created the Logical Reasoning Test (TOLT) to evaluate middle school and older students' capacity for logical thought. Each of the following five kinds of reasoning—proportional reasoning, controlling variables, probabilistic reasoning, correlational reasoning, and combinatorial reasoning was tested by two of the test's ten items. Participants have to select a correct response and reasoning from a range of options for each of the ten items. The reliability coefficient of the test was .85 and confirmed that the test addressed one main underlying component called formal thought .88 students from grades 10 through college were evaluated using the TOLT and five interview tasks as part of a study that provided evidence of criterion-related validity. A correlation of .80 indicated a significant connection between the two formal reasoning measures. The internal consistency estimate of each two item subset ranged from .56 to .82.

Evans et al. (1995) developed the abstract conditional inference task. In this measure participants are given a conditional rule, such as "If the letter is M, then the number is 5," coupled with a premise pertaining to the rule, "The letter is M," and then a conclusion deduced from the rule and premise, such as "The number is 5." After that, the participant determines whether or not the inference leading to the conclusion is valid. The task consists of 16 items that fall into one of four categories: Modus Tollens (MT), Denial of the Antecedent (DA), Affirmation of the Consequence (AC), and Modus Ponens (MP). Both the order of the issues and the lexical content of the rules (letters and integers) were generated at random.

Mapeala and Siew (2015) developed a Test of Science Critical Thinking for fifth graders to measure the three critical thinking skill constructs: sequencing, comparing and contrasting, and identifying cause and effect. The test contains 30 items and the content validity index derived from three expert judgements equaled or exceeded .95. Additionally, test-retest reliability showed good, statistically significant correlations ($r = .76$, $p < .01$) and the Kuder-Richardson reliability value was found to be appropriate and relatively high with scores of .70, .73, and .92 for identifying cause and effect, sequencing, and comparing and contrasting, respectively.

Baserer (2020) developed the Logical Thinking Scale, a likert type scale consisting of 25 items on four dimensions such as reasoning, language-meaning, DTG and concept. Items addressing various inferential reasoning principles and procedures can be found in the scale's reasoning dimension. While the DTG dimension has items relating to accuracy, consistency, and validity, the language-meaning dimension has items related to polymorphism and uncertainty. Items that describe idea types and interactions between concepts are included in the concept dimension. The first sub factor of the scale had a Cronbach’s alpha value of .83, the second sub factor had a value of .75, the third sub factor had a value of .74, and the fourth sub factor had a value of .74. The factor's Cronbach’s alpha value was .71, while the overall Cronbach’s alpha value was .83.

Ramganesh and Reddy (2021) developed the Logical Reasoning Questionnaire for high school students (LRQHSS) consisting of 25 items on the dimensions deductive reasoning, inductive reasoning, analogical reasoning, problem solving, critical thinking, sequential reasoning. The split half method of reliability was used to measure reliability and reliability coefficient was .759.

Li et al. (2022) developed a Critical Thinking Self Evaluation Scale for college students. The dimensions of the scale consisted of three dimensions: Discipline Cognition (DC), Critical Thinking Disposition (CD), and Critical Thinking Skills (CS). The scale is used to measure perspectives such as analysis, interpretation, inference, self regulation and evaluation. The Cronbach's alpha coefficient of the scale was 0.909 and the Cronbach's alpha coefficient of individual dimensions of the scale ranged from .724 to .878.

Theoretical Overview of Mathematics Anxiety

According to Keable (1989), anxiety is a socio-psycho-physiologic phenomenon that is experienced as a frightening dread or threat to the human organism, whether the threat is caused by internal, actual, or imagined dangers. The sources of which may be conscious or unconscious, or whether the threat is secondary to the actual environmental threats of a biosocial, biophysical, or biochemical nature. Dollard and Miller (1950) viewed anxiety as a sub type of fear as a breakdown in homeostasis that ultimately has to do with the incidence of unpleasant stimulus. Additionally, anxiety is a very normal reaction to threat, and in some seriously dangerous circumstances, it may even be useful in getting us ready to take action (Crocq, 2015). However, anxiety becomes an issue when it happens too frequently and for no obvious reason, or when it starts to affect our daily lives. As a result, anxiety is a typical occurrence in daily life and is essential to human existence since worry affects each and every one of us in many ways (Goodstein & Lanyon, 1975). Anxiety is related to the specific behaviours of fight-or-flight responses, defensive behaviour or escape (Heeren, 2020). Barlow and Ellard (2020) defined anxiety as a future-oriented mood state in which one is not ready or prepared to attempt to cope with the upcoming negative events.

With modern society's growing competitiveness and complexity, anxiety is now widely recognised as the primary cause of a wide range of behaviours, including insomnia, debilitating psychological and psychosomatic symptoms, immoral sinful acts, and even instances of creative self-expression (Spielbirger, 1972). The development of an individual's personal capacity and the assessment of success or failure depend, among other things, on external forces occurring in his or her immediate environment as well as on internal elements dependent on the individual (Rozgonjuk et al., 2020). Internal components, such as mathematics self-efficacy, mathematics anxiety, and other emotional variables, as well as external ones, such as the classroom atmosphere in a particular setting or the subject of mathematics, are crucial in explaining the achievements in mathematics as an indication for success (Rozgonjuk et al., 2020). Many researchers have explained the relationship between anxiety and achievement (Hembree, 1990; Jackson and Leffingwell, 1999; Ma, 1999; Zoopp, 1999; Strawderman, 2010; Wu et al., 2012; Zedan and Bitar, 2014).

Meaning of Mathematics Anxiety

Individuals who become anxious and fearful because of the prospect of performing mathematics are said to have 'mathematics anxiety' (Richardson & Suinn, 1972). Dreger and Aiken (1957) first identified mathematics anxiety as the occurrence of a syndrome of feelings related to arithmetic and mathematics and coined the phrase "math anxiety" to characterise students' challenges with mathematics from an attitude perspective. According to Tobias and Weissbrod (1980), mathematics anxiety is the fear, helplessness, inactivity, and mental disarray that some people experience when they are asked to solve mathematical problems. It is a fear of math that is both cognitive and emotional.

According to Bursal and Paznokas (2006), mathematics anxiety as indicator of discomfort the fact that occurs in reactions to situations that involve mathematical tasks which are threatening to self-esteem and the panic, helplessness, paralysis, and mental disorder arising among a few people when they are needed to solve a mathematical problem. Oxford and Vordick (2006) defined mathematics anxiety as an eliminating condition when students struggle with mathematical concepts. This condition is a specific and genuine fear of mathematics leading pupils to have a serious urge to avoid mathematics entirely.

Trujillo and Hadfield (1999) defined mathematics anxiety as the degree of unease that students experience in reaction to circumstances involving mathematical tasks, which are perceived as a danger to their self-ability. Tobias (1995) defined mathematics anxiety as a sense of anxiety and tension that occurs when someone engages in the manipulation of characters to solve mathematical problems in educational and daily-life circumstances. When one has math anxiety, it is simple to lose confidence and forget math formulae and anxiety is found to be associated with beliefs (Tobias, 1995). If one is frequently confronted with ideas like math is not essential for the world or they are not a mathematics person, these ideas may gradually become one's beliefs about their own mathematics proficiency (Chinn, 2008).

Dimensions of Mathematics Anxiety

Yanez-Marquina and Villardon-Gallego (2017) have proposed the dimensions of Mathematics Anxiety as everyday life's math anxiety, learning mathematics anxiety, test anxiety.

Everyday Life's Math Anxiety. Everyday life's math anxiety encompasses a broad range of affective responses to students' everyday situations that require mathematical reasoning (Yanez-Marquina & Villardon-Gallego, 2017).

Learning Mathematics Anxiety. Math learning anxiety includes affective responses that a math student may experience during different situations of the math learning process that take place in the scholar setting (Yanez-Marquina & Villardon-Gallego, 2017).

Math Test Anxiety. Math test anxiety refers to feeling a math student may experience when either preparing or doing a math test. This dimension is considered different, though related to the previous one. In fact, It is conceivable that a student enjoys the subject of mathematics but feels nervous about doing a math problem (Yanez-Marquina & Villardon-Gallego, 2017).

Palke and Parker (1982) have proposed the dimensions of mathematics anxiety as learning mathematics anxiety and mathematics evaluation anxiety

Learning Mathematics Anxiety. This dimension measures the anxiety that individuals experience during the process of learning mathematics. It encompasses feelings of nervousness, worry, or discomfort when engaging with mathematical content in various learning environments, such as attending math classes, or understanding new mathematical concepts (Palke & Parker, 1982).

Mathematics Evaluation Anxiety. This dimension assesses the anxiety associated with being evaluated or tested on mathematical skills. It includes the stress and fear experienced during math exams, quizzes, or any form of assessment where mathematical performance is judged (Palke & Parker, 1982).

Arem (2003) makes the following three claims in relation to the relationship between mathematics anxiety and test anxiety in general such as inadequate test preparation, inadequate test- taking techniques and psychological stressors. Poor health practices, particularly with regard to diet and sleep, make it worse. Other biological research on math anxiety (Hopko et al.,1998) revealed that people with math anxiety have a weak inhibition mechanism, which causes working memory resources to be diverted to irrelevant distractions. Consequently, persons with high levels of anxiety do worse when using their explicit memory. Additionally, they discovered that no relationship between competence and mathematics anxiety. According to Ashcraft and Kirk (2001), anxiety reactions are characterised by attention to or commitment with aggravating ideas or worries. This means that students who perform poorly on an examination frequently cite confusion, an inability to concentrate, or an ongoing negative attitude about their mathematical skills as the cause of their low performance. Others have reported on similar findings on the cognitive mechanisms and emotional capacities that high- anxiety individuals of all ages experience (Ramirez et al., 2016). Anxiety throughout mathematics interferes with ongoing working memory activity, which in turns affects cognitive processing, or whether it genuinely affects mental processing during problem solving (Ascraft & Faust, 1994; Ashcraft, 2002). Results that supported the processing efficiency theory, developed by Eysenck and Calvo (1992) to explain the effects of general anxiety were discovered. According to this idea, general anxiety impairs continuous working memory functions because anxious individuals focus on their distracting thoughts and anxieties rather than the task at hand.

Measurement of Mathematics Anxiety

This section deals with the description of various instruments used to measure mathematics anxiety that are identified in reviewing the literature and related studies in mathematics anxiety.

Mathematics Anxiety Rating Scale (MARS) (Richardson & Suinn, 1972), is used in the assessment of mathematics anxiety. The test consists of 98 items with no dimension. Two-week and seven-week test-retest reliability values of .78 (N = 119) and .85 (N =.35) provided evidence for the MARS reliability. The internal consistency alpha coefficient of the scale is .97 (N = 397).

Fennema and Sherman (1977) developed Mathematics Attitude Scale (MAS) which includes a set of nine subscales: mathematics anxiety, attitude toward success in mathematics, confidence in learning mathematics, reflectance motivation in mathematics, father, mother, mathematics as a male domain, teacher, and usefulness of mathematics. Split-half reliability coefficient obtained is .89 (Fennema & Sherman, 1977).

Sandman (1980) developed Anxiety Toward Mathematics Scale (ATMS) which consists of a set of 6 subscales, resulting in a total of 48 items with dimension: perception of mathematics teachers, value of mathematics, self-concept in mathematics, mathematics anxiety, enjoyment of mathematics, motivation in mathematics. Reliability (for the subscales) is .69 to .89.

Plake and Parker (1982) created a more effective index of anxiety connected to statistics or mathematics courses, a 24-item abbreviated version of the 98-item Mathematics Anxiety Rating Scale (MARS). The modified scale had a correlation of .97 with a full scale MARS and produced a coefficient alpha reliability measured at .98. It has an association pattern with state, trait, and test anxiety that is similar to that of full-scale MARS. Additionally, the connection between mathematics proficiency and MARS (both the revised and full scale versions) was consistent. A principle axis factor analysis of the updated MARS revealed two distinct components, named 'mathematics evaluation anxiety' and 'learning mathematics anxiety'. For purposes relating to statistical or mathematical courses, revised MARS seems to be a desirable alternative to full scale MARS.

Spielberger et al. (1983) constructed the State-Trait Anxiety Inventory (STAI) consisting of 40-items to assess state and trait anxiety. The test-retest reliability is state: r = .71 to 76; Trait: r =75 to .86 and internal consistency is r = .86 to .95.

The students' level of mathematics anxiety was assessed using the Revised Mathematics Anxiety Rating Scale (RMARS) (Alexander & Martray, 1989). This scale was shortened from the original 98-item MARS (Richardson et al., 1972) instrument because it was too long to administer. This shorter scale only had 25 items on the three criteria identified by Alexander and Martray (1989) such as math test anxiety (15 items), numerical task anxiety (5 items) and math course anxiety (5 items).

Chiu and Henry (1990) developed Mathematics Anxiety Scale for Children (MASC) which consists of 22 items with four underlying factors: mathematics evaluation anxiety, mathematics learning anxiety, mathematics problem solving anxiety and mathematics teacher anxiety. The Cronbach's alpha for the factors is .90 to .93

Math Anxiety Questionnaire developed by Thomas and Dowker (2000) which consists of 36 items on four underlying factors: self-perceived performance, attitudes, poor performance, unhappiness and anxiety. Cronbach's alpha for the dimensions is .83 to 91.

Suinn and Winston (2003) created a Mathematics Anxiety Rating Scale (MARS 30-item), is an abbreviated version of the full Mathematics Anxiety Rating Scale (MARS; Richardson & Suinn, 1972) used to assess feelings of anxiety and tension related to mathematics related tasks or assessments. The two sub- dimensions of the scale are test anxiety and numerical anxiety. It is constructed as a 5 point likert scale ranging from Not at all (1) to Very much (5). High internal consistency was suggested by the Cronbach's alpha of .96, and the MARS 30-item's test-retest reliability was .90 ($p < .001$). The validity statistics show that the MARS 30-item test and the original MARS 98-item scale are equivalent.

The Abbreviated Mathematics Anxiety Scale (Hopko et al., 2003), which was created from the MARS-R, is one of the shorter instruments to assess mathematics anxiety. It is based on nine items on a Likert-format scale where respondents must rate how much they agree with each statement; higher scores indicate greater mathematics fear. A confirmatory factor analysis revealed that the items could be divided into two significant factors: mathematics evaluation anxiety and learning math anxiety, which are more closely related to testing situations. The response scale extended from 1 (low) to 5 (high), with 5 representing the highest response. The alpha coefficients for internal consistency ranged from .85 to .90, and the alpha coefficients for test-retest reliability ranged from .78 to.85. This 9-item measure was composed of two subscales, one of which contained five items that assessed learning mathematics anxiety, and the other of which contained four items that measured assessment mathematics anxiety. Confirmatory factor analysis revealed that the measure had high internal consistency (LMA and total AMAS score r =.88 and MEA and total AMAS score *r* =.92), divergent validity (*r* =.62), and 2-week test-retest reliability (LMA and MEA and total AMAS score r =.78).

Bai (2011) developed a 14-item, bidimensional Mathematics Anxiety Scale-Revised (MAS-R) which was empirically cross-validated using two separate samples of 647 secondary school students. The scale's exploratory component analysis revealed a distinct two-factor structure with excellent construct validity. An excellent model fit was revealed by the results of a confirmatory factor analysis (χ^2 is 98.32, df is 62; normed fit index is .92, comparative fit index is .97; root mean square error of approximation is .04). Inter factor correlation is .26, ($p < .001$), positive discrimination power, internal consistency (.85), test-retest reliability (.71), and test-retest reliability (.71). It is a valid and reliable tool for measuring mathematics anxiety.

Mathematics Anxiety Scale for students was developed by Ko and Yi (2011) to test mathematics anxiety which consists of 65 items on four underlying factors such as the nature of mathematics, learning strategy, test/performance and environment. Cronbach's alpha of the scale is .77, for the factor nature of mathematics Cronbach's alpha is .76, for learning strategy Cronbach's alpha is .73, for test/performance Cronbach's alpha .73 and for environment is .70.

Theoretical Overview of Achievement Motivation

According to (Cherry, 2020), motivation is the process or desire that starts, directs, and sustains goal-oriented conduct. It is what motivates an individual to act and one among the factors that steers people's actions. According to Feather (1963), motivation is a relatively consistent personality trait that may have an innate foundation but is more likely the result of early learning about how to approach or avoid stimuli. In many educational circumstances, the idea of motivation takes priority. According to Vidler (1977) achievement motivation is a pattern of action planning and emotions related to striving for an internalised standard of excellence, as opposed to, the power or friendship interactions between achievement motivation, value, and anticipation. Achievement motivation refers to the propensity to strive for success or the realisation of desired goals (McClelland, 1965). It is a key determinant of aspiration, effort and persistence when an individual anticipates that performance will be assessed in relation to some standard of excellence, which motivates an individual to excel, succeed or outperform others at some task.

Murray (1938) suggested that achievement motivation, sometimes known as the urge for achievement, is an important variable in determining aspiration, effort, and persistence when a person anticipates that their work will be evaluated against certain standards of absolute excellence. It is believed that achieving a challenging goal is desirable. Action follows the desire, thus the person puts up a lot of effort over a lengthy period of time to complete a challenging task. Murray (1938) defined personality as the concept of a hierarchy of configuration of fundamental psychogenic demands or motives. In his opinion, a need may come from within through visceral processes or from without through the impact of the current situation on the individual. Murray (1938) outlined a variety of needs such as manifest (overt) or latent (covert), conscious or unconscious, and primary and secondary needs, except needs for affiliation, achievement, nurturing, etc. have gotten more attention.

Murray (1938), Atkinson (1964), and McClelland (1965) advanced and improved the achievement motivation hypothesis. Achievement motivation theories hold that a person's drive to succeed in life or their pressing need to accomplish a particular goal are influenced by a variety of internal factors, including willingness, determination, punctuality, and personal drive, as well as a variety of external factors, also known as environmental factors, such as pressures, expectations, targets, etc., set by relevant organisations, family members, or the wider community (McClelland, 1965). According to the Achievement Needs Index (McClelland, 1965), a person's urge to do something and the driving force behind his or her general motivation to accomplish a particular goal. Motivation theory is typically internal to the person and is closely tied to their need for power and affiliation (Murray,1938). The main focus of achievement motivation theory is on how an individual's needs evolve over time as his experiences change and also describes how a person's demand for connection, authority, and achievement influences their behaviour (McClelland, 1965).

Self Determination Theory

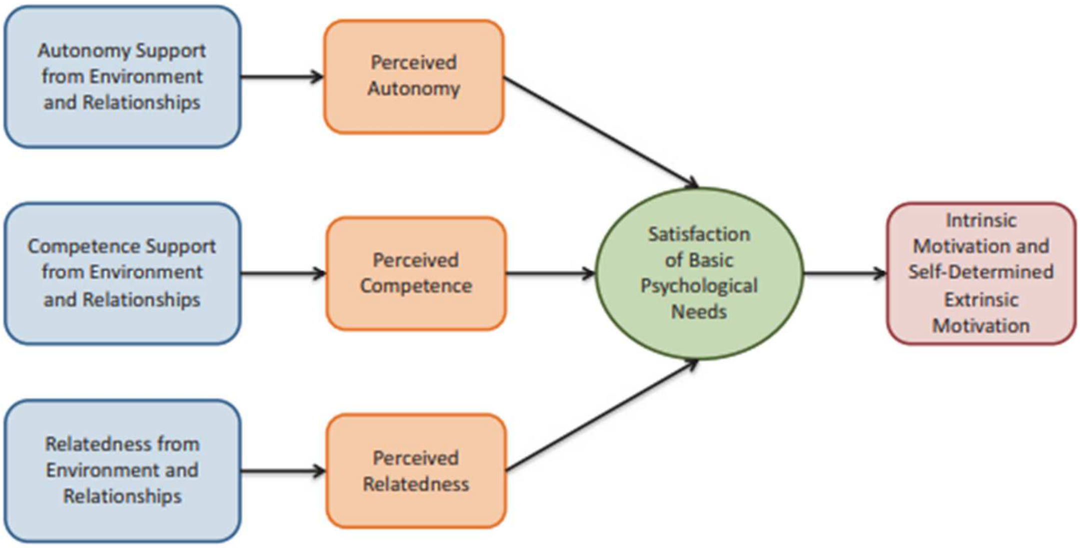
Self determination theory (Deci & Ryan, 1985) highlights the importance of individuals' intrinsic motivation and psychological needs for autonomy, competence, and relatedness in promoting optimal achievement outcomes. The theory proposes that individuals are more likely to achieve and experience greater satisfaction when their activities align with their intrinsic interests, they feel competent in their abilities, and they have a sense of autonomy and connection to others (Deci et al., 2001; Reeve, 2009; Wentzel & Wigfield, 2009). The environment and opportunities promote intrinsic motivation, engagement and well-being, leading to better outcomes in various domains, including education, work and personal life (Deci et al., 1994; Vansteenkiste et al., 1999; Reeve et al., 2004; Ratelle et al., 2007).

Self determination theory (Deci & Ryan, 1985) argues that the natural tendency for professional growth cannot be taken for granted and warns that individuals may face control, fragmentation, and alienation if their core psychological needs for autonomy, competence, and relatedness are not adequately supported by their social environment. In this context, self determination theory emphasized the ongoing dynamic relationship between individuals and their social world, where they are consistently pursuing the satisfaction of their needs while also responding to environmental factors that can either aid or hinder this process (Legault, 2017). Consequently, this interaction can lead to individuals feeling either engaged, curious, connected, and whole, or, alternatively, demotivated, ineffective, and disconnected (Deci & Ryan, 1985). The key components of self determination theory are basic psychological needs and types of motivation.

Basic psychological needs include autonomy, competence and relatedness. Autonomy. The need to feel free and self-directed and emphasized the importance of having a sense of violation and ability to make choices that align with one’s true self (Deci & Ryan, 1985). Competence is the need to gain mastery of tasks and learn different skills. Individual want to feel effective in their interactions with the environment and to achieve desired outcomes (Deci & Ryan, 1985). Relatedness is the need to feel connected to others, to love and care, and to be loved and cared for. Social connections and relationships are essential for well-being (Deci & Ryan, 1985). Types of motivation include intrinsic motivation and extrinsic motivation. When individuals engage in a behaviour because it is inherently interesting or enjoyable, it is referred to as intrinsic motivation. When behaviour is driven by external rewards or pressures, it is referred to as extrinsic motivation (Deci & Ryan, 1985). However, self determination theory suggests that extrinsic motivation can vary in its degree of autonomy, depending on how much the behaviour is aligned with the person's values and needs. The essence of self determination theory is presented in Figure 4.

Figure 4

Self Determination Theory (Source : Legault, 2017)



Abraham Maslow's Hierarchy of Needs

The hierarchy of needs theory by Maslow (1943) emphasises that motivation results from an individual's efforts to satisfy five basic needs: physiologic, safety, social, esteem, and self-actualization. Hartzell (2020), as a lower-level need is satisfied, the demand moves up, starting with the fundamental requirements. The five fundamental needs are:

Physiological Needs. Physiological requirements are necessary for human life which includes physical requirements for survival such food, drink, and shelter (Maslow, 1943).

Safety Needs. The absence of hazards, a lack of necessities, and other risks. Safety requirements cover all aspects of personal security, financial security, health, and protection from danger, accidents, and their negative impacts (Maslow, 1943)

Social Needs. (belongingness and love) The urge for affiliation, friendship, and other forms of association. Humans require social interaction in order to avoid feeling unhappy, lonely, and alone. This includes kinship, family, and intimacy (Maslow, 1943).

Esteem Needs. Self-respect is slightly more significant than earning the respect and admiration of others in terms of one's self-esteem (Maslow, 1943).

Self-actualization Needs. Self actualization is the desire for a person to realise their entire potential. It is very important for each person to realise their full potential. The highest level of need a person can aspirate is self-actualization (Maslow, 1943).

McClelland's Motivational Theory

McClelland (1965) coined the phrase 'n Ach" which assures that individuals will act in the manner for which they have been rewarded given acceptable circumstances. In motivational theory, McClelland (1965) highlighted the various forms of accomplishment motivation and contends that there are individual disparities in achievement motivation, which may reflect variations in the ability to attain goals with a generally agreeable and steady disposition that is learned over time. According to McClelland (1965), in order for the desire to succeed to be sparked during a performance-awesome action the person must believe that he is accountable for the result (success or failure), have specific understanding of the outcome so that he knows when he achieved his objective, and there must be an element of risk associated with the possibility of success.

According to McClelland's (1965) achievement motivation theory, there are three primary needs that drive human motivation such as the need for achievement, the need for affiliation, and the need for power.

Need for Achievement. The urge to accomplish and do better than others is known as the need for achievement. High achievers are frequently goal-oriented and willing to take calculated risks. Additionally, they are often autonomous and self-assured (McClelland, 1965).

Need for Affiliation. The need to be liked and accepted by others is known as the need for affiliation. People with a high need for affiliation are frequently cooperative and supportive, have a strong desire for social connection, a sense of belonging, work well in teams, and maintain positive relationships with others. They also have a strong want to be liked and accepted by their peers. They often excel in forming bonds with others and cooperating with them. The desire for social ties drives those with strong affiliation needs. They love friendly relationships and take pleasure in working with others (McClelland, 1965).

Need for Power. The urge to exert control over, influence over, or affect other people is known as a need for power. Power-hungry individuals frequently exhibit assertiveness and dominance. They are frequently adept at inspiring and motivating others. The need for power refers to a person's desire to control, affect, or exert influence over others. High power needs drive people's motivation to take charge, make decisions, and exercise authority over others. They aspire to positions of power and responsibility because they like having the upper hand (McClelland, 1965).

Deo-Mohan Achievement Motivation

According to Deo & Mohan (1985), the areas of achievement motivation are academic motivation, need for achievement, academic challenge, attitude towards education, work method, importance of marks, need to excel, meaningfulness of daily school tasks, individual concern, general interests, attitude towards teacher, interpersonal relationship, participation in school activities, and social organisation.

Academic Motivation. Academic motivation, the key element of achievement motivation, focuses on students' drive, interest, and persistence in academic activities and tasks. It includes all of the internal and environmental variables that affect how engaged and successful students are in their academic success (Deo & Mohan, 1992).

Need for Achievement. The need for achievement is a fundamental component of achievement motivation, reflecting individuals' inherent drive to succeed, accomplish goals, and demonstrate competence in challenging situations. Understanding and supporting the need for achievement can contribute to fostering motivation, enhancing performance, and promoting personal fulfilment and success (Deo & Mohan, 1992; 2018).

Academic Challenge. The obstacles and difficulties that are encountered by students in their academic work (Deo & Mohan,1992; 2018).

Work Method. Work method can be considered as a component of achievement motivation, particularly in the context of individuals' approaches to tasks and their work habits (Deo & Mohan, 2018). While it may not be explicitly defined as a separate component in traditional theories of achievement motivation. It encompasses how individuals approach their work, the strategies they employ, and their overall work ethic

Importance of Marks. Importance of marks can indeed be considered as a component of achievement motivation, particularly in educational contexts where academic performance is measured and evaluated through grades or marks (Deo &Mohan, 1992; 2018). It reflects individuals' motivation to attain high academic marks or grades as a measure of their success and competence in academic pursuits.

Need to Excel. Need to excel is a core component of achievement motivation, reflecting individuals' intrinsic drive and aspiration to achieve excellence in their endeavours (Deo & Mohan, 1992; 2018). Understanding and nurturing this component can empower individuals to pursue their goals with passion, determination, and a commitment to continuous improvement, ultimately leading to personal fulfilment and success in their chosen pursuits.

Meaningfulness of Daily School Tasks. The meaningfulness of daily school tasks is a vital component of achievement motivation, reflecting students' perceptions of the relevance, significance, and personal value they attribute to their academic activities and assignments. Fostering a sense of meaningfulness in daily school tasks can enhance students' intrinsic motivation, engagement, and academic success, ultimately contributing to their overall well-being and fulfilment as learners (Deo & Mohan,1992; 2018).

Attitude Towards Teacher. Attitude towards teachers is a critical component of achievement motivation, reflecting students' perceptions, feelings, and interactions with their teachers, which can profoundly influence their motivation, engagement, and academic success. Fostering positive teacher-student relationships, creating supportive learning environments, and providing effective feedback and encouragement are essential strategies for promoting a positive attitude towards learning and cultivating students' motivation to excel academically (Deo & Mohan, 2018).

Interpersonal Relationship. Interpersonal relationships can indeed be considered as a component, reflecting the quality of relationships and interactions that students have with their peers, teachers, and other members of the academic community (Deo & Mohan, 1992; 2018).

Participation in School Activities. Participation in school activities is indeed a crucial component of achievement motivation, reflecting students' engagement, involvement, and investment in various extracurricular, co-curricular, and academic activities within the school community (Deo & Mohan, 1992; 2018).

Social Organisation. Social organisation significantly influences individuals' motivation and behaviour within social contexts. Positive social environments characterised by support, encouragement, collaboration, and recognition can enhance individuals' motivation to achieve their goals, while negative social dynamics may hinder motivation (Deo & Mohan, 1992; 2018).

Expectancy Value Theory

Expectancy value theory (Wigfield & Eccles, 2000) is a comprehensive framework that explains individuals motivation and achievement related choices.

According to expectancy value theory, individuals' motivation is influenced by two key factors: their expectations for success and the subjective value they attach to the outcomes of a task or domain (Wigfield & Eccles, 2000). Expectancy refers to an individual's belief in their ability to succeed in a particular task or domain. It represents the perceived probability that one's efforts will lead to successful performance (Eccles, 2005). For example, in the context of mathematics, an individual with high expectancy believes they have the necessary skills, knowledge, and strategies to perform well in mathematical tasks. The expectancy component is influenced by any factors, including past performance experiences, feedback received, and self-perceptions of ability (Weiner,1985). According to Weiner (1985), when individuals have high expectancy, they are more likely to approach tasks with confidence, persist in the face of challenges, and use effective problem-solving strategies.

Value represents the subjective worth or importance that individuals attribute to a task or domain is classified into intrinsic value and extrinsic value (Wigfied & Eccles, 2000). In the case of mathematics, individuals may find intrinsic value in problem solving, logical reasoning, or the beauty of mathematical concepts. Extrinsic value could be influenced by factors such as the perceived usefulness of mathematics in real life contexts or the recognition and rewards associated with mathematical achievement (Eccles & Wigfied, 2002). The value component is shaped by personal interests, societal expectations, cultural influences, and personal goals. When individuals perceive high value in mathematics, they are more likely to engage in tasks, persist in the face of difficulties, and invest effort to achieve success (Eccles &

Wigfied, 2002). Expectancy value theory emphasises that individuals' motivation and achievement related choices are a result of interaction between expectancy and value (Wigfield & Eccles, 1997, Hulleman et al., 2008; Linnenbrink- Garcia & Patall, 2016). If an individual perceives high expectancy but low value in mathematics, they may not be motivated to invest effort and may choose to disengage from mathematical tasks (Meece et al., 1990; Urdan & Midgley, 2003; Wigfield et al., 2006). Conversely, when individuals perceive both high expectancy and high value, they are more likely to be motivated, set challenging goals, and strive for excellence (Eccles et al., 1998; Hidi & Renninger, 2006; Wigfield et al., 2006).

Expectancy value theory (Wigfield & Eccles, 2000) includes fostering positive self beliefs, providing meaningful and relevant learning experiences, highlighting the value and applicability of mathematics in real world contexts, and creating a supportive and engaging learning environment. By considering both expectancy and value, educators and policy makers can design interventions and strategies to enhance motivation, engagement, and achievement in various domains, including mathematics (Harackiewicz et al. 2002; Urdan & Mestas, 2006; Hulleman et al. 2008).

Types of Achievement Motivation

Different forms of motivation include extrinsic, intrinsic, psychological and achievement (Atkinson, 1964; Harackiewicz et al., 2002). Extrinsic motivation describes behaviour that is motivated by rewards from outside sources. These benefits may be material, like cash or grades, or immaterial, like acclaim or celebrity (Cherry, 2001). Intrinsic motivation is used to describe behaviour that is motivated by personal rewards. In other words, a person is motivated to engage in a conduct because it is intrinsically fulfilling. A key idea in developmental psychology is intrinsic motivation, which plays a major role in spontaneous exploration and curiosity (Deci & Ryan, 1985).

Intrinsic Achievement Motivation. The term 'intrinsic achievement motivation' describes the internal drive or desire people have to complete activities or goals for the intrinsic satisfaction and personal fulfilment the activity itself provides (Ryan and Deci, 2000). According to Rayan and Deci (2000) internal reasons and personal happiness are the sources of intrinsic motivation, which includes intrinsic accomplishment motivation. It is motivated by a person's innate interest, delight, or sense of fulfilment they get from doing something (Deci, 2000). Intrinsic motivation for achievement emphasises the innate drive to master a task, achieve personal progress, or achieve a sense of competence (Deci & Ryan, 1985). Intrinsic achievement motivation is not influenced by external variables like monetary prizes or praise, in contrast to extrinsic motivation, which incorporates external rewards or incentives (Lazaro, 2023). Instead, those who are intrinsically motivated to acquire value in the activity itself are more likely to work on activities because they are enjoyable, challenging, or satisfying. Following a pastime or passion, engaging in creative activities, or seeking knowledge merely for personal betterment are some instances of intrinsic achievement motivation (Fishbach & Woolley, 2022). Strong intrinsic accomplishment motivation makes people more determined, inquisitive, and motivated to acquire and master new abilities or concepts (Dichev, 2000).

Extrinsic Achievement Motivation. Extrinsic achievement motivation refers to the concern yourself about success in interpersonal competitiveness and social recognition (Newmann, 1993). Extrinsic motives are so named because an outside source is where they originate. When we act because someone else wants us to, it is said that we are extrinsically driven (Oudeyer, 2007). Rewards like money and grades, compulsion, and the prospect of punishment are typical extrinsic motivators (Oliver, 2020). Competition is typically extrinsic since it motivates participants to succeed and surpass their rivals rather than to take pleasure in the activity's intrinsic benefits. Trophies and crowd support are two other examples of extrinsic rewards (Deci & Ryan, 1985).

According to Atkinson (1964), achievement motivation is the propensity to work hard to achieve a goal. A particular motivation is focused on achieving a certain kind of objective. Atiknson and Feather (1966) classified achievement motivation as a personality component and made the assumption that it interacts intrinsically with value and anticipation. Achievement motivation, according to McClelland (1961), is the desire to change one's current circumstances for the better. High achievement motivation motivates good performance at work, according to studies on entrepreneurial behaviour and achievement motivation. According to McClelland et al. (1953), there is a direct correlation between the level of drive for accomplishment among a culture's citizens and the level of economic achievement in that civilization. Atkinson and Litwin (1960) came to the conclusion that three factors; motivation, likelihood of success (or failure), and incentive value determine actual achievement.

Measurement of Achievement Motivation

This section deals with the description of various instruments used to measure the achievement motivation that are identified in reviewing the literature and related studies in achievement motivation.

Deo- Mohan Achievement Motivation (n-Ach) Scale was developed by Deo and Mohan (1985). This scale consists of 50 items having the components of academic motivation, need for achievement, academic challenge, achievement anxiety, importance of grade, meaningfulness of task, relevance of school to future goals, attitude towards education. Work methods, attitude towards teachers, interpersonal relations, individual concern, general interests, dramatics, sports etc. It is a five point Likert scale. The Cronbach’s alpha reliability coefficient ranges from .70 to .80 and the test retest reliability ranges from .60 to .80

The Achievement Motivation Profiles developed by Friedland et al. (1996) is a self-report assessment instrument to measure a student's motivation to achieve as well as their personality traits, interpersonal abilities, and working methods. The 140 self-descriptive sentences in the AMP are each followed by a 5-point Likert scale response. The AMP has been applied in educational settings with pupils 14 years of age and older. The following topics are measured under the profile's section on motivation for achievement: • Achiever (ACH) - Task completion and Achievement, goal accomplishment, and follow-through. • Motivation (MOT): The capacity of one's inner feelings, needs, and values; inner drive. • Competitiveness (COMP): Need to win, to perform better than others, or exceed expectations in terms of performance or achievement. • Goal Orientation (GOAL)-Having specific aims and goals. The AMP significantly correlated with the overall grade-point averages of high school students in which coefficients ranged from .58 to .84, averaging .75; and test-retest reliability scores were estimated to range from .61 to.89.

The Questionnaire on Current Motivation (QCM) was developed by Rheinberg et al. (2001) to assess four motivational dimensions: anxiety, challenge, interest, and probability of success. The questionnaire consisted of 18 items. Five items of dimension interest and anxiety, four items of dimension challenge and probability (chance) of success.

The Achievement Motivation Inventory (Schuler et al., 2004) consists of 17 facets and 170 components is a 7-point Likert scale. The total score's reliability (Cronbach's alpha) is .96, whereas the range for individual scales .66 to .83. Retest reliability for the overall score is r =.94, and for individual scales, it ranges from r =.71 to.89. In-depth research on all the key components of motivation for achievement and their incorporation into the test were used to establish content validity. AMI scales and associated personality scales have correlations that can reach r =.72, demonstrating the construct validity of the AMI scales.

Lang and Fries (2006) developed the Achievement Motives Scale (AMS) with hope of success and the fear of failure as two factors of achievement motivation. The AMS originally had 30 items. A revised form was developed by the authors Lang & Fries (2006) using confirmatory factor analysis. The updated 10-item Achievement Motives Scale (AMS-R) demonstrated criterion-related validity with achievement behaviour, lower interscale correlations, and satisfactory reliability. The Achievement Motives tool (AMS) is a well-known and widely used tool to evaluate the fear of failing and the expectation of succeeding. Researchers can quickly assess two important characteristics associated with achievement motivation using the 10-item updated AMS-R.

Smith et al. (2019) created the 13-item self-report Achievement Motivation Measure (AMM) to assess motivation for achieving goals, which holds that motivation for achievement is a function of two factors—the person's need for achievement (NACH) and their expectation of success (E)—is the foundation for the AMM. The Achievement Thoughts (AT) and Achievement Behaviours (AB) subscales of the AMM are used to measure NACH and E. The AT subscale assesses a person's attitudes and beliefs about success, including their drive to succeed, focus on challenges, and risk-taking propensity. The AB subscale assesses the person's actual achievement-related behaviours, including goal-setting, preparedness, and perseverance in the face of obstacles. In a range of contexts, including educational, clinical, and organisational settings, the AMM is a useful instrument for assessing accomplishment motivation. The AMM can be used to evaluate individual differences in motivation for achievement, to identify potential contributing reasons to low achievement, and to develop interventions to boost motivation for achievement. With scores ranging from 0 (never) to 4 (always), the AMM employs a 5-point Likert-type response format. The lowest possible score is 0 and the highest possible score is 52 (Smith et al., 2019). High achievement motivation is indicated by higher scores, and low achievement motivation is shown by lower scores. AMM had strong internal consistency (r =.87) and test-retest reliability (r =.78). The reliability coefficients for Achievement Thoughts (r =.80) and Achievement Behaviour (r = .60) were both moderate. The AMM's total alpha coefficient was.83.

The Contextual Achievement Motivation Scale (CAMS) (Smith & Karaman, 2019) is a distinctive tool for evaluating achievement motivation across contexts. The CAMS examines motivation for achievement in the context of work, education, family, and community. CAMS is a 24-item self-reported measure of achievement motivation in five contexts: school, work, family, community, and leisure The items are rated on a 5-point Likert scale. Cronbach's alpha reliability coefficient range from .70 to .90 and test retest reliability coefficient was ranging from .60 to .80. Construct validity of CAMS was .40.

Theoretical Overview of Mathematical Beliefs

Over the past four decades, emphasis has been placed on the critical role that the affective domains play in education generally and mathematics education in particular (McLeod & Adams, 1989; DeBellis & Goldin, 1997; Leder & Grootenboer, 2005; Pepin & Roesken-Winter, 2015; Hannula et al., 2019). Beliefs about mathematics are a concept that have an impact on students' learning and teaching, and consequently have an impact on their success either directly or indirectly (Thompson, 1984; Cobb, 1986; Schoenfeld, 1989; Kloosterman & Cougan, 1994; Kloosterman, 1996). Students' mathematical viewpoints and beliefs, which influence how they view the world of mathematics, are very important for mathematical applications.

According to the research findings, it is beneficial to have a good attitude towards mathematics and be able to explain what one has learnt about math concepts when teaching math (Cobb, 1986; Thompson, 1992; Raymond, 1997). A number of studies (Thompson, 1984; Kloosterman, 1991; Kloosterman & Cougan, 1994) have also suggested that students' beliefs about the nature and education of mathematics have an impact on their abilities to learn the subject as well as their mathematics education. One of the elements of the affective domain, which is crucial for mathematical learning, is mathematical belief. The affective component, which comprises attitude, interest, self-concept, and belief, impacts a student's performance in learning mathematics (Wardhani, 2004). The National Council of Teachers of Mathematics made clear the contributions that cognitive and affective factors make to the acquisition of mathematics (Wahyudin, 2008). Both factors have an impact on how well pupils perform mathematically. The perception of mathematics as a discipline, which is related to mathematical education and learning, can be influenced by a student's belief in mathematics (Radzali, 2007).

According to Op't Eynde and De Corte (2003), students' implicitly or overtly held subjective perceptions regarding mathematics education are considered to be true both about the context of the mathematics class and about themselves as math learners. These ideas influence each other, the past knowledge of the students, and the mathematics learning and problem-solving activities that take place in class. According to Schoenfeld (1989), students' perceptions of mathematics influence how they engage in mathematical activities through their mathematical beliefs.

Kloosterman (1996) explained mathematics beliefs are the individual presumptions that pupils base their decisions and students' behaviour in the classroom is influenced by these ideas. Reyes (1984) conceived a student's ideas about mathematics that can be related to how they feel about the subject, the classroom, or even regarding themselves as mathematicians.

Adnanet et al. (2012) emphasized that mathematical beliefs have a significant impact on the effectiveness and quality of mathematics teaching and learning. The affective domain is very significant in education which is composed of beliefs, attitudes, interests, values and emotions (Mcleod, 1992; De Bellis & Goldin, 1999). Affective learning characterizes the emotional area of learning reflected by beliefs, values, interest and behaviour of learners (Smith & Ragan, 1999; Gronlund & Brookhart, 2009). Affective learning is concerned with how learners feel while they are learning, as well as with how learning experiences are internalised so they can guide the learners attitudes, opinions and behaviour in the future (Miller, 2005). Affect plays a significant impact in mathematics learning and the development of beliefs is one of the key outcomes of mathematics learning (McLeod & Adams, 1989; Leader & Gunstone, 1990). Students' beliefs about their own performance and long term expectations are likely to be reflected in and reinforced by the values held by peers (Ryan & Deci, 2001). Students' beliefs are things they are aware of or experience that have an impact on their efforts and their efforts to learn mathematics (Kloosterman, 2002).

Dimensions of Mathematical Beliefs

The dimensions of mathematical beliefs are described from the viewpoint of various educationists.

According to Green (1971), each individual's beliefs are quasi-logically connected, and the logic linking beliefs is specified uniquely. Green (1971) described three dimensions of a belief system.

1. First, think about the belief system's somewhat logical form. Some of the beliefs are fundamental, while others are derived. A student's primary belief that mathematics is helpful to him or her in life is an example of a primary belief. He or she decides to concentrate hard in class while learning mathematics as a result. Working on problem-solving exercises while attempting to apply the lessons learned to real-world situations is an example of a derivative belief (Green, 1971).

2. The second belief system, according to Green (1971) consists of central beliefs and peripheral beliefs. The central beliefs are stronger and more significant. With experiences, routines, and affirmation, these beliefs become more ingrained. For instance, whereas the ideas of experienced teachers are more fundamental and deeply ingrained, those of newly appointed instructors in a school are more peripheral but still changeable and flexible. It has been noticed that beliefs can occasionally present insurmountable challenges to growth (Green, 1971). These peripheral ideas are more easily altered. Peripheral beliefs are less central and less important within an individuals' belief system.

These beliefs are more flexible, more likely to change in response to new information, and generally have less impact on a person’s overall worldview (Green ,1971).

3. Thirdly Green (1971) introduced the term cluster to indicate that beliefs tend to occur in interconnected groups rather than existing independently. This clustering phenomenon can account for the inconsistencies observed in beliefs held by students and teachers alike. When discussing the beliefs systems related to mathematics, there are multiple ways to recognise these beliefs.

Kuhs and Ball (1986) described three distinct and popular concepts of the optimal teaching and learning of mathematics.

1. The first is the *learner-focused perspective*, which emphasises how social contact helps students build their mathematical knowledge.

2. The second viewpoint is *content-focused* and places a focus on conceptual comprehension.

3. The third strategy regards *performance* as the primary objective, whose achievement depends on the knowledge of rules and procedures.

Schoenfeld (1987) categorized mathematics education beliefs into two main types such as beliefs about mathematics and nature of mathematical tasks and beliefs about oneself and others as doers/ learners of mathematics. These beliefs reflect one's "mathematical worldview" Because they "establish the context in which mathematics is done" (Schoenfeld, 1987). Factor analysis done by Schoenfeld (1992) confirmed some of the beliefs of students regarding the nature of mathematics such as there is never more than one correct solution to a mathematics problem, Mathematics is a solitary activity, undertaken by individuals in isolation, there is only one correct way to solve any mathematical problem, ordinary students cannot expect to understand mathematics; they expect to simply memorise it and apply what they have learned mathematically and without understanding and the mathematics learnt in school has not much or no application in the real world. According to Schoenfeld (1992), a person's beliefs in mathematics are their understanding and sentiments about the subject matter that influence how they conceptualise and behave in relation to the subject matter. Affective factors like interest, attitude, and values are crucial since they frequently shape future behaviour and pointed out that it is important to encourage pupils to have a positive outlook on studying because those students are more likely to continue their studies in the future (Popham, 2011). According to Schoenfeld (1989), students who underestimate their mathematical ability tend to attribute their mathematical success to luck and their failures to a lack of ability, whereas those who believe they are good at mathematics attribute their success to their abilities.

Underhill (1988) formed categories of mathematical beliefs such as beliefs about mathematics as discipline, beliefs about mathematics learning, beliefs about teaching mathematics, and beliefs about the social context of mathematics. Students' beliefs about the nature of mathematics affects their approach specific to mathematics content, mathematics learning and mathematics problem solving (Underhill, 1988). Underhill (1988) pointed out that what learners know and what they think are frequently indistinguishable as well for some students, their beliefs allow them to 'know' mathematics through memorization and algorithms, but their beliefs do not promote integration and relational learning.

According to Garofalo (1989) students believe that the ability to absorb, recall, and apply facts, rules, formulae, and processes constitutes mathematical thinking. The majority of the middle school and elementary school curricula emphasise mathematical calculation. Students who believe that the goal of mathematics is to be able to do computations rapidly and effectively are constantly interested in finding solutions to problems that cannot be found quickly through calculation.

Ernest (1991) classified belief systems to five main belief systems authoritarian, utilitarian, mathematics-centred, progressive, and socially conscious that are thought to be present among teachers and described a developmental cycle for each of these belief systems. Ernest's (1991) contribution demonstrated that these attitudinal representations can be connected to ideas about the theory of mathematics, learning mathematics, teaching mathematics, and assessment in mathematics, as well as to beliefs about the objectives of mathematics education. Ernest (1991) argues that the teacher's philosophy of mathematics, which can range from absolutist to social-constructivist ideals, is the most crucial of these categories.

The cultural context of the classroom has a significant impact on how students construct their conceptions of mathematics (Schoenfeld, 1988; McLeod, 1992). The three key components to students' affective experiences in learning mathematics, according to McLeod (1989, 1992) are:

1. When studying mathematics, students may develop either a good or negative attitude depending on the comparable or identical experiential events they encounter.

2. Students' self-perceptions and attitudes about mathematics play a significant effect on their affective reactions.

3. Interruptions are an inevitable part of studying mathematics, children will feel both positive and negative emotions while they do so.

Renne (1992) conceptualised four alternative teachers' ideas of teaching and learning mathematics using the purpose of schooling/knowledge matrix. In the category of *educational goals*, there are two types of teachers: those that focus on school knowledge and those who prioritise child development. According to the school knowledge group teachers, learning is the process of reproducing information, whereas teaching is the act of imparting knowledge to others (Renne, 1992). At the same time, school-knowledge focused teachers place a lot of importance on the curriculum and syllabus as a way to direct their education. As a result, teachers who are focused on child development are more likely to prioritise the requirements and features of the students when making decisions about their education (Renne,1992). The *second component* in the matrix links educators' beliefs to how they view knowledge in general. Teachers that focus knowledge acquisition in the classroom create activities that emphasise learning in terms of 'what' is going to be taught (Renne, 1992). As a result, this kind of knowledge is more focused on drill and rules. Because it does not assist the learner in connecting isolated knowledge chunks to the overall framework, this type of knowledge is particularly dispersed. Teachers who focus on child development, in contrast, are more concerned with helping students understand mathematical topics within a comprehensive and relevant knowledge structure that is interconnected (Ranne, 1992).

Kloosterman (1996) described mathematics-related beliefs, and the nature of mathematics and how it is learned. The first category discusses how students view mathematics as a discipline, how they perceive mathematical problems, how beneficial mathematics is, and how mathematics relates to other topics (Kloosterman, 1996). The second group explains students' attitudes towards word problems, their perceptions of themselves, their mathematical prowess, the social setting in which they study maths, and the teacher's function (Kloosterman, 1996). Kloosterman (1996) believed that students' impressions of the many branches of mathematics can significantly affect what they feel is important to learn and how they approach it. Students who think that mathematics consists merely of rules and processes aren't willing to connect mathematical issues or comprehend any underlying mathematical notions. Those people need to be inspired to learn the procedure and rules.

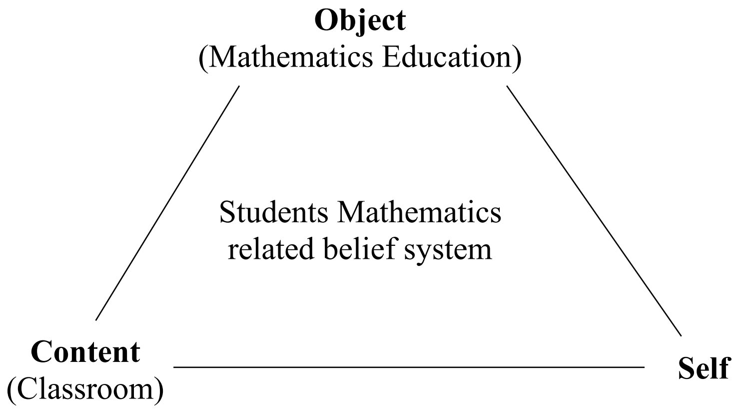
The self-efficacy beliefs theory of Pajares (1996) is grounded in the broader framework of social cognitive theory, originally developed by Bandura (1977). Pajares (1996) extended Bandura’s theory to academic settings, particularly focusing on the impact of self-efficacy on student performance, motivation, and learning. Pajares (1996) defines self-efficacy as an individual's beliefs in their ability to successfully complete a task or achieve a specific goal. Students with high self-efficacy beliefs believe that they can successfully solve math problems, for example, they are more likely to engage in tasks, persist when faced with challenges, and achieve better outcomes. Students with low self-efficacy beliefs doubt their abilities, they are more likely to avoid tasks, give up easily, and perform poorly, even if they have the requisite skills (Pajares, 1996). Pajares (1996) emphasised four main sources from which students derive their self-efficacy beliefs and the first source is *mastery experiences* which refers to past success or failures. Students who experience success in a particular subject (e.g., mathematics) are more likely to develop strong self-efficacy beliefs. Conversely, repeated failure diminishes self-efficacy (Pajares, 1996). The second source of beliefs according to Pajares (1996) is *vicarious experiences* which are derived by observing peers succeed or fail influences students' self-efficacy. For example, seeing a classmate successfully solve problem might boost another student's beliefs that they too can succeed. Third source of beliefs is *verbal persuasion* (Pajares, 1996) which is related to encouragement and feedback from teachers, parents, peer influence self-efficacy, and positive environment ("You can do this!") can enhance a students' belief in their ability to succeed. Finally, Pajares (1996) listed that *physiological and emotional reactions to a task* also affect their self-efficacy. For example, feeling anxious or stressed before an exam can lower self-efficacy, while feeling calm and prepared can boost it.

Raymond (1997) noted that past school experiences, early family experiences and the teacher education program have the greatest effect on developing pre-service teachers' mathematical beliefs. All teachers possess beliefs about their profession, their students, how learning takes place and the subject areas they teach, and their practices should flow from these beliefs. Thus, they transfer their own attitudes and beliefs to their students. As a result of their past experiences, pre-service teachers come to their education courses with deeply rooted anxieties and attitudes about mathematics.

Op't Eynde et al. (2002) who also expressed the opinion that beliefs about learning mathematics are the students' beliefs about learning strategies, which include what students believe to be productive and non-productive strategies; for instance, learning mathematics is primarily memorization. According to Underhill (1988) and Op’t Eynde et al. (2002) it was challenging to distinguish between views about the nature of mathematics, mathematics learning, and mathematics instruction. According to De Corte et al. (2002) there are three main categories of mathematical beliefs: those regarding social environment, those about the self in connection to mathematics, and those regarding mathematical education. According to Op't Eynde and De Corte (2003), there are three different categories of mathematical beliefs that students hold that are included in this framework of beliefs. These belief systems involve beliefs about mathematics education, beliefs about the self, and beliefs about the social context. The framework of the mathematical belief system by Op't Eynde and De Corte (2003) are presented in Figure 5.

Figure 5

Framework of Mathematical Belief System



Belief About Mathematics Education. The students' belief about mathematics education is the first category. According to Op't Eynde and De Corte (2003), this speaks to students' perceptions about the nature of mathematics. Students' perceptions that mathematics is challenging or based on a set of rules, for instance, would fall under this category and also includes the students' opinions about the value of mathematics outside of the classroom.

Beliefs About Self. Students' beliefs about the self are the second kind of beliefs presented by Op't Eynde and De Corte (2003). Self-efficacy beliefs, control beliefs, task-value views, and goal orientation beliefs are some of the four sub categories that fall under this area. Self-efficacy beliefs concentrate on how successful and unsuccessful students think they are at studying mathematics (Pajares & Miller, 1994). An example of this would be a student who is certain that they comprehend the challenging subject in a particular mathematics unit (Op't Eynde & De Corte, 2003). Control beliefs are the student's beliefs that they can successfully complete a task. One such assumption is that students will be able to learn the content if they study effectively (Op't Eynde & De Corte, 2003). Task-value beliefs concentrate on the motivations behind a student's learning and problem-solving activities. The notion that it is crucial to master the subject in a mathematics lesson is an illustration of a task-value belief (Op't Eynde & De Corte, 2003). Also included in this is the notion that the learner is aware of the significance of learning mathematics. The driving forces behind a student's attempts to excel in a course are part of goal orientation beliefs. A student who believes the ultimate goal in a mathematics course is to try to understand the content as thoroughly as possible is an example of a student who holds this belief as opposed to a student who holds this belief as getting a passing grade even if he or she does not understand the course material (Op't Eynde & De Corte, 2003).

Beliefs About Social Context. The views concerning the social context of the classroom make up the third type of belief in the definitions of students' beliefs connected to mathematics (Op't Eynde & De Corte, 2003). The students' opinions and perceptions of the classroom norms that direct teacher and student behaviour in that particular classroom are referred to by these beliefs. The perceived social norms that exist in the classroom fall under this kind of belief. The students' beliefs about the role of teacher and the pupil's roles in the mathematics classroom as well as ideas about elements of classroom culture that have to do with math-related activities is included in this category (Op't Eynde & De Corte, 2003). A belief about the social context can be one regarding what constitutes an appropriate response or explanation in their classroom.

Mathematics is a challenging subject that is governed by rules, despite what students think. These ideas, which strive to provide more difficult mathematical problems than the notion that maths is simple and based on logical thinking, are not themselves emotionally charged. According to Lampert (1990), one's understanding of mathematics is shaped by their experiences in school, where doing mathematics entails adhering to the rules established by the teacher, knowing mathematics entails remembering and using the right rule whenever the teacher poses a question, and mathematical truth is established when the answer is corrected.

Schommer (1990), a multidimensional framework can simultaneously contain simple knowledge, certain information, fixed ability, fast learning, and both naive and sophisticated beliefs. According to Muis (2004), sophisticated and naive views can be divided into availing and non-available beliefs. Availing beliefs are described as having a positive impact on learning, whereas non-available beliefs have the opposite effect. Chaiou (1995) claims that knowledge and experience are the foundations of belief. Belief is knowledge-based since it is supported and limited by domain knowledge and is based on experience since it is the result of years of practice. Without sufficient information and experience, we could not have had belief. Beliefs held by students may have a beneficial or detrimental impact on their learning. Since these beliefs are held inside by the pupils, outsiders cannot really see them, but they can infer them from a person's behaviour. Beliefs are primarily cognitive in nature and exist at the crossroads of cognitive and affective domains (Op't Eynde et al., 2002).

In order to explain the problem solving activities, purely cognitive factors are not sufficient (Schoenfeld, 1983) or teachers' classroom behaviour (Speer, 2005), beliefs play a significant role in problem solving thus the effect of these beliefs cannot be ignored. It is clear that basic mathematical skills and problem solving skills help to develop students' beliefs (Schoenfeld,1983). When students analyze mathematical problems, they go far beyond only using notions that are merely logical or mathematical in character; they also take into account their sentiments, beliefs, and dispositions (Lesh & Zawojewski, 2007). The mindset of students determines their ability to solve difficulties and has the capability to direct their behaviours and learning outcomes of students are strongly related to beliefs and attitudes towards mathematics (Andreassen, 2005).

Many students, according to Kloosterman (1996), have solid mathematical beliefs. The development of student belief was explored by Lee et al., (2004), which can be enlarged to include the influence of the students' circumstances and environment. Greer et al. (2002) held that teachers, textbooks, learning strategies, and the utilisation of real-world situations in learning activities have an impact on students' perceptions of mathematics and changes in pupils' mathematical beliefs are influenced by a variety of linked elements.

Measurement of Mathematical Beliefs

This section deals with the description of various instruments used to measure the mathematical beliefs that are identified in reviewing the literature and related studies in mathematical beliefs.

Schoenfeld (1985) developed Beliefs about Mathematics Test (BMT) to assess the mathematical beliefs of students. The BMT is a 25-item Likert-scale that assesses participants' perceptions of the nature of mathematics, the role of the instructor, and the role of the student in the learning of mathematics. The Cronbach's alpha reliability coefficient was in between .75 and .80,

Epistemological Questionnaire (SEQ) is the one of the most used instruments for evaluating the aspects of epistemological beliefs developed by Schommer (1990). In order to assess first-year and sophomore college students' personal epistemologies in terms of their sources of knowledge, structures of knowledge, certainty of knowledge, control of knowledge, and speed of knowledge acquisition. There are 63 items in the questionnaire's original iteration, divided into 12 subsets, with four factors added during the factor analysis to test the questionnaire's ability to predict outcomes. Numerous research (Schommer et al., 1992; Schommer-Atkins, 1994; Schommer & Walker, 1997) validated the questionnaire.

Mathematics Teaching Efficacy Beliefs Scale (MTEBS), developed by Pajares (1992) to assess the mathematical beliefs of teachers about their ability to teach mathematics effectively. The MTEBS is a 24-item Likert-scale that assesses one's perceptions of their capacity to effectively teach mathematics. There are subscales in the MTEBS such as personal teaching efficacy, confidence in one's own capacity to instruct mathematics., mathematics outcome expectancy, student learning motivation and mathematics instructional strategies.

Jehng et al. (1993) created the Beliefs about Learning Questionnaire, which consists of 60 statements and asks students to rate their agreement or disagreement on a seven-point scale based on the five dimensions of certain knowledge, omniscient authority, rigid learning, innate ability, and quick process. Internal consistency ranges from .70 to .85 and the validity was above .40.

Qian and Alvermann (1995) modified the epistemological belief questionnaire by removing one of the four variables, renaming it the revised epistemological questionnaire and adding 32 items relating to the three factors including such as quick learning, simple certain knowledge, and innate ability. a) Learning quick-contains 15 items with internal consistency .79, b) Knowledge is simple and certain- 11 items with internal consistency .68, c) Ability to learn is innate - 6 items with internal consistency .62. The overall Cronbach’s alpha was .77.

An Epistemological Beliefs Questionnaire was created by Chan and Elliott (2002) after revising Schommer's Epistemological Questionnaire. The 45 items in the instrument were later trimmed to 35 items on the factors such as individuals beliefs about the nature of knowledge and learning, stability of knowledge, the ability to learn, and process of knowledge acquisition. The values for the items' internal consistency on the Cronbach’s alpha coefficient scale range from .60 to.70.

The Epistemic Beliefs Inventory (Schraw et al., 2002) examined the elements linked to general epistemological beliefs of undergraduate psychology students and had 28 items related to the five hypothesised beliefs by Schommer (1990). The elements of certainty of knowing, simplicity of information, quick learning, omniscient authority, and innate ability were included in the Epistemic Beliefs Inventory. The inventory's test-retest reliability coefficient was determined to be $r = .78$.

University students' ideas about mathematics are measured using the Epistemological Belief Survey for Mathematics, developed by Wheeler (2007). Based on factors including knowledge source, certainty of knowledge, knowledge structure, speed of knowledge acquisition, innate ability (generic), innate ability (personal), and real-world applicability, ten to twelve statements were included in the instrument. The 75 items on the 75-item instrument have an alpha coefficient estimate of internal consistency $r = .93$.

A 23-item Mathematical Beliefs Questionnaire was created by Zakaria and Musiran (2010). The three dimensions of the mathematical beliefs questionnaire include beliefs about the nature of mathematics, beliefs about mathematics education, and beliefs about mathematics learning. The responses to the Likert-type questions from the participants ranged from 1 (strong disagreement) to 4 (strong agreement). The answers range from 1 (not important) to 3 (extremely significant) for questions 21 through 23, though. Higher scores indicated beliefs that were in line with the constructivist perspective. The Cronbach's alpha reliability index value for the beliefs about nature of mathematics and beliefs about the learning of mathematics is .74 and .71 respectively.

Briley (2012) constructed the instrument for Mathematics Teaching Efficacy Beliefs. The Mathematics Teaching Outcome Expectancy (MTOE) subscale and the Personal Mathematics Teaching Efficacy (PMTE) subscale are the two subscales that make up the (MTEBI)'s total of 21 items. The two dimensions of teacher effectiveness are represented by these subscales. The 13 items that make up the PMTE subscale are related to a pre-service teacher's confidence in their ability to instruct mathematics successfully. Eight items on the MTOE subscale are related to a pre-service teacher's conviction that successful mathematics instruction can lead to student learning. The ratings for the items range from Strongly Disagree (1) to Strongly Agree (5) on a 5-point Likert scale. Better results on the MTOE subscale suggest higher expectations of student learning of mathematics, but higher scores on the PMTE subscale reflect more personal mathematics teaching efficacy. The For scores relevant to the full MTEBI, Cronbach’s alpha was.81. For the PMTE subscale scores and the MTOE subscale scores, respectively, the Cronbach’s alpha was .87 and .67.

Hendy et al. (2014) created three psychometrically evaluated scales by implementing the self-efficacy theory, expectancy-value theory, and health belief model as their guides. A 5-point rating scale was utilised in this study to reflect different maths beliefs. Following factor analyses, three scales were created: an 11-item math barriers scale with two subscales; math anxiety and discouraging words, a 7-item single-dimension math confidence scale, and a 10-item math value scale with two subscales; class devaluation and no future value.

Kibrislioglu and Haser (2015) developed a Mathematics-Related Beliefs Scale for the fifth grade students based on Op't Eynde et al. (2003) framework. Three variables were identified by factor analysis such as self-efficacy beliefs, beliefs about the role of the teacher, and beliefs about mathematics and mathematics learning. The reliability of the scale was .77, indicating high reliability of the scale.

Purnomo (2017) developed and validated Mathematics Teachers Beliefs Scale for measuring teachers' beliefs towards mathematics, specifically their views on beliefs about the nature of mathematics, mathematics teaching, and assessment in mathematics learning. The scale has 54 items, of which 15 were related to ideas about assessment in maths learning, 23 to beliefs about the teaching of mathematics, and 16 to beliefs about the nature of mathematics. Confirmatory factor analysis (CFA) was used to verify the components identified by the exploratory factor analysis (EFA), which was used to assess the scale factor's structural integrity. The outcome showed that factor had a satisfactory internal consistency coefficient, which ranged from $r = .715$ to $r = .787$.

The instrument developed by (Aljaberi & Gheith, 2018) Mathematical Beliefs Questionnaire to test mathematical belief composed of 37 items calculating the Cronbach's alpha coefficient for both the dimensions and the entire instrument allowed researchers to assess the reliability of the tool. The values were .90 overall, .77 for beliefs regarding the nature of mathematics, .77 for beliefs regarding the teaching of mathematics, and .82 for views regarding the learning of mathematics.

Huisman et al. (2019) constructed a questionnaire to measure students' beliefs about Peer-Feedback (BPFQ) to gauge students' beliefs towards peer feedback. The

BPFQ consisted of four scales: "Valuation of peer-feedback as an instructional method" (VIM; four items), "Confidence in own peer-feedback quality" (CO; two items), "Confidence in quality of received peer-feedback" (CR; two items), and "Valuation of peer-feedback as an important skill" (VPS; three items). Every question was answered on a 5-point Likert scale; The labels for the scales VIM and VPS range from 1 (totally disagree) to 5 (absolutely agree), while those for the scales CO and CR range from 1 (completely not applicable to me) to 5 (completely appropriate to me).

Review of Related Studies on the Instructional Strategy and Dependent Variables

This section deals with the empirical studies related to the variables such as instructional strategy, Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs. This section is described under the following subsections.

- Related Studies on Instructional Strategy
- Related Studies on Achievement in Mathematics
- Related Studies on Logical Reasoning
- Related Studies on Achievement Motivation in Mathematics
- Related Studies on Mathematical Beliefs

Related Studies on Instructional Strategy

Yackel et al. (1991) analyzed the role of small group interactions in mathematics classrooms by examining how students engage in collaborative problem solving and meaning - making. The experimental study was carried out on a sample of second grade mathematics students. The result revealed that collaborative dialogue supported critical thinking, mathematical understanding, and development of mathematical identities. Students actively negotiated and constructed mathematical knowledge through their social interactions.

Hulleman et al. (2008) analysed whether the utility value intervention influenced interest and performance on a task and whether this intervention had different effect depending on individual's performance expectations. The sample consisted of 107 undergraduate students from introductory psychology class at the University of Wisconsin. The result of the study revealed that the utility value intervention increased perception of utility value and interest, especially the students who were low in expected or actual performance.

Pandya (2011) analysed the effectiveness of cooperative learning model on mastery goals compared to traditional models of teaching. The study used experimental method and the sample consisted of 153 students of ninth standard studying in affiliated schools to the SSC board and medium as English. The data were collected by using achievement tests in mathematics and learning goals inventory. The result found that cooperative learning models are more effective for enhancing academic achievement and mastery goals.

Ebrahim (2012) conducted a study to find the effectiveness of teacher-centered and cooperative learning on science achievement and the use of social skills. The sample consisted of 163 female elementary science students in eight intact grade five classes. The tools used to collect data were achievement tests and survey questionnaires. The research design used for the study is pre-test post-test design. The result revealed that cooperative learning strategy was more effective ($p > .05$) on both achievement and social skills than teacher-centered strategies.

McCarthy et al. (2016) conducted a study to test the effectiveness of teacher questioning strategies in mathematics classroom discourse. The sample of the study consisted of randomly selected two eighth grade teachers, from twelve middle school handing quadratic mathematical modeling. Findings of the study indicated that guiding teachers through an analysis of questions they ask and the responses they got from students during mathematical discourse, may enable them to recognize both effective and ineffective questioning strategies in their mathematical classroom discourse.

Herdiana et al. (2017) analysed the effectiveness of discovery learning model on mathematical problem solving. The sample consisted of 70 students of grade seven in one of junior high schools in West Bandung Regency. The study used quasi experimental research design. The instrument used for data collection was pre-test, post-test, and worksheet about problem solving of mathematics. The result of the study revealed that problem solving competency of experimental students was at level 80 percent and discovery model method was effective to improve mathematical problem solving.

Lanuza (2017) analysed how outcome-based education can be better applied in specific mathematics courses and some degree programmes of local colleges' students in the province of Lagunna. The sample of the study consisted of 350 local colleges' students in the province of Laguna. The study used descriptive method using a structured questionnaire for collecting data of OBE teaching strategy in the areas teaching methods, learning activities and assessment tools. The result revealed that OBE is perceived positively in good start with the emphasis on its weak points and it is not perceived in the perceived classroom practice. Results also indicated that OBE in teaching methods, learning activities and assessment tools were substantially and equally used in mathematics course.

The study conducted by Yeh et al. (2019) on improving students’ math performance and interest among low- achieving students using the Math-island teaching approach was carried out on a sample consisting of 215 elementary students with experimental research. The results indicated an improvement in math achievement particularly in calculation and word problem. Results also indicated that by using Math-island teaching approach low-achieving students in the experimental group performed better in word problems compared to those of the controlled group and both low- achieving and high- achieving students exhibited high interest in mathematics and the teaching method.

Bhatt (2020) analysed the effectiveness of the inquiry training model in teaching mathematics students of class IX. The sample consisted of 80 students of class 9. The study adopted equivalent group post-test experimental group design. The result showed that the inquiry training model was more effective than the traditional teaching method to enhance academic performance of students.

Hermawan et al. (2020) conducted a study to test the effectiveness of direct instructional model in learning mathematics. The sample consisted of second grade students in one of the elementary schools in south Tangerang, Indonesia. The result of the study showed that direct teaching model was effective to improve students' mathematics learning outcomes.

Abd Algani (2021) analyzed the effect of collaborative learning techniques on students' educational performance in mathematics. The sample of the study included

195 educators and 80 eighth grade students. The effectiveness of collaborative learning is measured by using questionnaires. The pre- test post- test analysis with the experimental and control groups revealed that students' performance in mathematics using collaborative learning techniques was superior to the students' performance using conventional teaching techniques.

Indrapangastyti et al. (2021) conducted a study to analyse the effectiveness of the blended learning model in mathematics learning to improve the achievement of mathematical concepts. The study adopted quasi experimental design with non-equivalent control group. The sample consisted of 60 ninth grade students in the 2019-2020 academic year. The result of the study revealed that the blended learning model was more effective than the conventional learning model for improving mathematical concepts.

Kaur and Kaur (2021) conducted a study to test the effectiveness of cooperative learning strategy on achievement in mathematics in relation to problem solving ability. The sample of the study consisted of ninth class students from schools of Gurdaspur district to Punjab School Education Board. The study used pre-test post-test research design. The analysis revealed a significant interaction effect of instructional strategies and problem-solving ability and achievement in mathematics. The result indicated that cooperative learning strategy was effective in enhancing problem solving ability and achievement in mathematics.

Sofyan (2021) conducted a study to analyse the effectiveness of the Missouri mathematics project learning model on students' mathematical problem-solving. Sampling technique used for the study was random cluster sampling and the statistical techniques were descriptive statistics and one sample *t*- test. The study concluded that the Missouri Mathematics Project learning model was effective in problem-solving, activities and students' responses in learning mathematics.

Vioshka et al. (2021) conducted a study to improve cognitive learning outcomes of senior high school students by utilizing videos created with the Bandicam application carried out in two cycles to enhance cognitive learning outcomes in mathematics. Sample of the study consisted of class X students. The techniques used to collect data were tests, observation, documentation, and used qualitative and descriptive data analysis methods. The results of the study indicated that the students achieved the average score of 67.60 at the first cycle, by the end of the second cycle, the average score increased to 77.40, onto trigonometric comparisons of right-angled triangles, and the cognitive outcomes of students increased.

Sunismi and Setiawan (2022) conducted a study to analyze the effectiveness of IDEA learning model in mathematics concept understanding. The study adopted quasi- experimental research design. The sample of the study consisted of first year academic students (academic year 2020-2021) at Malang Islamic university and majoring mathematics education study program. The result of the study revealed that the IDEA learning model was effective to assist students in understanding mathematical concepts.

Alzahrani and Alfadhli (2023) analysed the effectiveness of Driver’s Model (DM) in developing conceptual understanding of first class intermediate students in geometry and polygons. The sample consisted of 62 female students of first class intermediate students. The study adopted experimental method. The result of the study revealed a significant statistical variance in the mean scores between the experimental and control group students in the levels of explanation, interpretation and application for the experimental group with impact 0.31.

Ramadhani (2023) analysed the effectiveness of the discovery learning based mathematics learning module in terms of students' interest in learning mathematics. The sample of the study consisted of 28 students of class five, in Gunungpthi district. The tool used to study was a questionnaire of interest in learning mathematics and adopted quasi-experimental method. The research design used for the study was one group pre-test post-test design. Analysis showed that the interest in learning mathematics of class five students experienced an n- gain increase of 0.45 with medium correlation. The result showed that the discovery learning based mathematics learning enhanced interest in learning mathematics.

Sopamena et al. (2023) conducted a study to test the effectiveness of the flipped classroom model on mathematics learning achievement compared to traditional learning model. The research design used for the study was contrast group meta analysis. The result revealed that students' mathematical learning achievement by using flipped classroom model was more effective than traditional learning model (Cohen's $d = 0.494$, $p < 0.001$).

Vale and Barbosa (2023) conducted a study to understand and characterise the performance of pre-service teachers when experiencing active learning strategies during their mathematics classes. The sample consisted of 48 future teachers of primary education. The result of the study showed that active learning enhanced collaborative work and mathematical communication enabling the emergence of different strategies to solve the predefined tasks.

Summary of the empirical studies related to instructional strategy are presented in Table 1.

Table 1

Summary of Empirical Studies on Instructional Strategy

Sl. No.	Author (s)	Year	Findings
1	Yackel et al.	1991	The collaborative dialogue supported critical thinking, mathematical understanding, and development of mathematical identities.
2	Hulleman et al.	2008	The utility value intervention increased perception of utility value and interest, especially the students who were low in expected or actual performance
3	Pandya	2011	Cooperative learning models were more effective for enhancing academic achievement and mastery goals.
4	Ebrahim	2012	The cooperative learning strategy was more effective on both achievement and social skills than teacher-centred strategies.
5	McCarthy et al.	2016	Guiding teachers through an analysis of questions they ask and the responses they got from students during mathematical discourse, may enable them to recognise both effective and ineffective questioning strategies in their mathematical classroom discourse.

Sl. No.	Author (s)	Year	Findings
6	Herdiana et al.	2017	Discovery model method was effective to improve mathematical problem solving.
7	Lanuza and Maryann	2017	OBE is perceived positively in good start with the emphasis on its weak points and it is not perceived in the perceived classroom practice. OBE teaching methods, learning activities and assessment tools to be used in mathematics courses.
8	Yeh	2019	By using math-island teaching approach low-achieving students in the experimental group performed better in word problems compared to those of the controlled group and both low-achieving and high- achieving students exhibited high interest in mathematics and the teaching method.
9	Bhatt	2020	The inquiry training model was more effective than the traditional teaching method to enhance academic performance.
10	Hermawan et al.	2020	Direct teaching model was effective to improve students' mathematics learning outcomes.
11	Abd Algani	2021	Students' performance in mathematics using collaborative learning techniques was superior to the students' performance using conventional teaching techniques.

Sl. No.	Author (s)	Year	Findings
12	Indrapangastyti et al.	2021	Blended learning model was effective than the conventional learning model for improving mathematical concepts.
13	Kaur and Kaur	2021	Cooperative learning strategy was effective in enhancing problem solving ability and achievement in mathematics.
14	Sofyan	2021	Missouri mathematics project learning model is effective in problem-solving, activities and students' responses in learning mathematics
15	Vioshka et al.	2021	The cognitive outcomes of students increased by using videos.
16	Sunismi and Setiawan	2022	IDEA learning model was effective to assist students in understanding mathematical concepts.
17	Alzahrani and Alfadhli	2023	Driver’s Model (DM) was effective in developing conceptual understanding of first class intermediate students in geometry and polygons.
18	Ramadhani	2023	The discovery learning based mathematics learning enhanced interest in learning mathematics.
19	Sopamena et al.	2023	Flipped classroom model was more effective than traditional learning model in mathematical learning and achievement
20	Vale and Barbosa	2023	Active learning enhanced collaborative work and mathematical communication enabling the emergence of different strategies to solve the predefined tasks.

Related Studies on Achievement in Mathematics

Fennema and Sherman (1977) compared the mathematics achievement of female and male students. The sample consisted of 589 female students and 644 male students. The tool used for the study was the Test of Academic Progress. The result of the study revealed a difference in mathematics achievement between female and male students.

Hoang (2007) examines the connections between mathematics learning instruction, and mathematics achievement. The variables measured in the study were mathematics achievement, learning resources, student and family characteristics, and classroom instructional activities. Sample consisting of 565 pupils aged 12 years acknowledged a survey pertaining to the first four constructs. Multiple regression analysis revealed that students who attempted to solve new mathematical puzzles and discussed practical issues more frequently tended to score better in mathematics. According to classroom instructional activities, the researchers identified that students' mathematics performance improved when teachers frequently demonstrated how to solve mathematical problems during math lessons.

The study conducted by Ghazvinia and Khajehpour (2011) examined the gender differences in factors affecting academic performance of high school students and tried to know the gender differences in various variables and performance in school subjects of literature and mathematics. A sample of 363 high schools was selected. Results of this study explored that girls were scoring good marks in literature and boys were performing better in mathematics and girls had a more adaptive approach to learning tasks.

Sethi (2012) conducted a study to explore the relationship between creativity and academic achievement in mathematics. The study involved a sample of 700 students from various government and private schools in different districts of Punjab state, including both female and male students. The result revealed that students having high levels of creativity had higher mean scores in achievement compared to those with lower creativity. Additionally, students from private schools showed higher creativity compared to students from government schools.

Voss et al. (2013) analysed the structure of teachers' beliefs in mathematics and investigated the connections between these beliefs, teachers' instructional strategies, and students' mathematical achievement. Sample consisted of 3,483 students and 155 teachers. Results indicated that by their teaching practices, mathematics instructors' views were an indirect predictor of their students' learning outcomes while transmissive beliefs were found to be negative predictors of both outcomes.

Linnenbrink - Garcia and Patall (2016) examined the effects of expectancy and value beliefs on middle school students' achievement in mathematics. The study was conducted on a sample of 626 middle school students. The result of the study found that students' expectancy and value beliefs were positively related to their mathematics achievement, and that the relationship was mediated by their use of self regulated learning strategies. Individuals' motivation and achievement related choices were influenced by both expectancy and value beliefs, and that interventions targeting these beliefs can improve students' academic performance.

You et al. (2016) examined the impact of students' views of teachers' motivational behaviours on math achievement. The sample consisted of 6227 middle school students in Korea. The results revealed that teachers' motivational behaviours did not directly predict math achievement, but they were affected by students' intrinsic motivation and mathematics self-efficacy. Individuals’ motivation and achievement related choices are influenced by their beliefs about their ability to succeed and perceived value of the task or outcome.

Pooja (2017) conducted a study on the effect of different teaching methods on academic performance of school children of semi urban area’s schools of Lucknow city. The sample consisted of 60 ninth standard students. Survey method was adopted for the study. The percentage analysis revealed that 93.30 percent have moderate academic performance when adopting various teaching methods.

Rutherford et al. (2017) examined the teachers' valuing of professional development, teachers' self-efficacy, and students' mathematics achievement. Sample consisted of 11,335 elementary school students and 395 mathematics teachers. Results from multilevel structural equation modelling showed that math performance at the student level was predicted both directly and indirectly by earlier achievement (via advancement in spatial temporal mathematics). From the teacher level, students' mathematics performance was predicted by teachers' value for professional development both directly and indirectly (via teachers' self-efficacy beliefs about mathematics).

Bora and Ahmed (2018) analysed the influence of parental engagement on academic success of secondary school students in mathematics. The sample consisted of 460vmale and 440 female students, 449 male and 551 female parents. The study adopted survey method. The result revealed that parental involvement had significant effect on mathematical achievement of secondary school students.

Jayarani (2019) conducted a study on mental alertness, attitude towards mathematics and parental encouragement of higher secondary school students in relation to mathematical achievement. The study adopted normative survey method and the sample consisted of 800 second year higher secondary school students from Nagapattanam. The result showed a significant positive relationship between achievement in mathematics and mental alertness.

Hemavathi (2019) studied various socio- demographic and psychological factor which would affect academics in mathematics. The study adopted survey method. The sample consisted of 1200 secondary school students. The study concluded that gender, locality, management, annual income of the family, age, teacher characteristics, library facility, lab facility, students interest, achievement motivation, intelligence, personally, self-concept all contributed significantly to achievement in mathematics of secondary school students.

Farooqi and Khan (2020) conducted a study to analyse the influence of teaching methods on student academic achievement based on gender. The sample consisted of 150 students from the education department with random selection. The study adopted survey method. The tools used for data collection was the teaching method identification survey. The result revealed that the lecture method is often used as the main selection method by teachers, discussion method is second, and the reading of books is the third. The impact of 18.20 percent was explained by teaching methods. Female students had better grades in reading books, discussion, demonstrations, lecture methods and activities than male students.

Perera and John (2020) studied the connections between instructors' job satisfaction and mathematics achievement of their students. Sample for the study consisted of 1430 teachers. The findings revealed that teacher self-efficacy for teaching mathematics was observed to positively correlate with the class average of mathematical achievement, showing that classes taught by teachers with greater self-efficacy beliefs tended to have higher average mathematical achievement.

Milan and Somashekar (2021) analysed problem solving ability in mathematics, aptitude in mathematics and internet in mathematics as the predictor variable of achievement in mathematics. The sample of the study consisted of 688 secondary school students of Karnataka state. The research design of the study was descriptive as well as correlative. The result of the study indicated that the variables had very low positive correlation, but the variables were all the predictor of achievement in mathematics.

Sushil (2021) conducted a study to find the correlation between mathematics achievement and learning styles of high school students. The sample consisted of 1200 high school students in Surguja district. The study adopted descriptive research design. The result revealed that there was moderate effect of learning styles on mathematics achievement of high school students.

Appiash et al. (2021) conducted a study to analyse whether teacher-student relationships, student self-efficacy, and student perception affect mathematics achievement. The sample consisted of 400 students from senior high schools in the Ashani region. The study adopted survey method and the tool used for data collection was a structured questionnaire. Statistical analysis of the collected data was done using a structural equation model. The result indicated that the impact of teacher-student relationships on mathematics achievement was minimal, whereas student self-efficacy and perception had a positive influence on mathematics achievement.

Sert (2021) analysed the connection between students' levels of math self-efficacy sources and their math achievement. The sample selected for the study was 644 students from private and state schools studying in 9^{th}, 10^{th} and 11^{th} grade. Result revealed that a significant positive correlation between students' math achievement and their mastery experience (r = .74, p < .001) vicarious experience (r = .61, p < .001), social persuasion (r = 044, p < .001) and psychological tests (r =.50, p < .001). Additionally, gender differences and school types were analysed using independent sample t- tests in relation to students' math achievement. Result showed a significant difference between female (M = 84.76, SD = 13.45) and male (M = 77.68, SD = 18.14) students, favouring female students in math achievement with a medium effect size. Also, there was a significant mean difference between private and state schools, with a small effect size favouring math achievement among private school students.

Maamin et al. (2022) analysed the influence of student engagement and mathematical achievement. The sample consisted of 1000 secondary school students and questionnaires were used to collect data on student engagement and mathematics achievement. The results revealed that there was a significant connection between cognitive engagement, affective engagement, and behavioural engagement. Multiple linear regression analysis showed that affective engagement (β = 0.74, p < .001), followed by behavioural engagement (β = 0.58, p < .001), and cognitive engagement (β = -0.37, p < .01) contributed to mathematical achievement of students.

Venkatarao and Rao (2022) conducted a study to evaluate the math skills of 10^{th} grade students in Srikakulam district, Andhra Pradesh, on a group of 1000 students randomly selected from both rural and urban secondary schools. Results showed significant variations in the academic performance of 10^{th} grade students in math based on gender, school location, and school management type. Students in rural schools performed lower than those in urban schools, and students in government schools scored lower than those in private schools.

Tao (2022) conducted a study to find out the function of student engagement and explore the link between academic achievement and students' perception of teacher support. The result revealed a medium correlation (r = 0.16) between teacher support and students' achievement with the moderators grade level, teacher support, and academic achievement measures. The strongest influence on achievement among upper secondary students was found to be perceived teacher support, which also had a greater effect on course grades than result on standardized tests.

Kihwele and Mkomwa (2023) analysed the impacts of King and Queen of Mathematics Initiative (KQMI) on students interest in learning mathematics and academic performance. The sample consisted of 579 secondary school students, 77 grade three students and two teachers and the research design was case study design with mixed- method approach. Data collection method included documentary review, observation, and interviews. The result of the study indicated that KQMI significantly improved students' performance in mathematics ($t_{71} = 7.97$, $p < .05$).

Summary of the empirical studies related to Achievement in Mathematics are presented in Table 2.

Table 2

Summary of Empirical Studies on Achievement in Mathematics

Sl. No.	Author (s)	Year	Findings
1.	Fennema and Sherman	1977	Significant difference in mathematics achievement between female and male students.
2.	Hoang	2007	Students' mathematics performance improved when teachers frequently demonstrated how to solve mathematical problems during math lessons.
3.	Ghazvinia and Khajehpour	2011	Girls were scoring good marks in literature and boys were performing better in mathematics and girls had a more adaptive approach to learning tasks.

Sl. No.	Author (s)	Year	Findings
4.	Sethi	2012	The students having high levels of creativity had higher mean scores in achievement compared to those with lower creativity. Additionally, students from private schools showed higher creativity compared to students from government schools.
5.	Voss et al.	2013	Student teachers teaching practices, mathematics instructors' views were an indirect predictor of their students' learning outcomes while transmissive beliefs were found to be negative predictors of both outcomes
6.	Linnenbrink - Garcia and Patall	2016	Students' expectancy and value beliefs were positively related to their mathematics achievement, and that the relationship was mediated by their use of self regulated learning strategies. Individuals' motivation and achievement related choices were influenced by both expectancy and value beliefs, and that interventions targeting these beliefs can improve students' academic performance
7.	You et al.	2016	Teachers' motivational behaviours did not directly predict math achievement, but they were affected by students' intrinsic motivation and mathematics self-efficacy. Individuals' motivation and achievement related choices are influenced by their beliefs about their ability to succeed and perceived value of the task or outcome.

Sl. No.	Author (s)	Year	Findings
8.	Pooja	2017	The percentage analysis revealed that 93.30 percent have moderate academic performance when adopting various teaching methods.
9.	Rutherford et al.	2017	Math performance at the student level was predicted both directly and indirectly by earlier achievement (via advancement in spatial temporal mathematics)
10.	Bora and Ahmed	2018	Parental involvement had significant effect on mathematical achievement of secondary school students.
11.	Hemavathi	2019	Gender, locality, management, annual income of the family, age, teacher characteristics, library facility, lab facility, students interest, achievement motivation, intelligence, personally, self-concept all contributed significantly to achievement in mathematics of secondary school students.
12.	Jayarani	2019	significant positive relationship between achievement in mathematics and mental alertness
13.	Farooqi and Khan	2020	Lecture method is often used as the main selection method by teachers, discussion method is second, and the reading of books is the third. Female students had better grades in reading books, discussion, demonstrations, lecture methods and activities than male students.

Sl. No.	Author (s)	Year	Findings
14.	Perera and John	2020	Teacher self-efficacy for teaching mathematics was observed to positively correlate with the class average of mathematical achievement, showing that classes taught by teachers with greater self-efficacy beliefs tended to have higher average mathematical achievement.
15.	Appiash et al.	2021	The impact of teacher- student relationships on mathematics achievement was minimal, whereas student self-efficacy and perception had a positive influence on mathematics achievement.
16.	Milan and Somashekar	2021	Problem solving ability in mathematics, aptitude in mathematics and interest in mathematics had very low positive correlation, but the variables were all the predictor of achievement in mathematics.
17.	Sert	2021	Significant positive correlation between students' math achievement and their mastery experience vicarious experience ,social persuasion and psychological tests. Significant difference between female and male students, favouring female students in math achievement with a medium effect size. Significant mean difference between private and state schools, with a small effect size favouring math achievement among private school students.

Sl. No.	Author (s)	Year	Findings
18.	Sushil	2021	There was moderate effect of learning styles on mathematics achievement of high school students.
19.	Maamin et al.	2022	Significant connection between cognitive engagement, affective engagement, and behavioural engagement. Affective engagement followed by behavioural engagement and cognitive engagement contributed to mathematical achievement of students.
20.	Tao	2022	The strongest influence on achievement among upper secondary students was found to be perceived teacher support, which also had a greater effect on course grades than result on standardized tests
21.	Venkatarao and Rao	2022	Significant variations in the academic performance of 10th grade students in math based on gender, school location, and school management type. Students in rural schools performed lower than those in urban schools, and students in government schools scored lower than those in private schools.
22.	Kihwele and Mkomwa	2023	KQMI significantly improved students' performance in mathematics

Related Studies on Logical Reasoning

Handley et al. (2004) analyzed the connection between teacher-reported numeracy levels, a standardized mathematics measure, and reasoning skills in a limited group of 10 to 11-year-old children (*N*=32). Students were presented relational and conditional reasoning problems in which they adjusted the believability of the conclusions. Various indexes related to logic and believability of the problems showed strong correlations with numeracy skills. However, it remains unclear whether reasoning performance is linked to specific numeracy skills.

Terezinhanunes et al. (2007) analysed the role of logical thinking in elementary school students' learning of maths. The study adopted longitudinal research. Sample for the study consisted of 127 elementary school students. The results indicated that working memory and logical ability in six year old children predicted mathematical achievement 16 months later. However, working memory scores did not predict the same measure after controls for difference in logical ability, whereas logical scores did.

Morsanyi et al. (2013) explored the relationship between mathematical achievement and the ability to engage in analytical reasoning of system 2 type. There were a total of 43 children involved in the study, with 13 in the DD group (seven girls; average age of 10 years and 3 months), 16 in the control group (nine girls; average age of 10 years and 5 months), and 14 in the high maths ability group (four girls; average age of 10 years and 3 months). The distribution of girls and boys in each group was similar, as confirmed by a chi-square test (p = .26). The study compared children with developmental dyscalculia to typically developing children and those with exceptional mathematical abilities. The results indicated significant differences among the three groups. It is worth noting that the assessment of reasoning performance, which involved transitive inferences using believable and unbelievable premises and conclusions, was based on quantitative relationships. Therefore, it is understandable that children with developmental dyscalculia encountered challenges with reasoning performance.

Gomez- Chacon et al. (2014) examined the role of reasoning ability in mathematical performance of secondary school students. The study was carried out on a sample of 660 secondary school students. The tool used for cognitive reflection was cognitive reflection test and reasoning performance battery. The result of the study revealed that high cognitive reflection and overall reasoning performance were correlated with high mathematics performance, as measured by mathematics scores at the end of a secondary school mathematics course.

Frosch and Simms (2015) explored how reasoning ability influences mathematical achievement. The sample consisted of 68 undergraduate students who were subjected to fluency and calculation measures to assess mathematical ability, as well as the extended cognitive reflection test and a belief bias conditional reasoning task to gauge reasoning ability. The findings of the study revealed that performance on the cognitive reflection test predicted mathematical ability (β = .428, t = 4.08, p <.001), while conditional reasoning performance didn't have significant impact (β = 0246, t = 2.28, p = .026).

Sherafath (2015) conducted a study to analyse the relationship between critical thinking ability and the relevant element; reasoning ability and logical concluding ability and academic achievement. The sample of the study consisted of 625 high school students. Stratified random sampling method used for the study. The result showed a significant positive correlation between critical thinking ability, reasoning ability, and logical concluding ability.

Agah and Lamido (2015) analysed the determinants of logical reasoning and mathematics achievement. The sample consisted of 420 senior secondary school students of Nigeria. The research design used to conduct the study was ex-post-facto research design. The instrument used for the study was Mathematical Reasoning test. The result revealed that age, and class levels were the determinants of logical reasoning in mathematics of senior secondary school students

Noor et al. (2017) conducted a study to find the relationship between emotional intelligence, motivation and logical reasoning of secondary school students and used stratified random sampling procedure. The instruments used to collect data were Emotional Intelligence Self- Assessment, Students Work Preference Inventory Group Assessment of logical Thinking and academic achievement of students on PT3 results. Results indicated a significant difference in overall mean of logical thinking and academic achievement of secondary school students.

Kumar (2017) analysed the relationship between academic achievement and logical reasoning of high school students. The study adopted survey method and simple random technique. The sample consisted of randomly selected 100 high school students. The data was collected by using Logical Test Inventory. The result indicated a positive relationship between academic achievement and logical reasoning.

Nurismawati et al., (2018) conducted a study to find the relationship between students' critical thinking skill. The sample of the study consisted of 168 students from eighth grade students in Tasikmalaya City. Science Virtual Test and Test of Logical Thinking were used to collect data. The result concluded a positive and weak correlation between students' critical thinking and students' logical reasoning.

Jawad et al. (2019) conducted a study to examine the effect of logical thinking skill on the achievement of fifth grade biology students. The sample consisted of 82 fifth grade female students. The result indicated that logical thinking skill had a positive impact on enhancing achievement of the 5th grade biology students and it played a role in making students the centre of the communication process by their active participation in educational settings and increased students' self-confidence and encouraged them to persevere to raise their scientific level.

Anwar et al. (2020) conducted a study to analyse the effect of problem based learning model application reviewed from mathematical reasoning ability of grade eight. The sample consisted of 68 eighth grade students and conducted pre-test and post-test research design. The result concluded that there was a significant effect of problem based learning model application on mathematical reasoning ability of eighth grade students.

Reddy (2020) conducted a study on achievement in mathematics with reference to general intelligence, logical reasoning and problem solving ability as determinants. The sample consisted of 540 ninth standard students in Kanchipuram region. The result of the study revealed that general intelligence, logical reasoning and problem solving ability were determined factors of achievement in mathematics.

Can (2020) analysed the role of reading comprehension in relation between logical reasoning and word problem solving. The sample of the study consisted of 158 fourth grade primary school students. The instruments used to collect data were logical reasoning test, syllogistic reasoning test, and reading comprehension tests and word problems. The statistical technique used for the study was regression analysis.

Result revealed that reading comprehension had a partial mediating role in relationship between logical reasoning and word problem solving, a positive correlation between word problem solving and logical reasoning skills. The result concluded that reading comprehension developed logical and mathematical thinking.

Verma and Dubey (2020) tested the relationship between the impact of influence on the emotional state of adolescents and the performance of logical reasoning tasks. The sample consisted of 60 adolescents from school and colleges. The instruments used for the study were Positive and Negative Affect Scale (PANAS) and logical teasing task. The result revealed that the current mood state did not play any role in performance on the logical reasoning task.

Ramganesh and Reddy (2021) conducted a study to determine the degree to which 9th standard students' logical thinking serves as a predictor of their academic achievement in mathematics and to identify the significant relationship between logical reasoning and academic performance in mathematics. The study adopted a descriptive method with survey design. Through stratified random selection technique, 540 students of 9th standard were selected as the sample. The tool used for testing logical reasoning was a Logical Reasoning Questionnaire. The result showed a substantial association between logical reasoning and academic performance in mathematics, and that 67.80 percent of variations may be attributed to students' logical reasoning on academic performance of students in mathematics.

Shuib et al. (2021) conducted a study to find the effect of logical thinking on students' higher order thinking skills. The study adopted qualitative survey method and the sampling technique was random cluster sampling. The sample consisted of

388 participants out of the 18137 population. The result revealed that logical thinking had a significant effect on higher order thinking skills

Fathima et al. (2021) analysed the effect of play-based learning on developing logical reasoning in early childhood education in Islamabad. The study adopted quasi-experimental, pre-test and post-test research design. The sample consisted of 80 students from Headstart School located in Islamabad. The result concluded a relationship between experimental and control conditions for logical development by using play-based learning.

Khan and Rana (2021) analysed the influence of higher order thinking instructional model on 8th grade students' scientific reasoning. The study adopted quasi-experimental non-equivalent research group design. The sample consisted of 62 eighth grade students from public higher secondary school of Lahore, Pakistan. The instruments used for the study was Lawson's Classroom Test for Scientific Reasoning and the lesson plans based on higher order thinking instructional model. Result revealed that higher order thinking instructional model influenced the scientific reasoning of eighth grade students.

Latha and Vijaya (2022) examined the relationship between reasoning ability and learning style. The sample included 200 higher secondary students. The instruments used to collect data were two standardised reasoning ability tests, and Learning Style Scale. The result indicated a significant relationship between the reasoning ability and learning style of higher secondary school students, a significant difference in reasoning ability and learning style with respect to gender, and no significant difference between the Tamil medium and English medium students.

Summary of the empirical studies related to Logical Reasoning are presented in Table 3.

Table 3

Summary of Empirical Studies on Logical Reasoning

Sl. No.	Author (s)	Year	Findings
1	Handley et al.	2004	Various indexes related to logic and believability of the problems showed strong correlations with numeracy skills
2	Terezinhanunes et al.	2007	Working memory and logical ability in six year old children predicted mathematical achievement 16 months later.
3	Morsanyi et al.	2013	Children with developmental dyscalculia encountered challenges with reasoning performance.
4	Gomez- Chacon et al.	2014	High cognitive reflection and overall reasoning performance were correlated with high mathematics performance, as measured by mathematics scores at the end of a secondary school mathematics course.
5	Agah and Lamido	2015	Age, and class levels were the determinants of logical reasoning in mathematics of senior secondary school students
6	Frosch and Simms	2015	Performance on the cognitive reflection test predicted mathematical ability while conditional reasoning performance didn't have significant impact

Sl. No.	Author (s)	Year	Findings
7	Sherafath	2015	A significant positive correlation between critical thinking ability, reasoning ability, and logical concluding ability.
8	Kumar	2017	A positive relationship between academic achievement and logical reasoning.
9	Noor et al.	2017	A significant differences in overall mean of logical thinking and academic achievement of secondary school students
10	Nurismawati et al.	2018	A positive and weak correlation between students' critical thinking and students' logical reasoning.
11	Anwar	2019	There was a significant effect of problem based learning model application on mathematical reasoning ability of eight grade students.
12	Jawad	2019	Logical thinking skill had a positive impact on enhancing achievement of the 5^{th} grade biology students and it played a role in making students the centre of the communication process by their active participation in educational setting and increased students self-confidence and couraged them to persevere to raise their scientific level.
13	Can	2020	Reading comprehension developed logical and mathematical thinking.
14	Reddy	2020	General intelligence, logical reasoning and problem solving ability were determined factors of achievement in mathematics.

Sl. No.	Author (s)	Year	Findings
15	Verma and Dubey	2020	The current mood state did not play any role in performance on the logical reasoning task.
16	Fathima et al.	2021	Play-based learning was effective in development of logical reasoning.
17	Khan and Rana	2021	Higher order thinking instructional model influenced the scientific reasoning of eight grade students.
18	Ramganesh and Reddy	2021	a substantial association between logical reasoning and academic performance in mathematics was found, and that 67.80 percent of variations may be attributed to students' logical reasoning on academic performance of students in mathematics.
19	Shuib et al.,	2021	Logical thinking had a significant effect on higher order thinking skills
20	Latha and Vijaya	2022	A significant difference in reasoning ability and learning style with respect to gender, and no significant difference between the Tamil medium and English medium students.

Related Studies on Mathematics Anxiety

Pancholi (2001) analyzed the relationship between student characteristics such as anxiety, reading prowess, personality, and sexual orientation and mathematical conceptual understanding. A reading proficiency exam was given to the initial for a sample of 780 sixth-grade students at the school who were chosen at random from the Mehsana and Patan districts. Finally, 160 students took the mathematics conceptual comprehension test. The results indicated a substantial difference in the conceptual understanding scores of students who reported high and low levels of anxiety as well as significantly improved mathematical conceptual comprehension test scores who had anxiety.

Comparative study among boys and girls conducted by Bhansali and Trivedi (2008) of s students in 16-18 years to know the academic anxiety prevailing amongst them. In the selection of the sample, incidental purposive sampling technique was used. A total sample consisted of 240 adolescents, 120 boys and 120 girls from different high schools of Jodhpur city were selected. The results of this study revealed that a considerable amount of academic anxiety prevailed amongst the students, girls on the whole had more academic anxiety in comparison to boys.

Olatunde (2009) conducted a study on mathematics anxiety and academic achievement among senior secondary schools in South western Nigeria. The sample consisted of 1750 senior secondary school students. The study adopted descriptive survey design and simple percentage is used to analyze data. The result revealed that some of the students were afraid of mathematics, because of the fear of the subject and fear of failing tests. The study also indicated that the majority of the students do not know how to study for the mathematics test.

Moore (2010) conducted a study on gender and the differential effects of active and passive perfectionism on mathematics anxiety and writing anxiety. The sample consisted of 307 students. The result revealed that girls had higher mathematics anxiety than boys.

Rana and Mahmood (2010) examined the relationship between test anxiety and academic achievement of students studying at post graduate level. From seven different science departments a sample of 414 students was randomly selected. Data collected by using the Test Anxiety Inventory. Correlational analysis indicated a significant negative relationship exists between test anxiety scores and students' achievement scores.

Vitasari et al. (2010) explored the relationship between study anxiety level and students' academic performance. Sample consisted of a total 205 male and female students of second year of engineering from University Malaysia, Pahang participated. State Trait Anxiety Inventory (STAI) was used to study the level of anxiety. Students' academic performance was measured by using Grade Point Average. The results indicated that there was a significant correlation of high level anxiety and low academic performance among students, with significant correlation (p= .000) and the correlation coefficient is small with r =-.264.

Yousefi et al. (2010) analyzed the relationship between test-anxiety and academic achievement among Iranian adolescents. The sample used for the study consisted of 400 students (200 boys and 200 girls) in the age range of 15-19 years old that were randomly selected from nine high schools in Sanandaj, Iran. A self administered questionnaire was used for data collection which includes a Test-Anxiety Inventory (TAI), Grade Point Average (GPA) score and personal information. Results showed that there was a significant correlation (r = - .23, p = .000) between test anxiety and academic achievement among adolescents.

Nejad et al. (2011) investigated the relationship between test anxiety and academic performance of medical students of Iranian university. The questionnaire on anxiety was administered to 150 students (80 female and 70 male). Analysis of the study revealed that test anxiety has a negative effect on participants' academic performance of the students. Final test and the grade point average (GPA) of the last semester at the time of research was identified for data analysis. There was a negative correlation between test anxiety and academic performance (GPA). However, there was a positive correlation between age and test anxiety.

Mokashi et al. (2012) assessed the gender differences on anxiety and academic achievement. The study was conducted on a purposively selected sample of 330 residential children from VIII, IX and X standards. Anxiety was measured by using Cattel’s Anxiety Scale and to assess academic achievement marks obtained in the previous final examination. Findings of this study revealed that the anxiety of residential students was high and their academic achievement was found to be high. Boys were significantly having higher anxiety and low academic achievement while girls were higher in academic achievement and low anxiety.

Jain (2012) studied the relationship among academic anxiety, intelligence and academic achievement. Academic Anxiety Scale for Children (AASC) and Reading Comprehension Test were used for collecting data. By using a non-probability sampling technique the sample of 128 students (91 boys and 37 girls) of class VIII were selected. The sample of the study was taken from the four schools, following NCERT syllabus. Results of the study revealed that academic anxiety is negligibly negatively correlated with academic achievement. There was no significant relationship among academic anxiety, intelligence and academic achievement. Hence there was no significant difference between academic anxiety of boys and girls studying in VIII grade

Mohammadyari (2012) conducted a comparative study of the relationship between general perceived self-efficacy and test anxiety with academic achievement of male and female students. In this study, 350 students (175 males' and175 females) were selected by random sampling method. The results showed that there was a negative significant relationship between test anxiety and students' academic achievement. The results of regression analysis showed that in academic achievement of female students, test anxiety had a significant predictive. Regression analysis showed that only test anxiety had a significant negative effect on academic achievement among the female students.

Kumar (2013) analyzed the relationship between academic anxiety and academic achievement of secondary school students in relation to gender difference. The sample of the study consisted of 200 secondary school students of Mandi district of Himachal Pradesh. Lottery method was used for collection of the data. Academic Anxiety Scale for Children (AASC) was used as the tool of data collection, and marks of class 9th students were taken as academic achievement. The findings of the study revealed that there is a significant difference in academic anxiety and academic achievement of male and female secondary school students. Girls found to be more academically anxious and had better academic achievement than boys.

A study was conducted by Nandini (2013) with the objective to know the relationship between academic anxiety and academic achievement of secondary school students. Sample of the study consisted of 300 secondary schools of Banglore city. Results of the study revealed a significant negative relationship between academic achievement and academic anxiety and boys were more anxious than girls.

Shamsuddin et al., (2013) assessed the prevalence of depression, anxiety and stress, and identified their correlates among university students. Sample of this study consisted of 506 students between the ages of 18 and 24 from four public universities in Malaysia. A cross-sectional study was conducted to achieve the objective. After analysis it was found that among all students, 34 percent had moderate, and 29 percent had severe or extremely severe anxiety. Anxiety scores were significantly higher among older students (20 and above) and those born in rural areas.

Akinsola and Nwajei (2013) explored the relationship between test anxiety, depression, and academic performance. Study was carried out on a sample of 420 senior secondary school students. The instruments used for data collection were state-trait anxiety inventory, Test anxiety Inventory, Symptoms distress checklist and mathematics test. The results showed that test anxiety, trait anxiety and depression coexisted and were positively correlated, and negatively correlated with academic achievement.

Aparnath (2014) assessed the difference between religion and gender, regarding academic anxiety. Sample consisted of 120 school children were chosen from different schools at Kapadwanj town, Gujarat. Academic Anxiety Scale for children (AASC Scale) was used to collect data. The result showed that there was no significant difference between the academic anxiety of muslim boys and girls and hindu girls and muslim girls. Results also indicated that there was more academic anxiety among hindu girls than hindu boys and more academic anxiety in muslim boys than hindu boys.

Banga (2014) assessed the influence of academic anxiety on academic achievement. Data was collected from 200 secondary students by using a lottery method of random sampling. The tool used for the study was Academic Anxiety Scale for Children (AASC) and their marks of class 9th were taken as the measure of academic achievement. The findings indicated that there exist significant differences in academic anxiety and academic achievement of male and female secondary school students. Girls were more academically anxious and had better academic achievement than boys. This study also showed that there was no difference in the means of academic anxiety of students belonging to nuclear and joint families but students coming from joint families have slightly higher mean than their counterparts belonging to nuclear families.

Bihari (2014) studied the academic anxiety of secondary school students of North East Delhi. The sample of the study consisted of 114 secondary school students from four government and two private schools. Simple random technique was used for data collection. Academic anxiety of the students was assessed using Academic Anxiety Scale for Children (AASC). The statistical techniques used to analyse data were descriptive and inferential statistics. The result of the study revealed that no significant differences were found between the mean scores of secondary school boys and girls and rural and urban students on their academic anxiety while government and private secondary school students significantly differ in their mean scores of their academic anxiety.

Das et al. (2014) analyzed the academic anxiety and academic achievement of secondary level school students. A sample of 237 (128 boys and 109 girls) of secondary level students of class VIII were selected randomly. The tool used to test academic anxiety was "Academic Anxiety Scale for Children (AASC-SG)". The result showed that girl students had more academic anxiety than boys. It was also found that there was a negative and significant correlation (r = -0.10) between academic anxiety and academic achievement. It also indicated that academic anxiety and academic achievement was negatively correlated. The correlation was very low which indicates that the negative correlation is not statistically significant.

Mishra and Chincholikar (2014) explored the relationship of academic achievement with teaching aptitude, attitude and anxiety in M.Ed. students. The sample of the study consisted of 296 M.Ed. students from the department and colleges of Education affiliated to Dr. Babasaheb Ambedkar Marathwada University, Aurangabad. Linear regression analysis revealed that anxiety had a negative relationship to academic achievement.

Parvez and Shakir (2014) conducted the study to know the relationship and effects of academic anxiety on the academic achievement of students. Sample consisting of 352 students of senior secondary school was taken through purposive sampling technique. Standardized Anxiety Scale was used to collect the data. Research findings revealed an inverse relationship or negative correlation between the academic achievement and the academic anxiety of students. A significant difference was found in the academic achievement of high and low academic anxiety groups of senior secondary school students. No significant difference was found in the academic achievement of high and low academic anxiety groups of science students. But a significant difference was found in the academic achievement of high and low academic anxiety groups of social science students. Results also indicated no significant difference was found in the academic achievement of high academic anxiety groups of science and social science students and also no significant difference was found in the academic achievement of low academic anxiety groups of science and social science students.

Siddiqui and Rehman (2014) assessed the level of academic anxiety among secondary school students. A comparison between the level of academic anxiety and gender (male- female) was also done. For the sample of the study 222 secondary school students of Aligarh district have been selected. Academic Anxiety Scale for Children was used as a tool for data collection. The result of the study inferred that a significant difference exists between male and female students in regard to academic anxiety and female students were found more anxious than male students of secondary school.

Syokwaa et al., (2014) investigated the relationship between anxiety levels and academic achievement among students in some selected secondary schools in Langata district, Kenya. The design used for the study was ex-post facto design and the sample of the study consisted of 180 students (90 boys and 90 girls) of secondary school. To assess anxiety, personality anxiety self-examination quiz and an anxiety test examination were administered to students. The study revealed that anxiety levels and academic achievement were correlated, high anxiety levels had a negative impact on the quality of academic achievement of students. The study also found that students faced some high anxiety affect their ability to perform effectively.

Zirk-Sadowski et al. (2014) examined gender differences in mathematics mediated by independent control or uncontrollability on a sample of 200 secondary school students of Mandi district of Himachal Pradesh by adopting lottery method of random sampling. The tools used for the study were ‘Academic Anxiety Scale for Children (AASC) and their marks of class 9th were taken as academic achievement. The findings showed that test anxiety strongly impacted academic performance among students. Also, students demonstrating heightened anxiety got lower grades as opposed to superior scores of those experiencing reduced anxiety.

Finlayson (2014) analysed the approaches used by pre- service educators to overcome math anxiety. The sample consisted of 70 teachers. The result of the study revealed that the causes of mathematics anxiety are deficiency of self confidence, instruction practices, anxiety of failure, non-engagement of learners, and futile learning practices.

Banga (2016) carried out a study to find out the levels of anxiety among 400 senior secondary boys and girls of Himachal Pradesh. The study revealed that there existed a significant difference in the levels of anxiety between boys and girls, and girls were more prone to anxiety than that of boys.

Hasan (2016) studied the academic anxiety of male and female secondary school students in relation to their academic achievement. Sample of the study consisted of 204 secondary school students of Aligarh district. The study revealed that there existed a significant difference in the levels of anxiety between boys and girls, and girls were more prone to anxiety than that of boys.

Khemka and Rathod (2016) assessed the academic anxiety of secondary school students. Purposive sampling technique was used for selecting the school and students were selected by stratified random sampling technique. The total sample was 400 students. The research method used for the study was a survey method. Results of percentage analysis indicated that 18.50 percent of students had low academic anxiety, 75 percent of students had average academic anxiety and about 6.50 percent of students had high academic anxiety. Female students were more academically anxious than male students. Boys of government schools had more academic anxiety than boys of private schools. Girls of private schools had more academic anxiety than girls of government schools.

Yusuph (2016) investigated the causes and effect of anxiety on the academic performance of secondary students of Domodo, Tanzania. The sample of the study consisted of 62 secondary school students. The study adopted survey method and simple random sampling was used. The instruments used to collect data were questionnaires. Results revealed that the major cause of anxiety among students was corporal punishment followed by school milieu and potentials (capabilities) of the students, and a significant number of the students are affected by it. Moreover, there was an inverse relationship between anxiety and academic performance. Results also indicated that the girls were more prone to anxiety as compared to boys.

Alam (2017) conducted a study on the relationship between academic anxiety and academic achievement among school students in Murshidabad District. The sample consisted of 200 secondary and senior secondary school students. The Academic Anxiety Scale for Children was used to collect data. Results of the study revealed that academic anxiety and academic achievement are negatively related; high and low levels of academic anxiety decrease the level of academic achievement. Results also indicated that moderate academic anxiety is good for the academic achievement of secondary school students.

Islam and Razzak (2017) conducted an exploratory study of academic anxiety of secondary school students in relation to their intelligence and gender on a sample of 100 secondary school students, studying in Aligarh Muslim University. The results of the study revealed that there was no significant difference in the level of academic anxiety with regard to gender.

Azeem (2018) conducted a study to analyse the relationship between academic anxiety and academic achievement among secondary school students. The sample of the study consisted of 340 secondary school students from various schools of Aligarh. The instruments used to collect data were Academic Anxiety Scale and achievement test to collect CGP of students. The result of the study revealed a significant and negative relationship between academic anxiety and academic achievement among secondary school students.

Chanchal et al., (2021) conducted a study to test the relationship between academic anxiety and academic achievement. The sample of the study consisted of 50 secondary school students from various schools of Noida. The study adopted survey method. The result revealed a significant and negative relationship between academic anxiety and academic achievement.

Niaei et al., (2021) conducted a study to find out the effectiveness of flipped teaching on math anxiety and maths performance in fifth grade students. The sample of the study consisted of 56 fifth grade female students in Maranad City. The study adopted pretest post-test experimental research design. The instruments used for the study were Mathematical Anxiety Scale to evaluate the performance of mathematics course. The result of the study revealed that flipped classrooms increased the motivation of teachers and made classrooms more attractive and communicative. The result also concluded that students' self-confidence increased as a result such students would have less anxiety compared to students who learn math in traditional way.

Tsegaw et al., (2021) successful teacher pedagogic practices for reducing mathematics anxiety and improving student outcomes in secondary school students in Ethiopia. The sample consisted of 514 teachers and 17274 secondary school students. The study adopted purposive sampling technique. The instruments used for the study were questionnaire for mathematics teachers and questionnaire for students. The result of the study revealed that teaching structure reduced mathematics anxiety among secondary school students.

Yaftin and Barghamadi (2022) conducted a study to analyse the effect of teaching using multimedia system on students motivation and anxiety in mathematics. The study adopted quasi- experimental pretest posttest research design. The sample of the study consisted of 57 seventh grade students. The instruments used for the study were Mathematics Anxiety Questionnaire and the study of internal research Questionnaires. The statistical technique used for the study were descriptive statistics and MANCOVA. The result of the study revealed that multimedia systems had enhanced motivation and reduced anxiety in mathematics of students.

Agarwal and Suvidha (2022) analysed the academic anxiety among teenage girls. The sample included 200 girls in 12^{th} grade commerce stream. The study adopted survey method and the instrument used to collect data was Academic Anxiety Scale. The result of the study revealed a significant difference in the degree of anxiety between arts and commerce students.

Das and Kumar (2022) conducted a study to find the correlation between academic anxiety and academic achievement. The sample of the study consisted of 241 senior secondary school students from various schools of Purulia district of West Bengal. The study adopted descriptive survey method. The instruments used to collect data were Academic Anxiety Scale and the previous year's academic record. The result revealed that male students had significantly higher academic achievement than female students and female students have significantly higher level of academic anxiety than male students. Study also revealed that there was a negative and significant correlation (r = -0. 224) between academic anxiety and academic achievement of senior secondary school students.

Summary of the empirical studies related to Mathematics Anxiety are presented in Table 4.

Table 4

Summary of Empirical Studies on Mathematics Anxiety

Sl. No.	Author (s)	Year	Findings
1	Pancholi	2001	Substantial difference in the conceptual understanding scores of students who reported high and low levels of anxiety as well as significantly improved mathematical conceptual comprehension test scores who had anxiety.
2	Bhansali and Trivedi	2008	A considerable amount of academic anxiety prevailed amongst the students, girls on the whole had more academic anxiety in comparison to boys.
3	Olatunde	2009	Some of the students were afraid of mathematics, because of the fear of the subject and fear of failing tests. Majority of the students do not know how to study for the mathematics test.
4	Moore	2010	Girls had higher mathematics anxiety than boys.
5	Rana and Mohmood	2010	Significant negative relationship exists between test anxiety scores and students' achievement scores.
6	Vitasari et al.	2010	Significant correlation of high level anxiety and low academic performance among students
7	Yousefi et al.	2010	Significant correlation between test anxiety and academic achievement among adolescents.

Sl. No.	Author (s)	Year	Findings
8	Nejad et al.	2011	Negative correlation between test anxiety and academic performance (GPA). There was a positive correlation between age and test anxiety (p = .05).
9	Mokashi et al.	2012	The anxiety of residential students was high and their academic achievement was found to be high. Boys were significantly having higher anxiety and low academic achievement while girls were higher in academic achievement and low anxiety.
10	Jain	2012	No significant relationship among academic anxiety, intelligence and academic achievement. There was no significant difference between academic anxiety of boys and girls studying in VIII grade
11	Mohammadyari	2012	In the academic achievement of female students, test anxiety had a significant predictive. Only test anxiety has a significant negative effect on academic achievement among the females' students.
12	Kumar	2013	Significant difference in academic anxiety and academic achievement of male and female secondary school students. Girls found to be more academically anxious and had better academic achievement than boys.
13	Nadini	2013	Significant negative relationship between academic achievement and academic anxiety and boys were more anxious than girls.

Sl. No.	Author (s)	Year	Findings
14	Shamsuddin et al.	2013	Anxiety scores were significantly higher among older students (20 and above) and those born in rural areas.
15	Akinsola and Nwajei	2013	Test anxiety, trait anxiety and depression coexisted and were positively correlated, and negatively correlated with academic achievement.
16	Aparnath	2014	No significant difference between the academic anxiety of muslim boys and girls and hindu girls and muslim girls. There was more academic anxiety in hindu girls than hindu boys and more academic anxiety in muslim boys than hindu boys.
17	Banga	2014	Significant differences in academic anxiety and academic achievement of male and female secondary school students. Girls were more academically anxious and had better academic achievement than boys. There was no difference in the means of academic anxiety of students belonging to nuclear and joint families but students coming from joint families have slightly higher mean than their counterparts belonging to nuclear families.
18	Bihari	2014	No significant differences were found between the mean scores of secondary school boys and girls and rural and urban students on their academic anxiety while government and private secondary school students significantly differ in their mean scores of their academic anxiety.

Sl. No.	Author (s)	Year	Findings
19	Das et al.	2014	Girl students had more academic anxiety than boys. It was also found that there is a negative and significant correlation between academic anxiety and academic achievement. It also indicated that academic anxiety and academic achievement is negatively low correlated.
20	Mishra and Chincholikar	2014	Anxiety had a negative relationship to academic achievement.
21	Parvez and Shakir	2014	An inverse relationship or negative correlation between the academic achievement and the academic anxiety of students.
22	Siddiqui and Rehman	2014	Significant difference exists between male and female students in regard to academic anxiety and female students were found more anxious than male students of secondary school.
23	Syokwaa et al.	2014	Anxiety levels and academic achievement were correlated, high anxiety levels had a negative impact on the quality of academic achievement of students. Students faced some high anxiety affect their ability to perform effectively.
24	Zirk-Sadowski et al.	2014	Test anxiety strongly impacted academic performance among students. Students demonstrating heightened anxiety got lower grades as opposed to superior scores of those experiencing reduced anxiety.

Sl. No.	Author (s)	Year	Findings
25	Finlayson	2014	The causes of mathematics anxiety were deficiency of self confidence, instruction practices, anxiety of failure, non-engagement of learners, and futile learning practices.
26	Banga	2016	Significant difference in the levels of anxiety between boys and girls, and girls were more prone to anxiety than that of boys.
27	Hasan	2016	Significant difference in the levels of anxiety between boys and girls, and girls were more prone to anxiety than that of boys.
28	Khemka and Rathod	2016	Percentage analysis indicated that 18.50 percent of students had low academic anxiety, 75 percent of students had average academic anxiety and about 6.50 percent of students had high academic anxiety. Female students were more academically anxious than male students. Boys of government schools had more academic anxiety than boys of private schools. Girls of private schools had more academic anxiety than girls of government schools.
29	Yusuph	2016	The major cause of anxiety among students was corporal punishment followed by school milieu and potentials (capabilities) of the students, and a significant number of the students are affected by it. there was an inverse relationship between anxiety and academic performance. The girls were more prone to anxiety as compared to boys.

Sl. No.	Author (s)	Year	Findings
30	Alam	2017	Academic anxiety and academic achievement are negatively related; high and low levels of academic anxiety decrease the level of academic achievement. Moderate academic anxiety is good for the academic achievement of secondary school students.
31	Islam and Razzak	2017	No significant difference in the level of academic anxiety with regard to gender.
32	Azeem	2018	Significant and negative relationship between academic anxiety and academic achievement among secondary school students.
33	Chanchal	2021	A significant and negative relationship between academic anxiety and academic achievement.
34	Niaei et al.	2021	Flipped classrooms increased the motivation of teachers and made classrooms more attractive and communicative. Students' self-confidence increased as a result such students would have less anxiety compared to students who learn math in traditional way.
35	Tsegaw et al.,	2021	Teaching structure reduced mathematics anxiety among secondary school students.
36	Yaftin and Barghamadi	2022	Multimedia systems had affected students, enhanced motivation and reduced anxiety in mathematics of students.
37	Agarwal and Suvidha	2022	Significant difference in the degree of anxiety between arts and commerce students.

Sl. No.	Author (s)	Year	Findings
38	Das and Kumar	2022	Male students had significantly higher academic achievement than female students and female students had significantly higher level of academic anxiety than male students. There was a negative and significant correlation between academic anxiety and academic achievement of senior secondary school students.

Related Studies on Achievement Motivation

Kishore and Rana (2010) assessed the achievement motivation level among secondary school students on 200 secondary schools students selected by purposive sampling method. The findings of the study indicated a significant difference in achievement motivation levels between urban and rural students.

Awan et al. (2011) examined the relationship between achievement motivation, self concept and achievement in English and mathematics at secondary level. The sample consisted of 336 students where 146 males and 172 females of intact groups of all eight schools enrolled in 9^{th} grade. The tools used for the study were Academic Self – Description Questionnaire II and General Achievement Goal Orientation Scale. Correlation analysis revealed that achievement motivation and self-concept were significantly related to academic achievement.

Payyanatt and Manichander (2012) analyzed the achievement motivation among secondary school students. The sample consisted of 200 students of tenth standard in different schools of Thripunithara sub district. The sampling technique used for the study was purposive sampling and the tool was Deo- Mohan Achievement Motivation Scale. The results revealed that there exists a significant difference in the level of achievement and motivation of students of rural and urban, rural boys and urban boys, rural girls and urban girls.

Emmanuel et al. (2014) investigated achievement motivation, academic self concept and academic achievement among high school students. The study used students' profiles to ascertain the levels of achievement motivation, self- concept and academic achievement. The sample consisted of 120 high school students and the tools used for the study were Inventory of School Motivation (ISM) and the Self Concept Scale. Correlation analysis revealed a positive relationship between achievement motivation and academic achievement, but the correlation was not so significant.

Bansal and Pahwa (2015) examined influence of school related facts and achievement motivation on academic achievement of secondary school students. The sample consisted of 250 ninth standard students from various schools. Results of the study indicated a significant relationship between academic achievement and achievement motivation but no significant relationship was found between academic achievement and school related hardiness. Also revealed a significant interaction between school related hardiness and achievement motivation with regard to academic achievement.

Case study conducted by Sarangi (2015) to investigate the effect of achievement motivation on academic achievement of high school students. The sample consisted of 200 students from tribal and non tribal communities in relation to their sex and locale. Achievement Motivation Scale was used to collect the data. Results of the study indicated that there was no significant difference between tribal - non tribal and boy - girl students as well as urban students have higher achievement motivation than rural students. Results also emphasized that there was no significant relationship between achievement motivation and academic achievement of boys and rural students. Also, there existed a significant relationship between achievement motivation and academic achievement of non-tribal students, girl students, rural and urban students. Thus, achievement motivation enhanced the academic achievement of the students.

Roy (2015) examined the relationship between academic achievement and achievement motivation in a sample of 1000 government school children in classes 5 to 8. Deo-Mohan Achievement Motivation Scale was used to measure Achievement Motivation. Exam results from the school's official records were used to determine each student's academic achievement. Results showed that motivation for achievement was positively correlated with academic success. The majority of the students had average drive for achievement, while a small percentage of them had low or very high motivation. The achievement motivation of the students was unaffected by their gender or location.

The study conducted by Wani and Masih (2015) to assessed the achievement motivation level, difference in achievement motivation among gender and academic streams. It also aimed to calculate the significant differences in achievement motivation among government and private school students of higher secondary level.

The sample consisted of 200 higher secondary school students where 100 boys and 100 girls. Deo-Mohan Achievement Motivation Scale was used to collect the data. Results revealed that 46.50 percent of the sample had an average level of achievement motivation. Girls' achievement motivation score and boys' achievement motivation score were 127.82 and 12.89 respectively and girls are having higher achievement motivation than boys. A significant difference was found in achievement motivation among government and private stream students. The study also revealed that students of government schools had high achievement motivation.

You et al. (2016) examined the impact of students' views of teachers' motivational behaviours on math achievement. Data was collected from a sample of 6,227 middle school students in Korea. The results revealed that teachers' motivational behaviours did not directly predict math achievement, but they were affected by students' intrinsic motivation and mathematics self-efficacy. Individuals' motivation and achievement related choices are influenced by their beliefs about their ability to succeed and perceived value of the task or outcome.

Thaer and Thaer (2016) conducted a study to test the effectiveness of ARCS motivational model on achievement motivation and academic achievement of tenth grade students. The sample consisted of 113 tenth grade students. The instruments used for the study were Motivation Achievement Test(MAT) and Achievement Test (AT). The result showed that there was a significant difference on MAT and AT due to ARCS motivational model.

Mohanty (2016) tested the effectiveness of inquiry training models on the development of motivation and achievement in geography among secondary school students. The sample consisted of 164 high students in the district of Jajpur. The study adopted pretest posttest experimental research design. The tools used for the study were Intelligence Test, Motivation Scale and Achievement Test. The result of the study revealed that inquiry model was effective [t(0.01) = 6.18] for development of motivation and achievement in geography among secondary school students.

Sharma and Sharma (2017) conducted a study to find the difference in achievement motivation between executives and technocrats as well as between men and women. The difference in achievement motivation between 200 CEOs and 200 technocrats was calculated by using the Deo Mohan scale. The results showed that there were significant differences in achievement motivation between executives and technocrats as well as between men and women. Results showed that executives, who are the organization's planners, had higher levels of achievement motivation than technocrats. When it comes to motivation, women demonstrated greater drive to succeed than men.

Kaur and Sankhian (2017) analysed the effect of the activity based method in mathematics on achievement motivation and academic achievement. The sample consisted of 60 ninth standard students studying in a private senior secondary school of Ambala city, Pannab. The study adopted pretest posttest experimental research design. The instruments used to collect data were Deo-Mohan Achievement motivation scale, self prepared modules of five selected topics and Achievement Test. The finding of the study revealed that students taught mathematics through activity based method differ significantly [t(0.01 = 5.39] Academic achievement and achievement motivation of senior secondary school students.

Baloria (2018) assessed the achievement motivation of rural youth and also to find out the gender difference among them. The sample consisted of 100 participants with 50 girls and 50 boys. The Achievement Motivation Scale was used to collect the data. Results of the study indicated that there is a significant difference between the achievement motivation of boys and girls.

The study conducted by Bhatt and Bahadur (2018) analyzed the correlation between self esteem, self efficacy and achievement motivation among college students. The sample consisted of 400 students of private and government colleges of Lucknow. Achievement Motivation Scale was used to collect the data. The result indicated a weak positive correlation between self efficacy and achievement motivation.

Bency (2019) investigated the association of achievement motivation and achievement based on locality, type of management, type of family and monthly income. The sample consisted of 300 higher secondary school students. The findings of the study indicated that there was a significant association in the achievement motivation of higher secondary school students based on locality and there was no significant association in the achievement motivation of higher secondary students based on the type of management, type of family and monthly income.

Chaturvedi (2019) explored the relationship of academic anxiety and achievement motivation with academic achievement of high school students. The sample of the study consisted of 300 high school students studying in tenth standard in five different schools of Bhopal. The tools used to assess the achievement motivation and academic anxiety were Deo- Mohan Achievement Motivation Scale and Academic Anxiety Scale. The result showed that gender plays a significant role in determining motivation and academic achievement and girls showed significantly higher achievement motivation than boys, achievement motivation leads to higher academic achievement. Results also indicated that the achievement motivation was a significant predictor of academic achievement and students who were nervous about mathematics perform poorly on a mathematics question because of mathematics anxiety or because they are not proficient in arithmetic. Results also observed that those who struggle with maths perform well on the first part of the performance assessment. But accuracy and mathematics anxiety had a greater negative correlation on the later and more challenging part of the test.

Veesar and Khaskheli (2019) analysed the effects of teaching strategies on students' motivation in learning mathematics at secondary level. The sample consisted of 100 secondary school students. The study adopted quantitative research design. The result revealed that cooperative learning had positive and significant impact ($r = 0.959$) on students' motivation in learning mathematics at public secondary schools of Khairpur.

Bhatt and Bahadur (2020) explored the gender differences for the psychological variables self efficacy and achievement motivation and differences in the achievement motivation and self efficacy among students. The sample consisted of 400 professional course students and non-professional course students. The tool used for assessing achievement motivation was the Achievement Motivation Scale. Results indicated a weak positive relation between self efficacy level and achievement motivation level and non professional course students had higher self efficacy as well as no difference in achievement motivation among students from professional and non professional course students. According to family structure there was no difference found between self efficacy score and achievement motivation score.

Simbolon et al., (2020) conducted a study to find out the effectiveness of learning models (PQ4R and SQ3R) and achievement motivation for english learning comprehension. The sample consisted of 78 students. The instruments used for the study were test and observation. The result of the study revealed that there was no interaction between PQ4R and SQ3R models and achievement motivation on reading students' understanding of english.

Amir et al., (2020) conducted a study to analyse achievement motivation through role play. The sample of the study consisted of 323 tenth grade students 6 Bandung in the 2019/2020 academic year. The study adopted quasi experimental, non equivalent, pretest posttest research design. The result of the study revealed that role play technique was effective to increase the achievement motivation of high school 6 students.

Villa and Sebastian (2021) examined achievement motivation, locus of control and study habits of freshman students. The sample consisted of 258 freshman students taking non-board examination programmes in mathematics at university in southern Luzon, Philippines. The research design used for the study was descriptive correlational research design and the sampling techniques were purposive sampling techniques. Findings indicated that most of the students had average achievement motivation, internal locus of control, desirable study habits and average mathematics achievement. The result also showed that there was a significant relationship between achievement motivation and mathematics achievement and also it showed that achievement motivation was the only predictor of mathematics achievement it revealed that achievement motivation is effective in enhancing mathematics achievement.

Elsayed and Nasef (2021) conducted a study to identify the effectiveness of mathematics learning programs based on developing both academic achievement motivation level and creative thinking skills in mathematics. The sample consisted of 22 fifth level students Prince Sattam Bin Abdulaziz university students. The study adopted semi experimental method. The instruments used were academic achievement motivation scale, creative thinking mathematics test, and the program based on the mind habits. The result showed that the program had positive effects on developing the academic achievement motivation and creative thinking in mathematics among fifth level students.

Ziden et al., (2022) tested the effectiveness of augmented reality on students' achievement and motivation in learning science. The sample consisted of 50 science students. The study adopted pretest posttest experimental research design. The result revealed augmented reality was effective in enhancing motivation and achievement on science.

Summary of the empirical studies related to Achievement Motivation in Mathematics are presented in Table 5.

Table 5

Summary of Empirical Studies on Achievement Motivation in Mathematics

Sl. No.	Author (s)	Year	Findings
1	Kishore and Rana	2010	Significant difference in achievement motivation levels between urban and rural students.
2	Awan et al.	2011	Achievement motivation and self-concept were significantly related to academic achievement.
3	Payyanatt and Manichander	2012	Significant difference in the level of achievement and motivation of students of rural and urban, rural boys and urban boys, rural girls and urban girls.
4	Emmanuel et al.	2014	Positive relationship between achievement motivation and academic achievement, but the correlation was not so significant.
5	Bansal and Pahwa	2015	Significant relationship between academic achievement and achievement motivation but no significant relationship was found between academic achievement and school related hardiness. Significant interaction between school related hardiness and achievement motivation with regard to academic achievement.
6	Sarangi	2015	No significant relationship between achievement motivation and academic achievement of boys and rural students. Significant relationship between achievement motivation and

Sl. No.	Author (s)	Year	Findings
			academic achievement of non-tribal students, girl students, rural and urban students. Achievement motivation enhanced the academic achievement of the students.
7	Roy	2015	Motivation for achievement was positively correlated with academic success. The majority of the students had average drive for achievement, while a small percentage of them had low or very high motivation. The achievement motivation of the students was unaffected by their gender or location.
8	Wani and Masih	2015	Significant difference was found in achievement motivation among government and private stream students. The study also revealed that students of government schools had high achievement motivation.
9	You et al.	2016	Teachers' motivational behaviours did not directly predict math achievement, but they were affected by students' intrinsic motivation and mathematics self-efficacy. Individuals’ motivation and achievement related choices are influenced by their beliefs about their ability to succeed and perceived value of the task or outcome.
10	Thaer and Thaer	2016	ARCS motivational model was effective in enhancing motivation and achievement.

Sl. No.	Author (s)	Year	Findings
11	Mohanty	2016	Inquiry model was effective for development of motivation and achievement in geography among secondary school students.
12	Sharma and Sharma	2017	Significant differences in achievement motivation between executives and technocrats as well as between men and women. Executives, who are the organization's planners, had higher levels of achievement motivation than technocrats. When it comes to motivation, women demonstrated greater drive to succeed than men.
13	Kaur and Sankhian	2017	Students taught mathematics through Activity based method differ significantly in academic achievement and achievement motivation of senior secondary school students.
14	Baloria	2018	Significant difference between the achievement motivation of boys and girls.
15	Bhatt and Bahadur	2018	Weak positive correlation between self efficacy and achievement motivation.
16	Bency	2019	There was significant association in the achievement motivation of higher secondary school students based on locality and there was no significant association in the achievement motivation of higher secondary students based on the type of management, type of family and monthly income.

Sl. No.	Author (s)	Year	Findings
17	Chaturvedi	2019	Gender plays a significant role in determining motivation and academic achievement and girls showed significantly higher achievement motivation than boys, achievement motivation leads to higher academic achievement. Achievement motivation was a significant predictor of academic achievement and students who were nervous about mathematics perform poorly on a mathematics question because of mathematics anxiety or because they are not proficient in arithmetic. Those who struggle with maths perform well on the first part of the performance assessment. But accuracy and mathematics anxiety had a greater negative correlation on the later and more challenging part of the test.
18	Veesar and Khaskheli	2019	Cooperative learning had positive and significant impact on students motivation in learning mathematics.
19	Bhatt and Bahadur	2020	Weak positive relation between self efficacy level and achievement motivation level and non professional course students had higher self efficacy as well as no difference in achievement motivation among students from professional and non professional course students. According to family structure there was no difference found

Sl. No.	Author (s)	Year	Findings
			between self efficacy score and achievement motivation score.
20	Simbolon et al.	2020	There was no interaction between PQ4R and SQ3R models and achievement motivation on reading students' understanding of english.
21	Amir et al.	2020	Role play technique was effective to increase the achievement motivation of high school students.
22	Villa and Sebastian	2021	Most of the students had average achievement motivation, internal locus of control, desirable study habits and average mathematics achievement. There was a significant relationship between achievement motivation and mathematics achievement. Achievement motivation was the only predictor of mathematics achievement it revealed that achievement motivation is effective in enhancing mathematics achievement.
23	Elsayed and Nasef	2021	Mathematics learning programme had positive effects on developing the academic achievement motivation and creative thinking in mathematics.
24	Ziden et al.	2022	Augment reality is effective in enhancing motivation and achievement in science.

Related Studies on Mathematical Beliefs

Furinghetti and Pehkonen (2000) conducted a comparative study on students' beliefs concerning their autonomy in doing mathematics. The sample included 246 Italian and 260 Finnish seventh graders. Questionnaires on Mathematical Beliefs were used to collect the required information. The results revealed that there are some fundamental similarities between the two nations, particularly when it comes to the problem of classroom interaction and the students' demand for teachers' assistance. The factors pertaining to the utilisation of trial-and-error techniques and the potential for students to solve mathematical problems on their own identified were the most discrepancies between these two nations.

Kloosterman (2002) analyzed beliefs of secondary school students regarding mathematics learning. Interview schedule on Mathematical Beliefs were used to measure personal and environmental beliefs. The study revealed that students' beliefs regarding mathematics had a direct impact on the efforts and their willing to exert in learning the subject. Students who had negative beliefs about mathematics were more likely to withdraw and demonstrate lower levels of motivation to learn.

A critical review conducted by Muis (2004) examined the personal epistemology mathematics beliefs of identified five categories such as beliefs about mathematics, development of beliefs, effect of beliefs on behaviour, domain of differences and chaining beliefs. On examining the studies of beliefs about mathematics revealed consistent patterns of non-availing beliefs at all educational levels and development of beliefs about mathematics were influenced by mathematics instructional environments. Results also revealed that all studies show a significant relationship between cognition, motivation and academic achievement. In addition to that the results also indicated that descriptive studies showed a relationship between beliefs and learning behaviours. The studies examining domain differences found significant variations in beliefs across disciplines and concluded that the studies focussing on chaining beliefs were successful, which was attributed to appropriate changes in instructional style.

Aikins et al. (2005) examined the structure of middle school students' general epistemological beliefs and domain specific mathematical problem solving beliefs. The sample consisted of 1200 seventh and eighth grade students. The tools used for the study were Epistemological Questionnaire, Indiana Mathematical Beliefs Scale and Fennema- Sherman Usefulness scale. The results indicated that the beliefs in quick or fixed learning, and studying aimlessly, studying without strategy were significantly related to beliefs about effortful maths, useful maths, understanding maths concepts and maths confidence. It also suggested that the general and domain specific epistemological beliefs predicted academic performance as measured by solving mathematical problems and overall grade point average.

Philipp (2007) analysed the effects of early field experience on the mathematical content knowledge and beliefs of prospective elementary school teachers. The sample consisted of 159 prospective elementary school teachers. The study adopted experimental method. The result revealed that individuals who studied mathematical thinking while learning mathematics increased more sophisticated beliefs about mathematics, teaching and learning and enhanced their mathematical content knowledge to a greater extent than those who did not. Additionally, the beliefs of those who observed in easily accessible classrooms experienced less transformation compared to the beliefs of participants in control group.

Berkaliev and Kloosterman (2009) explored students' beliefs about mathematics. Sample of 162 first-year students doing calculus were given the Indiana Mathematics Belief Scale to measure the variable. The results of factor analysis revealed that was carried out to look at the factor structure and the factors extracted are effort, usefulness, challenging tasks, comprehension, and steps.

Sangcap (2010) analyzed the mathematics related beliefs of Filipino college students, negative and positive beliefs about mathematics and mathematics problem solving and also analyzed the possible significant differences in mathematics related beliefs in relation to gender, year and field of specification. Sample of the study consisted of 336 college students of Filipino. Study adopted stratified random sampling method. The instrument used to collect data was self report questionnaire. The result revealed that positive beliefs that students valued effort in increasing one's mathematical ability, considered mathematics as a useful subject in their daily life. The study also indicated that all word problems can be solved by simple step by step procedure and they considered word problems to be not important. Gender difference in positive beliefs that effort can increase mathematical ability and in the usefulness of mathematics was significant.

Zakaria and Musiran (2010) investigated the beliefs about the nature of mathematics, mathematics teaching and learning among trainee teachers. The sample consisted of 100 teacher trainees from Malaysia. The tool used for collecting the data is Mathematical Beliefs Questionnaire consisting of three dimensions namely, beliefs about mathematics, beliefs about teaching and beliefs about teaching mathematics. The results of the study revealed that the beliefs of the mathematics trainee teachers were positive towards the constructivism approach, teacher trainees had the belief that mathematical problems can be solved in different ways, and teacher trainees believed that teaching mathematics involved the opportunity to use mathematics in daily life situations, and the need for understanding the concepts to learn mathematics. Result also indicated that there was a significant difference in considering the beliefs about the nature of mathematics and beliefs about learning of mathematics based on gender.

Tarmizia et al., (2010) conducted a study to explore how secondary mathematics teachers humanitize mathematics, focusing on students' perception of their teachers' classroom practices. Study also examines students' beliefs regarding the role and function of mathematics teachers within classroom environment. The sample consisted of 430 secondary school students from Malaysia. The instrument used to collect data was questionnaire related to students' beliefs about mathematics classroom context. The result of the study revealed that the average scores reflecting students' beliefs about their teachers' role and effectiveness in teaching mathematics were favourable, with particularly high ratings for demonstrating step by step methods in problem solving. Additionally, students expressed positive views on their teachers ability to create an enjoyable and engaging learning experience, making mathematics both comprehensible and meaningful while fostering a welcoming atmosphere.

Chouinard et al. (2011) investigated the relations between competence beliefs, achievement goals and utility value in mathematics. The sample consisted of 759 grade seven to eleven students, 389 male and 370 female students. Structural equation modelling technique results indicated that effort in mathematics was expressed by mastery goals and by competence beliefs as well as perception of parental support was associated with the valuing of mathematics and teachers' support strengthened most on competence beliefs.

Polly et al. (2013) examined the relationship between maths students' learning and teachers' beliefs as well as evaluated the beliefs of educators towards maths, maths education, and maths learning. Sample of the study consisted of 35 elementary school teachers and 494 elementary school students of the Southeastern United States. The instruments used for the study were Teachers' Beliefs questionnaire and content Knowledge Teaching Test and unit assessment. Results showed that the outcomes of student learning were significantly associated with teachers' beliefs and teachers' beliefs, practices, and pupils' problem-solving abilities were significantly positively correlated.

Campbell et al. (2014) examined the connection between perceptions of teachers, mathematical knowledge, and student performance. Sample of the study consisted of 266 upper elementary and 193 middle grade early career teachers of mathematics. The findings revealed that the middle school teachers' knowledge, teachers' beliefs, and their students' maths performance were significantly correlated. The findings also revealed that middle school teachers' knowledge, teachers' beliefs, and their students' maths performance were significantly correlated.

Rahayu and Kurniasih (2014) conducted a study to assess the impact of REACT learning methods on students' mathematical beliefs. The sample consisted of 43 students carried out within the mathematics education program at Prof. (Dr.)

Hamka University. A 2x2 treatment design was employed, within the independent variable being the instructional methods such as REACT and conventional approach. The results revealed that the REACT learning method significantly enhanced students' mathematical beliefs, indicating it's suitability for mathematics instruction aimed at future educators. Additionally the study concluded that the learning method influences mathematical beliefs independently of students initial abilities. The descriptive analysis indicated that the mathematical beliefs of mathematics education students at private university were generally classified as low.

A study was conducted by Hakim et al. (2016) on shifting of students' epistemological beliefs about mathematics in students studying in polytechnics. The aim of the study was to figure out students' epistemological belief shift about mathematics after having attended a lecture in polytechnic and also the relationship between their beliefs and mathematical beliefs. Sample of the study consisted of 223 polytechnic students from Negeri, Malang attending mathematics lecture in 2015 - 2016 academic year. The method adopted for the study was mixed method with an explanatory sequential design approach. Stratified random sampling method was adopted. The result revealed that students' epistemological beliefs about mathematics were poorly positive. About 95 percent of students' epistemological beliefs about mathematics shifted with the changes slowly increasing and the shifting was positively correlated (r =.204) with mathematics performance at .01 level of significance. Results also indicated factors such as curriculum, method of learning, assessment system, and students' orientation purpose affect the beliefs of students regarding mathematics.

Gafoor and Sarabi (2017) examined whether the affective dimensions of teacher- student and peer interactions consistent with instructional factors that serve as barriers to students mathematical achievement and whether students' beliefs, emotions, and attitudes play a more significant role than their self- assessed cognitive skills in impacting students' low achievement in mathematics. Sample of the study consisted of 720 grade 9 students of Kerala. The study adopted descriptive survey design. The instruments used to collect data were questionnaire on factors affecting mathematics learning, and Test on achievement in mathematics for grade 9 students. The results showed that, contrary to conventional wisdom, the learner's cognitive abilities, classroom instruction, and parental active involvement and support were what separate the low-high accomplishment continuum. High and low performers in mathematics were actually differentiated by the affective environment in school and at home, as well as the associated beliefs in the learner. Results also indicated that the schools with a high proportion of maths underachievers should recognise that improving students' performance over the long term depends on variables other than curriculum, instruction, and classroom management strategies.

Prendergast et al. (2018) analyzed the Irish students' beliefs about problem solving in mathematics. The sample consisted of 975 Irish secondary school students. The instrument used to collect data was Indiana Mathematical Belief Scale. The results indicated that the students who had completed more of their secondary school had a stronger opinion that not all issues could be resolved by the use of standard processes. The same students, however, had less confidence than their younger peers that they could work through difficulties and that conceptual comprehension was crucial. The results also showed that three of the five belief scores were significantly influenced by gender.

Muharam et al. (2018) investigated teachers’ and students’ beliefs of mathematics at state senior high schools of Semarang. The sample consisted of two teachers and 28 students from tenth grade natural science six (X IPA 6) and twenty students from natural science X. Mathematics Beliefs Questionnaire on the dimensions about the nature of mathematics, beliefs about teachers' role in mathematics teaching, and beliefs about mathematics learning was used to measure the beliefs of the students. The results of the study revealed that the majority of students believed that mathematics is a fixed and structured system of rules, formulas, and procedures that must be followed correctly to solve problems. Also, most of the students believed that success in mathematics largely depends on the teachers’ ability to explain concepts clearly and guide them through the problem solving process. Students also believed that learning mathematics acquires a strong emphasis on practice and repetition. Teachers believed that they view their role as guiding students through application of rules and ensuring students practise enough to master the necessary skills.

Gijsber et al., (2019) examined the effectiveness of teaching differential equations through guided small- group tasks in scientific, medical or economic context. The sample of the study consisted of 96 first year students, and 143 upper secondary school students. The instruments used to collect data were mathematics scale, pretest posttest intervention questionnaires. The study revealed that students' beliefs about the relevance of mathematics had progressed positively, and they expressed appreciation for the chance to observe the practical applications of mathematics in real- life situations.

Wang et al. (2019) canalyzed the Chinese high school students, mathematics related beliefs and their perceived mathematics achievement. Sample of the study consisted of 496 from different parts of China: Central China, North China, East China, Northwest China. The instruments used to collect data was Students' Mathematics Related Questionnaire. The result revealed that students' mathematical beliefs were positively related to teachers' praise, and students' perceptions of their own achievement rank (χ^2= 78.047) in their respective classes.

Yuniarti et al. (2019) investigated the influences of mathematical beliefs on mathematics anxiety among pre-service elementary school teachers. The sample consisted of 374 pre-service school teachers of the elementary school section of the education department. Mathematical Beliefs Questionnaire (MBQ) was used to measure the beliefs of teachers. The results of regression analysis revealed that there is a significant relationship between the mathematical beliefs and mathematical anxiety. Results also indicated that mathematical beliefs could predict mathematics anxiety in a small range.

Robas et al., (2020) analysed secondary school students' beliefs about mathematics and their repercussions on motivation. The sample consisted of 202 students (86 girls and 116 boys) from four years of secondary education. The first level secondary education students aged between 12 and 13, second level aged between 13 and 14, third level aged between 14 and 15 and fourth level 15 to 18. The instruments used to collect data were questionnaires. The results of the study revealed that beliefs about mathematics showed significant differences according to academic level. The result also showed that first year students drive the highest motivation for learning mathematics, while third year students experience the lowest.

Hidayatullah and Csikos (2022) assessed students' mathematics - related beliefs systems in the Indonesian context. The sample consisted of 281 eighth grade students from various schools across different regions in Indonesia. The study adopted survey method. The instrument used to collect data was belief questionnaire. Findings indicated that the students who were skilled in mathematics and who believed in the discipline as a whole were more inclined to believe in the role and status of their individual teachers. Results also showed that there was a gender gap among Indonesian students: boys' students had higher beliefs about their own abilities as maths learning than girl students (p = .005 < .05, t = -0.154), and also had excellent beliefs about mathematics as a subject (p = .018 < .0., t =-1.10) .

Trakulphadetkrai (2022) investigated the effect of gender, teaching experience level, educational level and socio economic setting of the schools on mathematical beliefs of primary teachers. Survey method was used to collect data from a sample of 745 primary teachers. The instrument used to collect data was Thai Teachers' Mathematics Education Related Beliefs questionnaire. The result revealed that gender had no effect on teachers' mathematical epistemic beliefs and gender was a significant predictor of teachers mathematical knowledge belief. The study also revealed that more experienced teachers tended to perceive mathematics as more interconnected and were less declined to believe that mathematical knowledge simply exist, waiting to be uncovered. In contrast, the level of education did not appear to influence these beliefs. However, both the socio- economic context of schools and teachers' year of experience did play a predictive role. The teachers in high socio economic environments were slightly more likely to believe that mathematics knowledge consists of interrelated topics and skills, is subject to change, and is a product of creation rather than something that is merely discovered.

Malvasi and Gil-Quintana (2022) conducted a multi-case study to analyse beliefs, performance, and applicability of mathematics in learning for life at secondary education institutes in Italy. The sample of the study consisted of 4845 Italian high school students and 12 secondary school teachers. The study adopted survey method and both quantitative and qualitative research design. Findings of the study indicated that the perception of mathematics as merely a tool for counting, calculating, and measuring may contribute to the decline in academic performance among second grade secondary school students. Many students limited the utility of mathematics to its arithmetic functions. Furthermore, no significant changes were observed in beliefs across different grades, macro areas, and school types, identified correlation between students' attitudes toward mathematics and academic outcomes.

Abebe et al., (2023) analysed the effect of context based approaches on high school students' epistemological beliefs. The sample of the study consisted of 131 grade ten students in government secondary schools in Debre Birhan, Ethiopia. The study adopted pretest posttest research design. The instrument used to collect data was Epistemological Beliefs Questionnaire. The result suggested that the context based approach positively influenced students' shifts in epistemological beliefs regarding expertise compared to traditional instruction.

Perdersen and Haavold (2023) conducted a study to analyse the learning experience, beliefs and motivations of students in classes by using inquiry based learning activities. The sample of the study consisted of 248 primary school students in the 11 to 16 age range. The results of the study revealed that the key features of inquiry - based mathematics were moderately reflected in students beliefs about the subject. Their attitude towards mathematics become less favourable from primary to secondary education, with more decline in motivation were observed among girls compared to boys. Also revealed a strong correlation between various beliefs and motivation subdomain, and inquiry based teaching effectively promoted positive attitude towards mathematics, students who experience inquiry based activities in classroom tend to view mathematics as an interesting and creative subject, and they expressed how mathematics is utilised in practical, real world context.

Rupnow (2023) analysed the relationship between mathematician’s beliefs, instructions, and students' beliefs. The study adopted case study method. The sample of the study consisted of two faculty members and 30 students of land- grant university in Mid-Atlantic United states. The result of the study revealed that the complexity of the material and conflicts with differing beliefs, such as the significance of interactivity, became evident. Students’ perceptions regarding teaching and learning were apparent, indicating that even slight modification in instructional methods can impact their beliefs about mathematics education.

Summary of the empirical studies related to Mathematical Beliefs are presented in Table 6.

Table 6

Summary of Empirical Studies on Mathematical Beliefs

Sl. No.	Author (s)	Year	Findings
1	Furinghetti and Pehkonen	2000	There are some fundamental similarities on mathematical beliefs between Italian and Finnish students, particularly when it comes to the problem of classroom interaction and the students' demand for teachers' assistance. The factors pertaining to the utilisation of trial-and-error techniques and the potential for students to solve mathematical problems on their own were the most discrepancies between these two nations.
2	Kloosterman	2002	Students' beliefs regarding mathematics had a direct impact on the efforts and their willing to exert in learning the subject. Students who had negative beliefs about mathematics were more likely to withdraw and demonstrate lower level of motivation to learn.
3	Muis	2004	Consistent patterns of non-availing beliefs at all educational levels and development of beliefs about mathematics were influenced by mathematics instructional environments. Significant relationship between cognition, motivation and academic achievement. Relationship between beliefs and learning behaviours. Significant variations in beliefs across disciplines. Chaining beliefs were successful, which was attributed to appropriate changes in instructional style

Sl. No.	Author (s)	Year	Findings
4	Aikins et al.	2005	Beliefs in quick or fixed learning, and studying aimlessly, that is, studying without strategy were significantly related to beliefs about effortful math, useful math, understanding math concepts and math confidence. General and domain specific epistemological beliefs predicted academic performance as measured by solving mathematical problems and overall grade point average.
5	Philipp	2007	Individuals who studied mathematical thinking while learning mathematics increased more sophisticated beliefs about mathematics, teaching and learning and enhanced their mathematical content knowledge to a greater extent than those who did not. The beliefs of those who observed in easily accessible classrooms experienced less transformation compared to the beliefs of participants in control group.
6	Berkaliev and Kloosterman	2009	The factors extracted such as effort, usefulness, challenging tasks, comprehension, and steps influence the mathematical beliefs of students.
7	Sangcap	2010	Positive beliefs that students valued effort in increasing one's mathematical ability, considered mathematics as a useful subject in their daily life. On the other hand, all word problems can be solved by simple step by step procedure and they considered word problems to be not important. Gender difference in positive beliefs that effort can increase mathematical ability and in the usefulness of mathematics was significant.

Sl. No.	Author (s)	Year	Findings
8	Zakaria and Musiran	2010	The beliefs of the mathematics trainee teachers were positive towards the constructivism approach. Teacher trainees had the belief that mathematical problems can be solved in different ways. Teacher trainees believed that teaching mathematics involved the opportunity to use mathematics in daily life situations, and the need for understanding the concepts to learn mathematics. There was a significant difference in considering the beliefs about the nature of mathematics and beliefs about learning of mathematics based on gender.
9	Tarmizia et al.	2010	The average scores reflecting students' beliefs about their teachers' role and effectiveness in teaching mathematics were favourable, with particularly high ratings for demonstrating step by step methods in problem solving. Additionally, students expressed positive views on their teachers ability to create an enjoyable and engaging learning experience, making mathematics both comprehensible and meaningful while fostering a welcoming atmosphere.
10	Chouinard et al.	2011	The effort in mathematics was expressed by mastery goals and by competence beliefs. Also, perception of parental support was associated with the valuing of mathematics and teachers' support strengthened most on competence beliefs.
11	Polly et al.	2013	The outcomes of student learning were significantly associated with teachers' beliefs. Teachers' beliefs, practices, and pupils' problem-solving abilities were significantly positively correlated.

Sl. No.	Author (s)	Year	Findings
12	Campbell et al.	2014	The middle school teachers' knowledge, teachers' beliefs, and their students' math performance were significantly correlated. The middle school teachers' knowledge, teachers' beliefs, and their students' math performance were significantly correlated.
13	Rahayu and Kurniasih	2014	REACT learning method significantly enhances students' mathematical beliefs, indicating its suitability for mathematics instruction aimed at future educators. The learning method influences mathematical beliefs independently of students initial abilities. The mathematical beliefs of mathematics education students at private university were generally classified as low.
14	Hakim et al.	2016	Students’ epistemological beliefs about mathematics were poorly positive. factors such as curriculum, method of learning, assessment system, and students' orientation purpose affect the beliefs of students regarding mathematics
15	Gafoor and Sarabi	2017	Contrary to conventional wisdom, the learner's cognitive abilities, classroom instruction, and parental active involvement and support were what separate the low-high accomplishment continuum. High and low performers in mathematics were actually differentiated by the affective environment in school and at home, as well as the associated beliefs in the learner. Schools with a high proportion of maths underachievers should recognise that improving students' performance over the long term depends on variables other than curriculum, instruction, and classroom management strategies.

Sl. No.	Author (s)	Year	Findings
16	Prendergast et al.	2018	Students who had completed more of their secondary school had a stronger opinion that not all issues could be resolved by the use of standard processes. The same students, however, had less confidence than their younger peers that they could work through difficulties and that conceptual comprehension was crucial. Three of the five belief scores were significantly influenced by gender.
17	Muharam et al.	2018	Majority of students believed that mathematics is a fixed and structured system of rules, formulas, and procedures that must be followed correctly to solve problems. Most of the students believed that success in mathematics largely depends on the teachers' ability to explain concepts clearly and guide them through the problem solving process. Students also believed that learning mathematics acquires a strong emphasis on practice and repetition. Teachers believe that they view their role as guiding students through application of rules and ensuring students practice enough to master the necessary skills.
18	Gijsber et al.	2019	Students' beliefs about the relevance of mathematics had progressed positively, and they expressed appreciation for the chance to observe the practical applications of mathematics in real- life situations.
19	Wang et al.	2019	Students' mathematical related beliefs were positively related to teachers' praise, and students' perceptions of their own achievement rank in their respective classes

Sl. No.	Author (s)	Year	Findings
20	Yuniarti et al.	2019	There was a significant relationship between the mathematical beliefs and mathematical anxiety. Mathematical beliefs could predict mathematics anxiety in a small range.
21	Robas et al.	2020	Beliefs about mathematics showed significant difference according to academic level. The first year students drive the highest motivation for learning mathematics, while third year students experience the lowest.
22	Hidayatullah and Csikos	2022	Students who were skilled in mathematics and who believed in the discipline as a whole were more inclined to believe in the role and status of their individual teachers. There was a gender gap among Indonesian students. Boys' students had higher beliefs about their own abilities as math learning than girl students and also had excellent beliefs about mathematics as a subject
23	Trakulphadetkrai	2022	Gender had no effect on teachers' mathematical epistemic beliefs and gender was a significant predictor of teachers mathematical knowledge belief. More experienced teachers tended to perceive mathematics as more interconnected and were less declined to believe that mathematical knowledge simply exist, waiting to be uncovered. In contrast, the level of education did not

Sl. No.	Author (s)	Year	Findings
			appear to influence these beliefs. However, both the socio- economic context of schools and teachers' year of experience did play a predictive role. The teachers in high socio economic environments were slightly more likely to believe that mathematics knowledge consists of interrelated topics and skills, is subject to change, and is a product of creation rather than something that is merely discovered.
24	Malvasi and Gil-Quintana	2022	The perception of mathematics as merely a tool for counting, calculating, and measuring may contribute to the decline in academic performance among second grade secondary school students. Many students limited the utility of mathematics to its arithmetic functions. Furthermore, while we observed no significant changes in beliefs across different grades, macro areas, and school types, identified correlation between students' attitudes toward mathematics and academic outcomes.
25	Abebe et al.	2023	Context based approach positively influenced students' shifts in epistemological beliefs regarding expertise compared to traditional instruction.

Sl. No.	Author (s)	Year	Findings
26	Pedersen and Haavold	2023	The key features of inquiry - based mathematics were moderately reflected in students beliefs about the subject. Their attitude towards mathematics become less favourable from primary to secondary education, with more decline in motivation were observed among girls compared to boys. Strong correlation between various beliefs and motivation sub domain, and inquiry based teaching effectively promoted positive attitude towards mathematics. Students who experience inquiry based activities in classroom tend to view mathematics as an interesting and creative subject, and they expressed how mathematics is utilised in practical, real world context.
27	Rupnow	2023	Complexity of the material and conflicts with differing beliefs, such as the significance of interactivity, became evident. Students' perceptions regarding teaching and learning were apparent, indicating that even slight modification in instructional methods can impact their beliefs about mathematics education.

Conclusions

Effective mathematics education recognizes the importance of creating meaningful learning experiences that engage students actively (Koskinen & Pitkaniemi, 2002). It encourages exploration, experimentation, and collaboration, enabling students to construct their own understanding of mathematical concepts through inquiry and problem solving (Koskinen & Pitkaniemi, 2022). Mathematics education also highlights the importance of nurturing mathematical mindsets, fostering a positive attitude towards mathematics and the beliefs in one's capacity to succeed (Boaler, 2013). Mathematics education significantly influences learning outcomes by developing critical thinking skills (Batanero & Garfield, 2015), problem solving abilities (Hiebert & Grouws, 2007), logical reasoning (DeFranco, 2014), numeracy (Griffin et al., 1994), conceptual understanding (Carpenter et al., 1998), persistence (Boaler & Staples, 2008) interdisciplinary connections (Herbel-Eisenmann et al., 2012) and facilitating higher education (Satge & Maple,1996), and career opportunities (Wrong et al., 2002). When students engage in mathematics learning, they bring their emotions, beliefs and attitudes towards the subject (Boaler & Dweck, 2006; Usher & Pajares, 2009; Pekrun et al., 2011; Gunderson, 2018).

The poor performance in mathematics of students in all levels has gained increasing particular attention over the past three decades and has been an issue of math educators worldwide (Bah,2022). The teaching method of the teacher is regarded as the main factor that mainly reduces the anxiety of the pupils (Atoyebi & Atoyebi, 2022). Thus, in order to improve the mathematical achievement of pupils, an intervention strategy must be proposed in order to lessen their maths anxiety.

According to the National Curriculum Framework (2005), several issues with school mathematics instruction are caused by children's feelings of failure and dread, which causes them to give up and stop taking their maths classes seriously. The curriculum is poor and does not meet the demands of both slow and high achievers. Exercises, issues, and evaluation techniques are mechanical and repetitive with a singular computation-focused purpose. Mathematical concepts like spatial reasoning are not developed enough in the curriculum because teachers lack the knowledge, assurance, readiness, and assistance. The nature of mathematics is such that values can be instilled through the teaching of mathematics utilizing a variety of cutting-edge methods.

The review revealed that various innovative teaching strategies have proven effective in enhancing mathematical achievement. Models such as Driver’s Model and IDEA Learning Model have shown significant improvements in students conceptual understanding and problem-solving skills. Active and collaborative learning approaches, including cooperative learning, flipped classrooms, and blended learning, were successful in fostering mathematical communication, interest, and overall academic performance. The review highlights several effective strategies and findings related to enhancing logical reasoning and its impact on mathematical achievement. The Problem-Based Learning (PBL) interventions have been shown to significantly improve problem-solving and creativity, as well as logical reasoning abilities. Studies have also identified key factors influencing logical reasoning, such as working memory, cognitive reflection, and critical thinking. These factors contribute to mathematical performance and are correlated with overall academic achievement in mathematics. Furthermore, the review of related studies also indicates that logical reasoning skills are vital for higher-order thinking and academic success, underscores the importance of developing these skills through various instructional approaches. To further enhance logical reasoning and its impact on mathematical achievement, several areas require additional research, thus further studies should explore the long term effects of different instructional models, and other active learning strategies, on students' logical reasoning and mathematical performance. Investigating how these methods influence the development of mathematical beliefs and values can provide insights into their effectiveness. Additionally, research should focus on the role prior knowledge in logical reasoning abilities and their impact on learning outcomes. By addressing these areas, educators can better understand and implement effective methods to improve logical reasoning and mathematical achievement.

The review of related studies underscores a consistent pattern where high levels of academic anxiety negatively impact students' mathematics achievement. Multiple studies have demonstrated that anxiety, particularly test anxiety and academic stress, is strongly correlated with lower academic performance. Female students often experience higher levels of anxiety compared to their male counterparts, and this anxiety adversely affects their mathematical understanding and performance. Strategies such as flipped classrooms and multimedia systems have shown promise in mitigating anxiety by enhancing motivation and making learning environments more engaging. These findings highlighted the critical needs for targeted interventions that address academic anxiety and foster positive mathematical beliefs and values. To effectively reduce mathematics anxiety and enhance students' mathematical performance, further research is needed in several key areas. Future studies should focus on identifying and implementing specific strategies that not reduce anxiety but also promote positive mathematical beliefs and self- confidence. This includes exploring the effectiveness of various instructional methods, such as flipped classroom and multimedia interventions, in diverse educational contexts. Additionally, research should investigate the role of teacher training in recognizing and addressing students' anxiety, as well as the impact of sociocultural factors on anxiety levels. Addressing these areas will help create supportive learning environments that reduce anxiety and improve mathematical outcomes.

The review of literature demonstrates a strong link between achievement motivation and academic success across various contexts and educational levels. Research studies consistently showed that higher levels of achievement motivation are associated with better academic performance. The factors such as gender, location, and instructional methods influences students' motivational level. For instance, girls often exhibit higher achievement motivation levels. Instructional strategies such as role-play, cooperative learning, and activity based methods were effective in enhancing students' achievement motivation, particularly in mathematics. These findings underscore the importance of implementing targeted strategies to boost motivation, thereby improving academic outcomes.

Despite these promising findings, further research is needed to fully understand and optimize these strategies. Under this, background studies that explore the long-term effects of teaching models and strategies compare their effectiveness across different mathematical domains and examine how individual student differences impact their success has to be concluded. Research that focusses on how to integrate mathematical beliefs and values in to teaching practices, will help to refine educational practices and enhance student achievement in mathematics. By reviewing the literature, the investigator comprehended that an approach that integrates values and beliefs in mathematics will be helpful in enhancing cognitive and affective outcomes of students. Through the analysis of related empirical studies, on the variables, the investigator found only a few approaches subjected. In order to fill the gap, the investigator decided to find out the effectiveness of Process Stage Model on select learning outcomes in mathematics among secondary school students.

Chapter III

METHODOLOGY

- Variables
- Objectives
- Hypotheses
- Design of the Study
- Instruments Used
- Sample Selected for the Study
- Data Collection Procedure
- Statistical Techniques Employed

METHODOLOGY

The present study, entitled EFFECTIVENESS OF PROCESS STAGE MODEL ON SELECT LEARNING OUTCOMES IN MATHEMATICS AMONG SECONDARY SCHOOL STUDENTS attempts to study the effectiveness of the independent variable, Process Stage Model on dependent variables, Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs of secondary school students.

The methodology adopted by the investigator for the present study is described under the following headings.

- Variables
- Objectives
- Hypotheses
- Design of the Study
- Instruments Used
- Sample Selected for the Study
- Data Collection Procedure
- Statistical Techniques Employed

Variables

As the study is experimental in nature, it consists of independent and dependent variables. The independent and dependent variables used in the study are

Independent Variables

The independent variables adopted in the study are two types of Instructional Strategies

a) Process Stage Model as Instructional Strategy for Experimental Group

b) Constructivist Model as Instructional Strategy for Control Group

Dependent Variables

The dependent variables in the study are select Cognitive and Affective Learning Outcomes in Mathematics.

Cognitive Learning Outcomes

Achievement in Mathematics

Logical Reasoning

Affective Learning Outcomes

Mathematics Anxiety

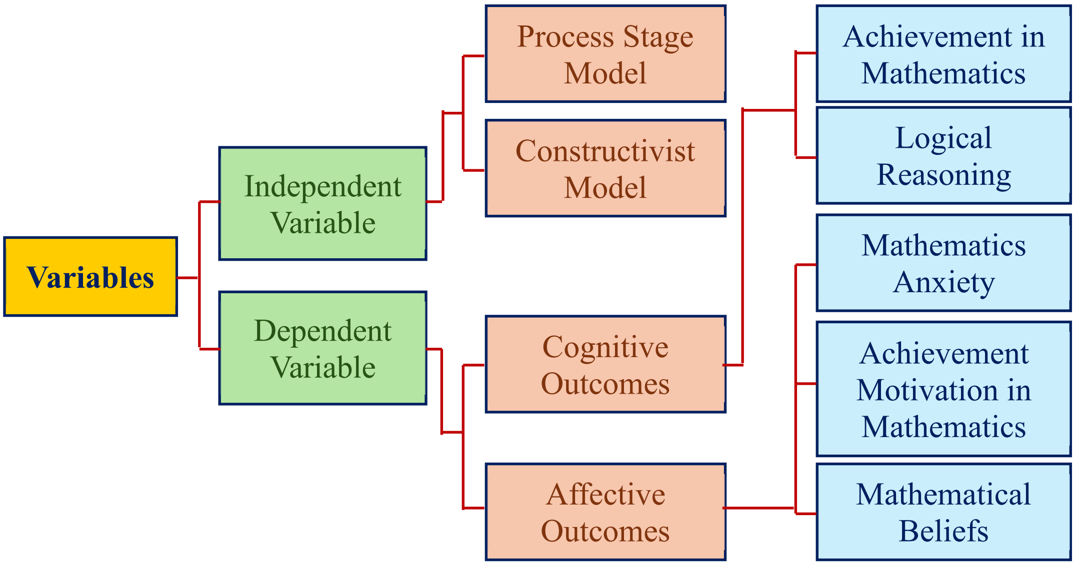
Achievement Motivation in Mathematics

Mathematical Beliefs

The variables adopted for the study are presented in figure 6.

Figure 6

Variables adopted for the study



Rationale for Selecting Variables

During the process of selecting independent variables, several factors were carefully considered. By analyzing research findings in the field of mathematics education, the researcher came to the conclusion that several teaching models have an impact on the cognitive and affective outcomes in mathematics among secondary school students (Pratama & Setyaningrum, 2018). The National Council of Teachers' of Mathematics (NCTM, 2014) pointed out the importance of teaching models adapted to different learning styles and suggested that educators must provide a learning environment that fosters students' active participation in mathematics discussions and supports students in developing a positive mathematical identity. Innovative pedagogies and models provide a wide range of activities, and they also help in figuring out how to connect these activities to another domain or up to a higher level (Buckley & Kukhareva, 2021)

Research studies have collectively highlighted the significance of teaching models and teaching strategies in mathematics education and stressed their impact on active learning, adaptation to different learning strategies to solve problems, problem-solving skills, cooperative work, creativity, and the establishment of mathematical concepts (Cross,1997; Fosnot & Jacob, 2010; Vale & Barbosa,2021). Collaborative models, such as cooperative learning, stress the importance of group interaction and shared responsibility where students work together to achieve common learning goals (Johnson & Johnson, 1999). The increased achievement, more positive attitude towards learning, acceptance of differences, and positive effect on many other learning outcomes are the impacts of cooperative learning experiences on students (Johnson & Johnson, 1985). According to Johnson and Johnson (1999) students who participate actively in group discussions and problem-solving exercises benefit from this cooperative structure's enhanced social interaction and communication skills. Roseth et al., (2008) found that cooperative learning strategies in pairs and small groups not only improve academic performance but also promote a supportive and positive learning environment, by achieving success reinforces mindset, leading to increased confidence and motivation to tackle more challenging tasks. When students feel positively challenged, they are more likely to take on mathematical challenges (Dweck, 2006). The ability to adapt learning experiences to individual needs can contribute to a more positive and secure approach to mathematics education and increase students' conceptual understanding of mathematical concepts, ultimately enhancing cognitive learning outcomes.

Studies have indicated that the utilization of inquiry-based learning methods had a positive influence on students' critical thinking ability (Ghaemi & Mirsaeed, 2017) and construction of knowledge (Keselman, 2003). By actively involving students in exploration and discovery, inquiry-based learning fosters deeper cognitive engagement and empowers students to inquire, investigate solutions, and cultivate a solid conceptual foundation in mathematics (Hiebert et al., 2007). Lage et al. (2000) suggested that flipped classroom models are not only educational strategies for improving learning outcomes but also for creating a supportive and reducing anxiety learning environment. Adapting instructional strategies to improve particular cognitive skills, such as logical reasoning, is possible with personalized learning by design. It has been demonstrated through the research that logical reasoning-focused teaching strategies enhanced students' ability to solve mathematical problems (Halmos, 1985). Logical reasoning enhances the ability to tackle challenges and achieve desired outcomes and is indispensable in addressing real-world problems across various domains.

Boaler and Staples (2008) emphasized the importance of teaching models connecting mathematics to application in the real world. The model emphasized the relevance of the real world, helps students to see the practical utility of mathematics, and fosters a deeper understanding of the subject. Problem-based learning improves the ability of students to analyse, synthesize and apply knowledge in real world contexts (Schmidt & Moust, 2000). The above mentioned studies offer evidence in favor of these affects, demonstrating how different teaching approaches can affect mathematical learning in both cognitive and affective domains.

The use of effective teaching models in mathematics education is essential for shaping students' educational experiences and outcomes. Through the deliberate selection of teaching models that prioritize active participation, collaboration, and individualised learning, educators have the capacity to augment the attitude for logical reasoning, elevate motivation to excel, establish an affirmative attitude towards mathematical concepts, and diminish unease associated with mathematics. These components not only generate enhanced academic achievement but also cultivate skills that endure throughout an individual's lifetime and foster a constructive perspective towards mathematics. Therefore, the investigator selected instructional strategies as independent variables. Here, the selected instructional strategies are Process Stage Model and Constructivist Model.

Studying mathematics within the context of secondary education is imperative for achieving scholastic triumph, fostering cognitive growth and equipping students with the necessary tools to confront the obstacles of an ever more intricate and interrelated global environment as well discovered that the acquisition of mathematical knowledge enhances overall cognitive capabilities (Cowan et al., 2017). Many research studies concluded that the cognitive learning outcomes influence the affective learning outcomes of learners (Hall & O'Donnell, 1996). Empirical evidence indicates a strong correlation between the emotional and cognitive domains, indicating that improvement in one might have a substantial effect on the other (Perkins & Saloomon, 1999). When individuals participate in cognitive tasks like problem solving, critical thinking, and learning new information, their affective outcomes, such as attitudes, beliefs, and emotions often undergo corresponding changes (Langdon & Engal, 2022). These changes can have a significant impact on their overall educational experiences (None, 2015). By influencing students' attitudes towards the subject, their sense of competence, and the application of mathematics to everyday life, the teaching model has an impact on students' beliefs about mathematics (Le & Le, 2022). Various studies of models and instructional strategies indicate the effectiveness of mathematical learning outcomes and through their interpersonal interactions, students actively explored and created mathematical knowledge (Prabowo et al., 2020). Hence, the researcher selected Process Stage Model as an instructional strategy as one of the independent variables which focuses on development of values and beliefs through various stages along with the cognitive outcomes.

Process stages in the development of values and beliefs suggested by Dewey (1939), emphasized that the cognitive and affective domains are interrelated and mutually influential. Learning is not only acquiring knowledge and skills but also developing attitudes, values, and emotional responses that shape how individuals engage with and apply what they have learned. By connecting learning to real-world problems and experiences, students develop a deeper understanding of the significance of certain beliefs, where values can be inculcated along with the formation of these beliefs (Dewey, 1939). According to Dewey (1939), through reflection and critical inquiry, students evaluate the implications of their beliefs and the mathematical value they hold. Hence, the researcher selected the instructional strategy as Process Stage Model which incorporates the Dewey's (1939) process stages as the independent variable.

While selecting the dependent variables, it was unable to select all learning outcomes in mathematics. Therefore, the researcher selected certain learning outcomes in Mathematics such as Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs. Choosing the right teaching approach is crucial when it comes to mathematics education since it has a significant impact on a number of important learning objectives (Urner, 2016). Firstly, achievement in mathematics stands as a cornerstone metric, reflective of students' comprehension and application of mathematical concepts. Achievement in education is not just about obtaining high grades. It reflects the development of skills, knowledge, and attitude that are essential for lifelong learning and personal growth (Tao et al., 2022). The cognitive learning outcome; academic achievement, enhances students self-efficacy beliefs, and success in academic tasks provides positive feedback to students, which strengthens their confidence and motivates them to persist in more difficult tasks (Schunck & Pajares, 2009). Students' belief in their ability to succeed is strongly influenced by experiences of success. These experiences contribute to their willingness to take on more challenging tasks as they develop confidence in their capabilities. When students achieve academic success, their self-efficacy also increases, leading them to engage in more challenging and demanding tasks with greater motivation (Bandura, 1997). Students, who achieve academic success are more likely to develop effective learning strategies, which further enhances their confidence and motivates them to pursue more challenging academic goals (Zimmerman, 2000). Success in mathematics is positively impacted by a teaching approach that incorporates practical exercises, group problem-solving, and conceptual knowledge because it promotes deeper involvement and comprehension (Valdes et al., 2020; Edelsbruner et al., 2023). By immersing students in experiential learning opportunities and encouraging exploration, such a strategy which emphasis on process stages facilitates the internalization of mathematical principles, resulting in tangible gains in achievement. Therefore, strengthening achievement among students is fundamental to their personal development, future opportunities, and overall success. It equips them with the skills, knowledge, and attitudes necessary to overcome the complexities of life and make meaningful contributions to society. Therefore, teachers must prioritize affording to support and enhance students achievement at all levels of education. Hence, the investigator selected Achievement in Mathematics as one of the dependent variables.

Furthermore, developing students' logical thinking skills is essential to mathematics education since it supports their ability to conduct methodical issue analyses and develop strong arguments (Setiawaty, 2022). Students' analytical abilities are fostered by approach to instruction that prioritizes logical thinking through organized problem- solving assignments, exercise in pattern detection, and challenges using deductive reasoning (Zhanatauov, 2023). Dewey (1939) emphasised that the process stages improve students' capacity to confidently and precisely tackle challenging mathematical environments by supporting their thought processes and directing them along logical problem- solving procedures, preparing students for real-world challenges with confidence, making informed choices, effectively communicating their ideas to others, and empowering them to become critical thinkers and informed decision makers. Adolescents reasoning ability, critical thinking ability, logical thinking ability, and academic achievement are positively related (Sherafat, 2015). According to Paul and Binker (1990), critical thinking must be at the centre of educational reform. When someone is thinking critically, they begin by analysing a topic using logical reasons that have been provided, and then they provide a logical conclusion based on the supporting evidence (DeWaelsche, 2015).

Certain learning strategies, such as collaborative learning, promote students' critical thinking as well as academic achievement (Gokhale,1995). Critical thinking has been shown to have favourable effects on emerging academic achievement (Chan, 2013; Tiruneh et al., 2014; Wang et al., 2015). Students possess strong critical thinking skills tend to develop a deeper understanding of new information and are more proficient in acquiring in new ideas and knowledge than students with less developed critical thinking skills (Halpern, 2003a). Students' entire cognitive growth is aided by logical thinking, which helps them to solve problems and succeed academically while also preparing them for life long learning (Klaczynski, 2001). Hence, education should have a special preference to cultivate critical thinking at all levels of education (Forawi, 2016). Also, overall reasoning ability is correlated with high mathematics performance (Gomez- Chacon et al., 2014: Ramganesh & Reddy, 2021). Therefore, enhancing secondary school students' logical thinking abilities is crucial for their future preparation, personal growth, and academic performance. Teachers can enable children to think critically, solve issues successfully, and prosper in a complicated and fast changing society by fostering these abilities in them. Hence, the researcher selected Logical Reasoning as one of the dependent variables.

Mathematics anxiety remains like an illusion posing various obstacle to participation and success for majority of the students (Ongcoy et al., 2023). The teaching method must be an integrated approach to address mathematics anxiety including aspects of personalized instruction, emotional support and stress reduction technique. Anxiety is recognised to have an impact on both learning and performance (McDonald, 2001). The programme study anxiety intervention reduces anxiety and manage to improve academic performance (Prima et al., 2010). It is clear that anxiety significantly influences academic performance outcomes (McCraty & Atkinson, 2000). Studies have shown that higher anxiety levels among students are linked to lower academic performance (McCraty, 2007; Heather & April, 2008), and that increased anxiety is associated with reduced academic achievement (Luigi et al., 2007), high level of anxiety reduces working memory, concentration, and reasoning (Cassidy & Lynn, 1989). The idea that math anxiety could be a sequence of poor math performance lead to the conclusion that strategies intended to enhance students' math skills may prove effective in decreasing math anxiety (Remirez et al., 2018). Recent research in math anxiety indicates that mathematical interventions may have a beneficial impact on reducing mathematics anxiety among school students (Supekar et al., 2015; Passolunghi et al., 2020; Vanbecelaere et al., 2020). Educators should try to reduce anxiety and provide a secure and welcoming atmosphere that supports mathematics learning by recognising different learning styles, and providing chances for students to practice, make mistakes, and get feedback. Hence, the investigator selected another dependent variable as Mathematics Anxiety for testing the effectiveness of the Process Stage Model.

A teaching strategy that develops achievement motivation in mathematics aligns with the theories of self-efficacy and goal orientation, emphasizing the importance of intrinsic motivation, mastery goals, and growth mindset. Achievement motivation is characterized by a strong drive to succeed in learning activities, along with the capacity to find fulfillment in achieving one's goals (Sarangi, 2015). Research indicates that students who exhibited high levels of academic motivation tend to achieve greater academic success and experience lower rates of dropout (Blank,1997). Abesha (2012) documented a meaningful and advantageous connection between motivation for academic achievement and the academic performance of students enrolled in teacher training institutes. In a related study Goldberg and Cornell (1998) discovered a positive relationship between intrinsic motivation and academic success. As noted by (Dave,1979) achievement motivation is characterised by the desire to succeed in relation to established standards of excellence. This underscores the significance of achievement motivation in fostering students success and enhancing learning experiences. In the teaching profession, it is crucial to actively work on sustaining and improving the motivation of learners. Many high school science teachers believe that nurturing student motivation is one of their most significant instructional roles (Sanfeliz & Stalzer, 2003). Additionally, gaining insight into each student's individual motivation for learning is essential for creating a more relevant educational experience. Thus, motivation is not only vital for encouraging students to engage in learning but also plays a significant role in their academic success (Anni, 2006). By framing mathematical challenges as opportunities for growth, acknowledging achievements, and offering insightful feedback, teachers can develop students' intrinsic motivation, encouraging a strong desire to achieve mastery-oriented learning objectives and succeed in mathematics. Achievement motivation serves as a driving force that guides individuals' action towards reaching their goals, establishing it as a significant factor determining academic success (Plante et al., 2013; Wigfield et al., 2016). Hence, the investigator selected Achievement Motivation in Mathematics as another dependent variable for testing the effectiveness of the teaching strategy.

Finally, a key component of mathematics education is the formation of mathematical beliefs, or the cognitive schema and attitudes that support students' views about their mathematical aptitude and nature of mathematics (Mues et al., 2022). Some researchers have demonstrated that students' beliefs about mathematics significantly impact their success in learning the subject (Odiri & Onoshakpokaiya, 2022). Various studies suggested that these beliefs are shaped by social context (Mcleod, 1992; Hassi & Laursen, 2009; Griese, 2011) curriculum (Taylor, 2009), and self (Lazim, 2004; Uden et al., 2014), which together form a motivational framework consisting of expectations, values and affective elements (Pintrich, 1992; Pintrich & Schrauben, 1992). The integration of metacognitive reflection, cognitive dissonance resolution, and belief affirmation approaches are teaching strategies that specifically target mathematical beliefs (Mues et al., 2022). Beliefs and values of students in learning mathematics affect their academic achievement (Sediarin et al., 2023). Through promoting critical evaluation of their mathematical identities, challenging limiting beliefs, and developing growth oriented perspective, teachers can help students to develop resilience, self- efficacy, and confidence in their mathematical abilities. Hence, the investigator selected Mathematical Beliefs as one of the dependent variables.

An effective teaching strategy in mathematics education must attend to various interconnected dimensions, including achievements in mathematics, logical reasoning, mathematics anxiety, achievement motivation in mathematics and mathematical beliefs. By employing a teaching strategy that prioritize these learning outcomes, teachers can create rich and supportive learning environment that empower students to excel in mathematics and develop a positive and enduring relationship with the subject. Focusing on these outcomes such as Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs not only enhances students' academic performance but also prepares them for future challenges in both academic and real world context. By addressing these areas, educators can help students to build a strong foundation for lifelong learning and success.

Objectives

The objectives framed for the study are;

Major Objective

- To find out the effectiveness of the Process Stage Model on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs of secondary school students.

Specific Objectives

The specific objectives are

1. To analyze the level of Mathematical Beliefs of secondary school students.

2. To compare the mean scores of pre-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs for experimental and control groups of secondary school students.

3. To compare the mean scores of post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs for experimental and control groups of secondary school students.

4. To compare the mean scores of pre-test and post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs for experimental group of secondary school students.

5. To compare the mean scores of pre-test and post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs for control group of secondary school students.

6. To compare the mean scores of gain scores on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in

Mathematics, and Mathematical Beliefs for experimental and control groups of secondary school students.

Hypotheses

The hypotheses framed for the study are;

1. Secondary school students are having moderate level of Mathematical Beliefs

2. There exists no significant difference in the mean scores of pre-test on Achievement in Mathematics for experimental and control groups of secondary school students.

3. There exists no significant difference in the mean scores of pre-test on Logical Reasoning for experimental and control groups of secondary school students.

4. There exists no significant difference in the mean scores of pre-test on Mathematics Anxiety for experimental and control groups of secondary school students.

5. There exists no significant difference in the mean scores of pre-test on Achievement Motivation in Mathematics for experimental and control groups of secondary school students.

6. There exists no significant difference in the mean scores of pre-test on Mathematical Beliefs for experimental and control groups of secondary school students.

7. There exists significant difference in the mean scores of post-test on Achievement in Mathematics for experimental and control groups of secondary school students.

8. There exists significant difference in the mean scores of post-test on Logical Reasoning for experimental and control groups of secondary school students.

9. There exists significant difference in the mean scores of Post-test on Mathematics Anxiety for experimental and control groups of secondary school students.

10. There exists significant difference in the mean scores of post-test on Achievement Motivation in Mathematics for experimental and control groups of secondary school students.

11. There exists significant difference in the mean scores of post-test on Mathematical Beliefs for experimental and control groups of secondary school students.

12. There exists significant difference in the mean scores of pre-test and post-test on Achievement in Mathematics for experimental group of secondary school students.

13. There exists significant difference in the mean scores of pre-test and post-test on Logical Reasoning for experimental group of secondary school students.

14. There exists significant difference in the mean scores of pre-test and post-test on Mathematics Anxiety for experimental group of secondary school students.

15. There exists significant difference in the mean scores of pre-test and post-test on Achievement Motivation in Mathematics for experimental group of secondary school students.

16. There exists significant difference in the mean scores of pre-test and post-test on Mathematical Beliefs for experimental group of secondary school students.

17. There exists significant difference in the mean scores of pre-test and post-test on Achievement in Mathematics for control group of secondary school students.

18. There exists significant difference in the mean scores of pre-test and post-test on Logical Reasoning for control group of secondary school students.

19. There exists significant difference in the mean scores of pre-test and post-test on Mathematics Anxiety for control group of secondary school students.

20. There exists significant difference in the mean scores of pre-test and post-test on Achievement Motivation in Mathematics for control group of secondary school students.

21. There exists significant difference in the mean scores of pre-test and post-test on Mathematical Beliefs for control group of secondary school students.

22. There exists significant difference in the mean scores of gain scores on Achievement in Mathematics for experimental and control groups of secondary school students.

23. There exists significant difference in the mean scores of gain scores on Logical Reasoning for experimental and control groups of secondary school students.

24. There exists significant difference in the mean scores of gain scores on Mathematics Anxiety for experimental and control groups of secondary school students.

25. There exists significant difference in the mean scores of gain scores on Achievement Motivation in Mathematics for experimental and control groups of secondary school students.

26. There exists significant difference in the mean scores of gain scores on Mathematical Beliefs for experimental and control groups of secondary school students.

27. The Process Stage Model is effective for enhancing Achievement in Mathematics of secondary school students.

28. The Process Stage Model is effective for enhancing Logical Reasoning of secondary school students.

29. The Process Stage Model is effective for reducing Mathematics Anxiety of secondary school students.

30. The Process Stage Model is effective for enhancing Achievement Motivation in Mathematics of secondary school students.

31. The Process Stage Model is effective for enhancing Mathematical Beliefs of secondary school students.

Design of the Study

Planning is a fundamental stage in the research process that creates the conditions for a successful, ethical, and well structured study. It assists researchers in navigating the many stages of the research process, from conception to execution and analysis, producing trustworthy and legitimate research findings (Creswell & Creswell, 2018). The crucial element of planning in the research process is the careful selection of an appropriate methodology, which acts as a detailed plan or strategy, providing a clear outline of how a research study will be executed.

In this section the method adopted for carrying out the study was detailed. The study adopted multi-methodology by incorporating both survey and experimental methods. Even though the main focus of the study is to find out the effectiveness of the Process Stage Model on select Learning Outcomes in Mathematics, before the experimentation the investigator analyzed the existing level of Mathematical Beliefs among secondary school students. Hence, the study adopted survey method and experimental method. The study was carried out in two phases and the phases are described in detail under the following headings;

Phase 1: Survey Phase

The independent variable, Process Stage Model, incorporates a value based approach, by integrating mathematical values and beliefs in the teaching learning process. The investigator decided to analyze the existing level of Mathematical Beliefs of secondary school students before conducting the experiment. Therefore, in the first phase of the study survey method was used to collect data from secondary school students by using Mathematical Beliefs Inventory (Radhika & Niranjana, 2022). The survey was carried out on a sample of 600 secondary school students studying in VIII standard in Kerala state.

Phase 2: Experimental Phase

The main focus of this study is to find out the effectiveness of the Process Stage Model on select Learning Outcomes in Mathematics such as Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs among secondary school students. Hence, in the second phase of the study, the experimental method is used to test the effectiveness of the Process Stage Model on select Learning Outcomes in Mathematics. The experiment was conducted on a sample of 62 secondary school students studying in VIII standard which is evenly distributed in experimental and control groups. Intact class was used in both experimental and control groups.

Design of Experimentation

The main aim of the study is to investigate the effectiveness of the Process Stage Model on select Learning Outcomes in Mathematics among secondary school students. Experimental method is used to test the effectiveness of the Process Stage Model. Among the various experimental designs, the researcher selected quasi-experimental design, which is the most commonly used experimental design in the field of social science research. In quasi-experimental design, pre-test post-test non-equivalent two group design was used to examine the effectiveness of the Process Stage Model on select Learning Outcomes in Mathematics such as Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs among secondary school students, in comparison to the existing constructivist model of instruction. The investigator identified two groups of participants using intact class, one group who taught with Process Stage Model, and another group with Constructivist Model. The design of the experimentation is as follows.

$$G_1: O_1 \text{ x } O_2$$

$$G_2: O_3 \text{ c } O_4$$

Where,

G_1 is the experimental group with pre-test O_1 and post-test O_2 and

G_2 is the control group with pre-test O_3 and post-test O_4.

Process of Experimentation

The process of experimentation consists of various phases such as validation phase, pre-treatment phase, treatment phase, and post-treatment phase.

Validation Phase. During the validation phase, the primary objective is to validate the developed Lesson Transcript on Process Stage Model and to standardize the instruments used for measuring the variables, Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs prepared by the investigator. The various instruments developed for measuring the variables are Achievement Test in Mathematics, Logical Reasoning Test, Mathematics Anxiety Scale, Scale on Achievement Motivation in Mathematics and Mathematical Beliefs Inventory.

For the validation of the developed Lesson Transcript on Process Stage Model, the lesson transcripts were discussed with subject experts in the field of mathematics and mathematics education to ensure its accuracy and reliability. After collecting suggestions from the experts, the developed lesson transcripts were modified, thus the content validity and face validity is ensured. In addition to that, the instruments used to measure Achievement in Mathematics, Logical Reasoning, Mathematical Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs for pre-test and post-test were also standardized. Pilot testing of the developed instruments such as Achievement Test in Mathematics, Logical Reasoning Test, Mathematics Anxiety Scale, Scale on Achievement Motivation in Mathematics and Mathematical Beliefs Inventory were carried out on a sample of 370 secondary school students studying VIII standard and the instruments were standardized by using item analysis procedure.

Pre- treatment Phase. Prior to evaluating the effectiveness of an experiment, it is essential to determine the early condition of treatment variables such as Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs. Pre-tests were administered on both the experimental and control group of secondary school students to ascertain the level of Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs of secondary school students. The investigator administered the Achievement

Test in Mathematics, Logical Reasoning Test, Mathematics Anxiety Scale, Scale on Achievement Motivation in Mathematics and Mathematical Beliefs Inventory to collect the required data for this purpose.

Treatment Phase. This phase represents the central part of the study. In this phase, both the experimental and control group of secondary school students were exposed to distinct treatments. The experimental group received treatment based on the Process Stage Model, while the control group was subjected to the Constructivist Model on the same mathematics curriculum of Kerala state prevailing in secondary schools of Kerala. To ensure consistency in the teacher factor, the investigator herself handled both the experimental and control group of secondary school students and to maintain consistency in terms of timing and duration of instruction, both groups were managed continuously. Lesson transcripts on Process Stage Model and Constructivist Model were meticulously prepared and implemented for both the experimental and control groups. Additionally, both groups were selected from the same institution to prevent any disparities in institutional types and locations.

Post- treatment Phase. The post treatment phase is concentrated on the measurement of Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs after treatment in both experimental and control groups. The same instruments used for pre-test were administered as the post-test to measure Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs. The scores of pre-test and post-test were subjected to statistical procedures to identify the effectiveness of the Process Stage Model on

Learning Outcomes in Mathematics such as Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs.

Instruments Used

In order to measure the variables, the investigator developed and standardized six instruments with the help of the supervising teacher. The instruments used are:

- Lesson Transcript on Process Stage Model (Radhika & Niranjana, 2022)
- Lesson Transcript on Constructivist Model
- Achievement Test in Mathematics (Radhika & Niranjana, 2022)
- Logical Reasoning Test (Radhika & Niranjana, 2022)
- Mathematics Anxiety Scale (Radhika & Niranjana, 2022)
- Scale on Achievement Motivation in Mathematics (Radhika & Niranjana, 2022)
- Mathematical Beliefs Inventory (Radhika & Niranjana, 2022)

The details of development and standardization procedure of instruments used in the study are described here.

Lesson Transcript on Process Stage Model (Radhika & Niranjana, 2022)

Teachers utilize theoretical frameworks or methodologies known as models of teaching to direct their educational activities. These models offer a framework for arranging and presenting instructional materials. Creating a dynamic and engaging learning environment through the international blending of many models is a common component of effective teaching. A model of teaching is a set of interrelated components arranged in a sequence which provides guidelines to realize specific goals (Metsapelto et al., 2021). It consists of guidelines for designing instructional activities and environmental facilities carrying out of these activities and realization of the stipulated objectives (Joyce & Weil, 1972). Consequently, teaching models consists of a well-organised, interrelated, and logically sequenced collection of instructional elements. This approach follows a systematic procedure that results in specific learning outcomes (Guter et al., 1990). In the study, the investigator decided to use the Process Stage Model to know the effectiveness of the model in enhancing Achievement in Mathematics, Logical Reasoning, reducing Mathematics Anxiety, enhancing Achievement Motivation in Mathematics and Mathematical Beliefs of secondary school students. The details of development of lesson transcripts on Process Stage Model are described in the following headings.

Planning of the Lesson Transcripts

Teaching models provide a framework for instructional design and delivery, guiding educators on how to facilitate learning experiences. Effective instruction refers to teaching methods that facilitate the acquisition of designed skills, knowledge, and attitude among students (Resiser & Dick, 1996). According to Rai et al. (2023), the choice of design of group work activities should align with the learning objectives, the nature of content and the characteristic of student population. Group work on the other hand, is a specific instructional strategy where students collaborate in small groups to achieve learning objectives, enriching learning process by promoting collaboration, social interaction, and active engagement among students. (Abadzi,1985).

The investigator decided to develop Lesson Transcripts of Process Stage Model on the basis of the process stage theory by Dewey (1939). According to Olatunji (2013), there are two predominant perspectives on affective education. The first perspective asserts that the essence of affect, including values, morals, and ethics, originates from external sources beyond human experience. Conversely, the second perspective argues that the essence of affect should primarily stem from an analysis of human experience itself. This viewpoint is rooted in the philosophy of pragmatism as articulated by Dewey (1939). According to this perspective, values are cultivated as individuals or groups progress through a series of stages. Dewey (1939) outlines these stages as follows:

Phase (1) Interact with the environment,

Phase (2) Reflective thinking on the meaning of the interaction,

Phase (3) Based on the reflective thought, formulating values or beliefs,

Phase (4) Based on reflective thinking apply the formulated values to new situations.

Hence, based on the theory of Dewey (1939), the investigator prepared a model namely Process Stage Model by incorporating 25 values and 18 beliefs in mathematics along with the content. The mathematical values includes, development of; power of reasoning, positive attitude, the understanding of correlation with other subjects, applicability for vocational aim, accuracy in doing mathematical problems, ability in analysing situations, ability to grasp situations, concentration, memorization, imagination, aesthetic skill, logical reasoning, analytical thinking, interest, problem solving ability, critical thinking, abstract thinking, creativity, communication skill, the confidence that mathematics concepts are understandable, mental discipline, view that mathematics is a part of human experience, self-reliance, importance of mathematics in daily life, and scientific attitude. The mathematical beliefs related to beliefs about nature of mathematics, beliefs about mathematics in daily life, beliefs about mathematics teaching and learning and beliefs about competency in mathematics are incorporated in Process Stage Model. Mathematical beliefs included are mathematics helps in the development of logical thinking, everyone can solve mathematics problems through hardwork, mathematics study enhances creativity, mathematical understanding can be strengthened through appropriate learning activities, mathematical learning helps in the development of scientific thinking, understanding of mathematics helps to earn for livelihood, mathematics represents the real world, study of mathematics supports the study of other subjects and mathematics learning helps students to discover things themselves. It also include more than one method is used to teach mathematics, mathematics is learned through an active process, mathematics helps students to design their communication strategies, mathematics is a subject that everyone can handle in a same manner, and mathematics is a subject that has opportunities for a wide variety of activities. In addition to that any difficult mathematics problems can be solved through systematic learning, mathematics learning helps to develop the ability to analyse the cause and effect relationship, mathematics learning helps to analyse facts and from general principles and mathematics is an ever evolving subject.

This model establishes a link between the environment and mathematical content as well as assists students in realizing that mathematics is not a distinct and scary topic, and that every aspect of the subject matter is highly relevant to their daily activities through the observation of their environment (Dewey, 1939). The Process Stage Model emphasises the situations and tasks of daily life situations that require social interaction and positive dependence for solutions. It also helps to formulate a mathematical principle related to the problem along with the content of the subject during students discussion in the class. Each phase of the model requires collective responses from the participants after group discussion. Through the phases, the students understand, verify and apply the mathematical principles in various life situations. Complementing the model of social family, Process Stage Model gives prominence to group inquiry among students for a solution. During the discussion, all students are free to share their ideas about the problem without hesitation, encourages the ideas of all members of the group, recognizes interconnectedness of experience, verification, reflection, abstraction, and application of knowledge in daily life, and help them to develop mathematical beliefs and to form mathematical values among students (Palmer, 2007). The investigator decided to develop lesson transcripts on the Process Sage Model on the basis of the phases developed by incorporating the processes in stages suggested by Dewey (1939).

Structure of Process Stage Model

The core of the Process stage model is from Dewey's (1939) process stages which is dynamic and living framework in which the students recognizes interconnectedness of experience, verification, reflection, abstraction and application of knowledge in daily life and help them to develop mathematical beliefs and to form mathematical values among students. While preparing the Process Stage Model lesson transcript the investigator thoroughly analysed the topics in order to detect suitable mathematical beliefs and values that can incorporate into the content. The investigator incorporated 25 mathematical values and 18 mathematical beliefs in the Process Stage Model lesson transcripts according to the context. The lesson transcripts start with an introduction part, and the activities are developed on the basis of the syntax of the model. The structure of the Process Stage Model is explained under the headings, focus, syntax, social system, principles of reaction, support system, instructional and nurturant effects.

Focus. Focus refers to the primary aim of the teaching learning process and the outcomes expected from students. The focus of Process Stage Model is to develop understanding and skills of mathematics along with mathematical beliefs and values.

Syntax of Process Stage Model. The various phases of the Process Stage Model by incorporating the processes in stages suggested by Dewey (1939) are

Phase One: Interact with the Environment. In this phase the teacher creates a mathematics classroom environment through social interaction as an interpretive framework and explains the interrelationship between the nature of the classroom environment and students' mathematical learning. Students actively engage with their surroundings, participating in hands-on activities and experiences. This stage emphasizes learning by doing, where students directly interact with the world to gain practical knowledge.

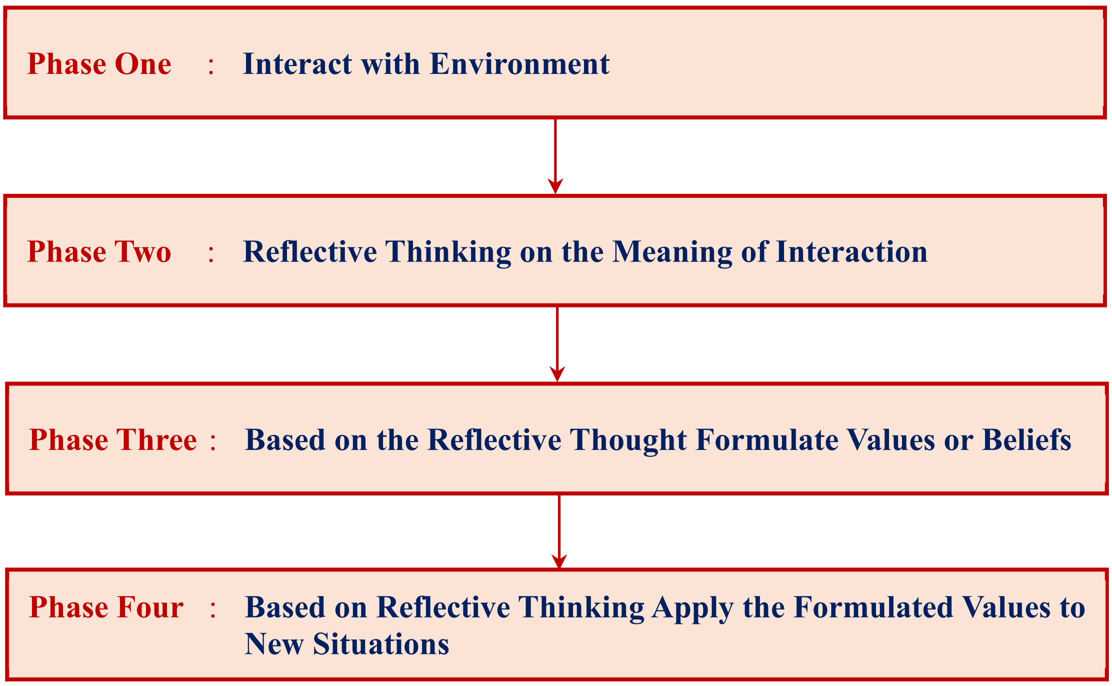
Phase Two: Reflective Thinking on the Meaning of Interaction. The reflective thinking phase and perception of relationships arises only in problematic situations. As long as the individual's interaction with the environment is a fairly smooth affair they may think of nothing or merely day dreams, but when this untroubled state of affairs is disrupted, they have a problem which must be solved before the untroubled state can be restored (Dewey,1933). A real problem arises out of present experiences, suggestions for a solution come to be found, relevant data are observed and a hypothesis is formed, acted upon and finally tested. After the initial interaction, students engage in reflective thinking. Students consider and analyze their experiences, trying to understand the underlying meanings and implications. This stage encourages critical thinking and self - awareness.

Phase Three: Based on the Reflective Thought, Formulate Values or Beliefs. Values or beliefs derives from our own experiences and reflections (Braithwaite, 2000). As a key part of self created beliefs and as a result of experiences students generalize, what they have discovered in one context is applicable to equal situations. Building on their reflections, students begin to identify and formulate values or beliefs. This step involves extracting broader principles or lessons from the experiences of the students, helping them to develop a deeper understanding of the content and its relevance to their lives. The teacher prompts the students to reflect phase 1 and phase 2 and the process they involved in the acquisition of knowledge. Teacher aligns their process of learning with identified beliefs/values and encourages the students to reflect their process to practices in phase 1 and 2 with identified beliefs.

Phase Four: Based on Reflective Thinking Apply the Formulated Values to New Situation. In this phase, students make connections and understand the relationship between the previous problem and the new one. Students are able to summarise their experiences and apply it to new learning as well to draw upon one event and apply it in another context. This habit builds beliefs and confidence and allows students to understand new learning much faster than students who do not apply it as well. Students take the values or beliefs they have derived from their reflective thinking and apply them to new situations. This step encourages the transfer of learning, enabling students to adapt and utilize their acquired knowledge and values in different contexts.

Figure 7

Phases of Process Stage Model



Social System. The social system refers to two elements: students' roles and teachers' roles (Persons, 1960). Specific learning is very much influenced by the kinds of relationships that are structured during the process of teaching. In the Process Stage Model, teachers act as scaffolders or facilitators. The teacher is the task master for providing an unbalanced and interactive situation. Students are active participants in this model. In the Process Stage Model, an interactive and intellectual environment is created. This model is moderately structured. In the first phase, teacher introduces the concepts, and students have no active role. In the first part of the second phase, students are the active participants, and in the last part of this phase, teacher and students have an equal role. In the third and fourth phases, students participate more with the help of the teacher. Throughout the phases, students are actively involved in making sense of mathematics tasks by using varied strategies and representations, justifying solutions, making connections to prior knowledge, familiar context, and experiences, and considering the reasoning of others.

Support System. The support system facilitates the successful implementation of the strategy in the teaching-learning process (Joyce & Weil, 1972). According to the nature of the content, the teacher can use charts, pictures, models, specimens, videos, narrations, field visit etc as support system to nurture the mathematical beliefs and values.

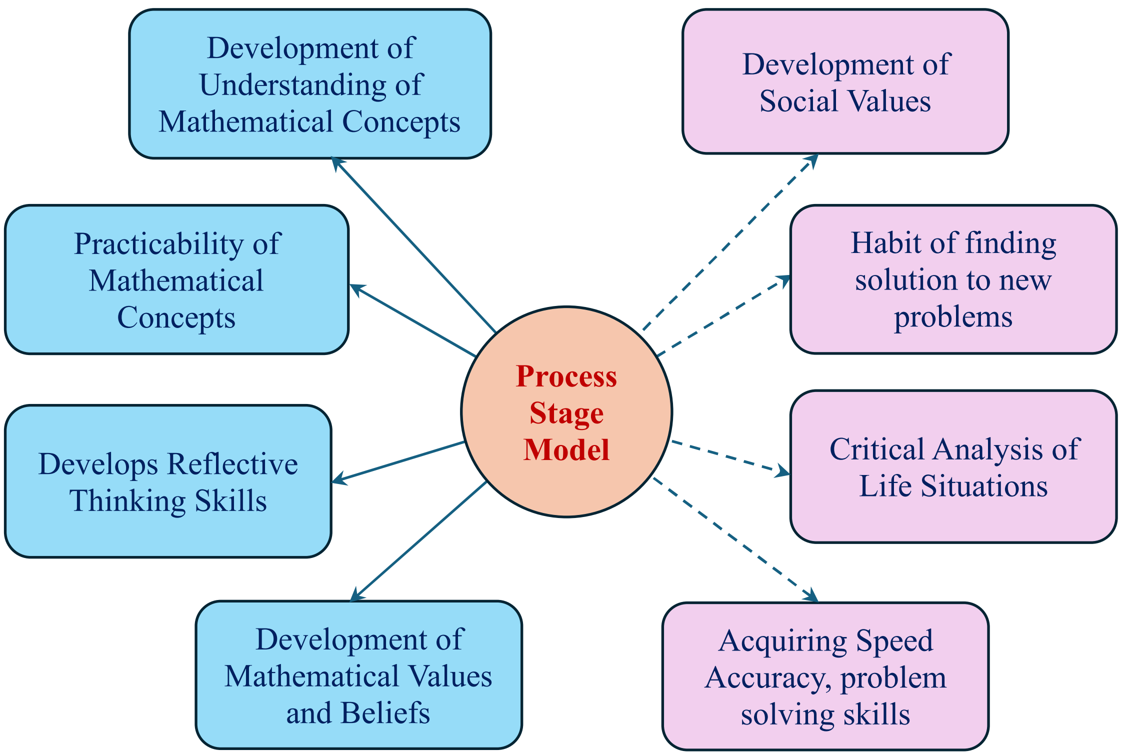
Principles of Reaction. Teacher provides an interactive situation to create an interactive section that provides a task for reflective thinking. Teachers can extend the students' beliefs about the nature of mathematics, beliefs about mathematics in daily life, and beliefs about mathematics teaching and learning and beliefs about competence in mathematics. The teacher's task is to facilitate discovery, nurture the process of inquiry, and induce the students to reflect on it. It should be noted that these tasks should encourage a good level of interaction and investigation.

Instructional Effects. The instructional effects of Process Stage Model are to develop the understanding of mathematical concepts, practicability of mathematical concepts, develops reflective thinking skills, development of mathematical values and beliefs.

Nurturant Effects. Along with instructional effects, the nurturant effects of Process Stage Model are to develop social values, habit of finding solutions to new problems, critical analysis of life situations and acquiring speed, accuracy and problem solving skills.

Figure 8

Instructional and Nurturant Effects of Process Stage Model



Validation of Lesson Transcripts on Process Stage Model

The developed Lesson Transcripts on Process Stage Model was subjected for validation prior the respondents receiving experimental treatment. For the purpose of validation, the investigator consulted with three subject experts in the field of mathematics and mathematics education in addition to the supervising teacher. The modifications suggested by the experts were duly incorporated in the developed lesson transcripts. Thus, the content validity and face validity of the developed Lesson Transcripts on Process Stage Model was ensured. A model of Lesson Transcript on Process Stage Model both Malayalam and English are given in Appendix I and II respectively.

Lesson Transcripts on Constructivist Model

According to Hein (2007), constructivism is the concept that learners independently create their own knowledge. Each learner, through both individual and social experiences, constructs meaning as they progress in their education. This perspective asserts that individuals form new understandings by merging their prior knowledge and beliefs with ideas, events, and activities they experience. Learning in constructivist contexts is characterized by active involvement, inquiry, problem-solving, and teamwork (Abdal-Haqq,1998). The activities helps students to identify their strengths and build knowledge in a way that meets their needs along with the other sections in their social responsibilities. For the intervention with the control group, the investigator created Lesson Transcripts on the Constructivist Model that is existing in the secondary schools of Kerala state. The replica of Lesson Transcripts on

Constructivist Model both Malayalam and English are attached in Appendix III and IV respectively.

Achievement Test in Mathematics (Radhika & Niranjana, 2022)

One of the dependent variables selected for the study is Achievement in Mathematics. In order to measure the Achievement in Mathematics of the experimental and control group of secondary school students before and after the experimentation the investigator prepared and standardized an Achievement Test in Mathematics under the guidance of the supervising teacher. The procedure adopted at different stages of preparation and standardization of Achievement Test in Mathematics is described below:

Planning of the Achievement Test in Mathematics

A thorough study of the curriculum, syllabus, and textbook of mathematics for class VIII for the academic year 2022-2023, was done by the investigator while planning the test. The investigator also consulted the experienced teachers handling mathematics who are working in the secondary schools for guidelines in preparing the Achievement Test in Mathematics. Achievement Test in Mathematics is intended to measure the Achievement in Mathematics of standard VIII students on the unit ‘Identities’. The investigator decided to include almost all concepts of identities of standard VIII as per the syllabus of Kerala State Board while preparing Achievement Test in Mathematics. The investigator also decided to prepare the Achievement Test in Mathematics based on the objectives of cognitive domain proposed in the Revised Bloom’s Taxonomy of Educational objectives (Anderson & Krathwhol, 2001). In addition to that, the investigator decided the duration of the test as 30 minutes and the maximum marks for the test as 30 marks.

Preparation of Preliminary Achievement Test in Mathematics

Items in the Achievement Test in Mathematics were prepared by giving due weightage to objectives, content, and difficulty level. It was decided to include 30 multiple choice test items in the final Achievement Test in Mathematics. The duration of the Achievement Test in Mathematics was decided as 30 minutes and the maximum marks as 30. The design of the Achievement Test in Mathematics for standard VIII students is described below:

Weightage to Objectives. Different levels of cognitive domain, as proposed by Anderson and Krathwohl (2001) in Revised Bloom's Taxonomy, were incorporated as the objectives for the Achievement Test in Mathematics. These objectives encompass various cognitive processes such as remembering, understanding, applying, analysing, evaluating and creating. The weightage given to the objectives in Achievement Test in Mathematics is given in Table 7.

Table 7

Weightage to Objectives

Sl. No.	Objectives	No. of questions	Marks	Percentage
1	Remembering	5	5	16.67
2	Understanding	9	9	30.00
3	Applying	7	7	23.34
4	Analysing	4	4	13.33
5	Evaluating	2	2	6.66
6	Creating	3	3	10.00
	Total	30	30	100

Weightage to Content. To ensure the comprehensiveness of the Achievement Test in Mathematics, adequate weightage has been given to each topic of the unit 'Identities' by analyzing the syllabus and mathematics textbook. The weightage given to the content in the Achievement Test in Mathematics is presented in Table 8.

Table 8

Weightage to Content

Si. No.	Content	No. of questions	Marks	Percentage
1	Product of sums	6	6	20
2	Square of a sum	9	9	30
3	Product of differences	7	7	23.33
4	Sum and differences	8	8	26.67
	Total	30	30	100

Weightage to Difficulty Level. While constructing the test items due care was given to include items in three levels of difficulty i.e., easy, average and difficult. The weightage given to the level of difficulty in the Achievement Test in Mathematics is presented in Table 9.

Table 9

Weightage to Difficulty Level

Sl. No.	Difficulty level	No. of questions	Marks	Percentage
1	Easy	4	4	13.33
2	Average	23	23	76.67
3	Difficult	3	3	10
	Total	30	30	100

Blue Print. The investigator has drafted a two-dimensional blueprint by incorporating weightage to content and objectives for the planned Achievement Test in Mathematics. The blueprint of Achievement Test in Mathematics is presented in the Table 10.

Table 10

Blueprint of Achievement Test in Mathematics

Sl. No.	Objectives / Content	Remembering	Understanding	Applying	Analyzing	Evaluating	Creating	Total no. of questions	Total marks
1	Product of sums	-	2(1)	2(1)	1(1)	-	1(1)	6	6
2	Square of a sum	1(1)	2(1)	3(1)	1(1)	1(1)	1(1)	9	9
3	Product of differences	2(1)	2(1)	1(1)	1(1)	-	1(1)	7	7
4	Sum and differences	2(1)	3(1)	1(1)	1(1)	1(1)	-	8	8
	Total no of questions	5	9	7	4	2	3	30	30
	Total marks	5	9	7	4	2	3	30	30

Note: Figure inside brackets indicate number of questions and those outside brackets indicate marks

It was decided to include 40 items while preparing the preliminary Achievement Test in Mathematics for the purpose of standardization. At most care was taken by the investigator while preparing the items to include the required number of items based on all objectives and content. The selection of items was done by consulting with the experienced teachers who are teaching mathematics and mathematics education at secondary schools in addition to the supervising teacher.

Examples of items based on the objectives are given below:

Remembering

1. $(X+Y)^2 = X^2 +$ ___

a) $X^2 + Y^2$ b) $X^2 + 2XY$ c) $Y^2 + 2XY$ d) $X^2Y^2 + 2X^2Y^2$

Understanding

2. $65^2 = 60^2 + 25 +$ ________

   a) 2×60 b) 2×5 c) $2 \times 60 \times 5$ d) $2 \times 65 \times 25$

Applying

3. A garden was 5 meters long and 3 meters wide. The length of the garden is increased by 2 meters and the width by 1 meter, what is the total area that can be planted in that garden?

   a) $44m^2$ b) $11m^2$ c) $34m^2$ d) $28m^2$

Analyzing

4. (Y + 2) (X+2) = XY + 2Y +2X + 4. Substituting 1 for 2 gives the answer (Y+ 1) (X+1) = ____________.

   a) YX + X+Y+1 b) 2XY + 1 c) XY + 2Y + X + 1 d) XY + Y+ 2X + 2

Evaluating

5. Which statement is correct about the algebraic expression

   $X(X+2) = (X+1)^2 - 1$?

   a) Algebraic form representing the product of any two even numbers.

   b) Algebraic form representing the product of any two odd numbers

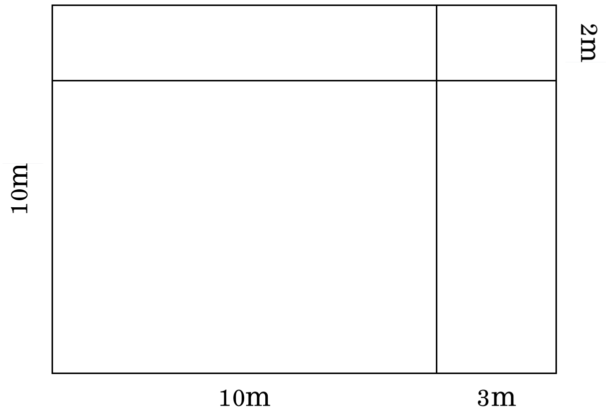
c) Algebraic form representing the product of any two alternative counting numbers

d) Algebraic form representing the product of any two prime numbers

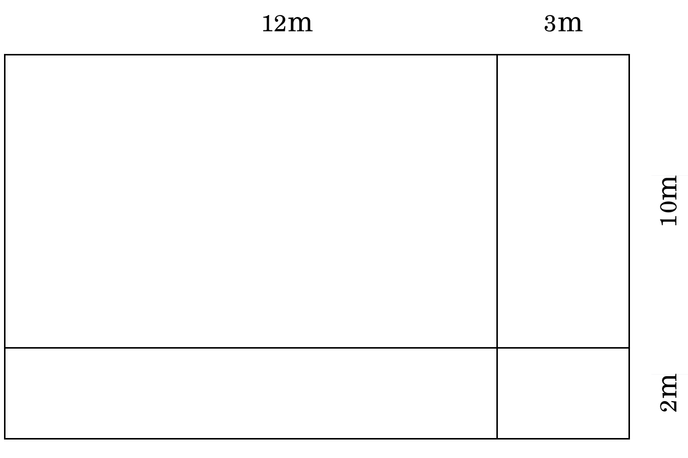
Creating

6. What is the geometric form of (10+2)(12+3)?

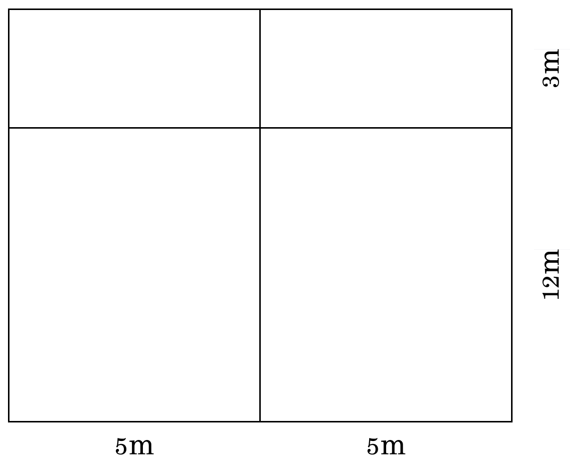
a)



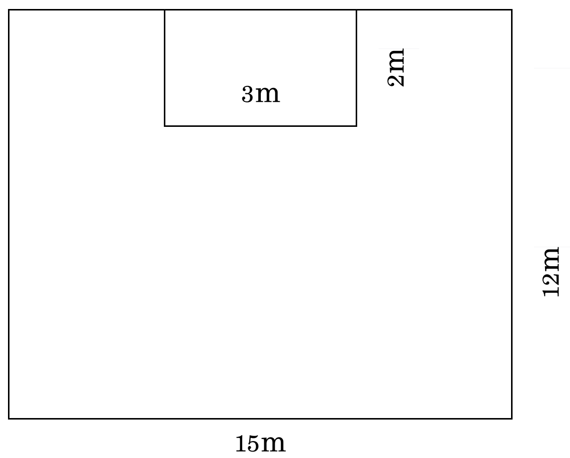
b)



c)



d)



Scoring Procedure

The Achievement Test in Mathematics was designed for standard VIII students in secondary schools was developed by giving due weightage to content, educational objectives, and difficulty level. The test exclusively consisted of multiple choice test items. Separate answer sheets were provided to the students for making their responses with alternatives a, b, c, and d and are required to choose the correct answers from four alternatives. To maintain objectivity in scoring, a scoring key was developed by the investigator. Each correct response was assigned a score of '1' while each incorrect response assigned a score of ‘0’. The total score obtained for each student was then calculated to assess the Achievement in Mathematics of secondary school students. The draft Achievement Test in Mathematics is presented in Appendix V (Malayalam).

Try Out

A sample of 390 secondary school students studying in standard VIII who follow Kerala State syllabus were selected to try out the developed Achievement Test in Mathematics. The draft Achievement Test in Mathematics was administered to the selected sample. Before administering the Achievement Test in Mathematics, the purpose of the test was briefed and necessary instructions were given to the students for filling the responses. The response sheets of 370 sample of secondary school students which are complete in all aspects were selected for item analysis.

Item Analysis

The investigator conducted item analysis of the items in Achievement Test in Mathematics to ensure the quality of the test items and to determine which items should be included in the final test. In order to conduct this analysis, the researcher utilized the procedure outlined by Ebel and Frisbie (1991). The answer sheets of 370 students were thoroughly examined and organized in descending order based on students’ overall scores on Achievement Test in Mathematics. This helped in the identification of both the upper and lower groups, specifically the top 27 percent and bottom 27 percent of the entire sample. The upper group consisted of the 27 percent of respondents with the highest total scores, totaling 100 secondary school students, while the lower group consisted of the 27 percent of respondents with the lowest total scores, i.e., 100 secondary school students. After identifying the upper and lower groups, the number of correct responses for each item within the upper and the lower groups were calculated. Then, the difficulty index and discriminating power of each item were calculated.

Difficulty index is the level of complexity for an item that can be determined by examining the proportion of students who provided a correct response to that particular item. The determination of the difficulty index was done by using the prescribed formula.

$$DI = \frac{U + L}{2N}$$

Where,

U is the number of right responses of an item in the upper group

L is the number of right responses of an item in the lower group

N is the size of the sample of the upper or lower group (N= 100)

The discriminating power of an item is the power of the item to discriminate between the upper and the lower group. The discriminating power (DP) was calculated by using the formula

$$DP = \frac{U - L}{N}$$

Where,

U is the number of right responses of an item in the upper group

L is the number of right responses of an item in the lower group

N is the size of the sample of the upper or lower group (N= 100)

The data and results of item analysis of items in Achievement Test in Mathematics are calculated and presented in Table 11.

Table 11

Data and Results of Item Analysis of Items in Achievement Test in Mathematics

Item. No.	N	U	L	DI	DP	Status
1.	100	66	52	0.59	0.14	Rejected
2.	100	70	46	0.58	0.24	Rejected
3.	100	70	47	0.59	0.23	Rejected
4.	100	76	54	0.65	0.22	Rejected
5.	100	75	51	0.63	0.24	Rejected
6.	100	76	46	0.61	0.30	Accepted
7.	100	69	28	0.49	0.41	Accepted
8.	100	70	52	0.61	0.18	Accepted
9.	100	67	50	0.59	0.17	Rejected
10.	100	76	32	0.54	0.48	Accepted
11.	100	63	30	0.57	0.33	Accepted
12.	100	67	28	0.58	0.39	Accepted
13.	100	71	33	0.62	0.38	Accepted
14.	100	89	37	0.63	0.52	Accepted
15.	100	75	36	0.56	0.39	Accepted
16.	100	54	32	0.43	0.22	Rejected
17.	100	67	36	0.52	0.31	Accepted
18.	100	65	33	0.49	0.32	Accepted
19.	100	67	21	0.44	0.46	Accepted
20.	100	67	27	0.47	0.40	Accepted
21.	100	72	30	0.51	0.42	Accepted
22.	100	72	34	0.53	0.38	Accepted

Item. No.	N	U	L	DI	DP	Status
23.	100	66	24	0.45	0.42	Accepted
24.	100	72	34	0.53	0.38	Accepted
25.	100	82	34	0.58	0.48	Accepted
26.	100	64	32	0.48	0.32	Accepted
27.	100	74	30	0.52	0.44	Accepted
28.	100	73	20	0.47	0.53	Accepted
29.	100	72	29	0.51	0.43	Accepted
30.	100	69	31	0.50	0.38	Accepted
31.	100	61	26	0.44	0.35	Accepted
32.	100	61	26	0.44	0.35	Accepted
33.	100	58	31	0.45	0.27	Rejected
34.	100	62	22	0.42	0.40	Accepted
35.	100	53	36	0.45	0.17	Rejected
36.	100	70	46	0.58	0.24	Rejected
37.	100	68	36	0.52	0.32	Accepted
38.	100	72	29	0.51	0.43	Accepted
39.	100	70	26	0.48	0.44	Accepted
40.	100	78	20	0.49	0.58	Accepted

Finalization of the Achievement Test in Mathematics

On the basis of the indices of discriminating power and difficulty index of each item, the items for final Achievement Test in Mathematics were selected by the investigator. Items having discriminating power more than 0.40 and difficulty index between 0.40 and 0.60 were selected initially. In order to give representation to all objectives those items having discriminating power more than or equal to 0.30 and those items having difficulty index between 0.30 and 0.70 were also selected. The final version of Achievement Test in Mathematics consisted of 30 multiple choice test items. The time limit fixed for completing the Achievement Test in Mathematics is 30 minutes and the maximum marks is 30 marks. The final version of the Achievement Test in Mathematics (Malayalam and English), the response sheet and scoring key are given in Appendix VI, VII, VIII and IX respectively.

Establishing Validity and Reliability of the Achievement Test in Mathematics

The content validity of the developed Achievement Test in Mathematics was established by properly analyzing its objectives and content and by constructing a blueprint that complied with curriculum criteria. Professionals in the field of teaching mathematics and mathematics education evaluated the test items. Experts attested to the appropriateness of the developed Achievement Test in Mathematics for measuring the Achievement in Mathematics of standard VIII secondary school students in relation to the unit ‘identities’. In addition to that the investigator ensured the comprehensiveness of the items with respect to objectives and content of the test. Thus, the investigator established the face validity and content validity of Achievement Test in Mathematics.

The criterion related validity of the Achievement Test in Mathematics was established by correlating the scores of prepared Achievement Test in Mathematics obtained from 30 secondary school students studying in VIII standard with that of the scores obtained to them for mathematics in quarterly examination. The validity coefficient obtained for the Achievement Test in Mathematics is .96 (N= 30) and the index shows that the Achievement Test in Mathematics is valid.

The test-retest method was used to determine the reliability of the developed Achievement Test in Mathematics. The same Achievement Test in Mathematics was administered to the same sample of students (*N* =30) twice over a three week gap. After tabulating the two sets of scores so acquired, the correlation coefficient was calculated and results of Pearson's product moment coefficient of correlation is .63 (*N*= 30). The Cronbach's alpha of the Achievement Test in Mathematics is .77. Thus, the Achievement Test in Mathematics is reliable.

Logical Reasoning Test (Radhika & Niranjana, 2022)

In order to measure the Logical Reasoning of experimental and control groups of secondary school students before and after the experimentation, the investigator developed and standardized a Logical Reasoning Test. The review of related literature demonstrates how logical reasoning can enhance understanding, critical thinking, and problem-solving ability, all of which are essential for succeeding in mathematics (Nurismawati et al., 2018; Anwar et al., 2020). It refers to the cognitive process through which the individuals, particularly school students, begin to develop their reasoning skills from an early age or during their initial years of higher education. When effectively nurtured within the classroom environment, this skill fosters significant reflective abilities (Jaramillo & Puga, 2016). Logical reasoning emerges from the interaction with objects and is cultivated within individuals, enabling them to comprehend the world around them (Suarez et al., 2017). Logical reasoning helps to reveal the inconsistencies present in everyday life. By engaging in logical reasoning, individuals are encouraged to inquire about the mechanisms of their surrounding environment (Mazenett et al., 2019). Logical reasoning serves as a crucial tool for addressing challenges. It emphasizes the importance of logical principles in the acquisition and dissemination of knowledge. The realms of logic and science are inherently interconnected, as logical reasoning supports and enhances mathematical concepts. This connection is enhanced by a thorough understanding and an efficient approach to problem-solving (Luna-Guevara et al., 2021). The detailed description of development and standardization of Logical Reasoning Test is described below.

Planning of the Logical Reasoning Test

Logical reasoning is a cognitive process that involves making inferences, drawing conclusions, and solving problems through a structured and systematic approach (Enyeart, 1980; Bronkhorst, 2020). It is a fundamental aspect of human thinking and decision making playing a crucial role in various domains, including mathematics, philosophy, science, and everyday problem solving. After reviewing the literature related to logical reasoning, the investigator decided to construct the Logical Reasoning Test on the bases of various forms of logical reasoning such as inductive, analogical, deductive and abstract reasoning (Enyeart et al., 1980; Flick & Uwe, 2013; Bronkhorst et al., 2020). The investigator also decided to include 40 multiple choice test items in the draft Logical Reasoning Test for a time duration of 40 minutes.

Preparation of Preliminary Logical Reasoning Test

To measure the Logical Reasoning of secondary school students, it was decided to use a test. The draft Logical Reasoning Test consisted of 44 multiple choice test items related to inductive reasoning, analytical reasoning, deductive reasoning, and abstract reasoning. The students have to select from the four options A, B, C, and D to mark their responses. After consultation with experts, some items were omitted and the items in the draft Logical Reasoning Test were confined to 40 items. The details of dimensions of the Logical Reasoning Test are explained here.

Inductive Reasoning. Inductive reasoning is a logical process that involves making generalizations based on specific observations or evidence. Unlike deductive reasoning, which starts with general premises and draws specific conclusions, inductive reasoning moves from specific instances to broader generalizations (Li & Vitanyi, 2019). It is an essential aspect of everyday problem-solving, scientific inquiry, and learning from experience. The key features of inductive reasoning are observation, pattern recognition and probabilistic conclusions (Copi et al., 2006).

Eg:

Fill in the blank

6,11,16,21, ----

A)26 B) 36 C) 25 D) 24

Analogical Reasoning. Analogical reasoning is a cognitive process that involves recognizing and applying similarities between different situations, objects, or concepts. It relies on the idea that if two things are alike in some respects, they are likely to be alike in other respects as well. Analogical reasoning is a common form of thinking and problem-solving that enables individuals to transfer knowledge from one context to another (Gentner & Smith, 2012)

Eg: 32: 64 :: 33: -----

A)99 B) 81 C) 65 D) 66

Deductive Reasoning. According to Evans (2005), deductive reasoning is a logical process in which conclusions are drawn from general principles or premises and involves moving from a set of specific statements, known as premises, to a logically certain conclusion. Deductive reasoning is characterized by the fact that if the premises are true and the reasoning is valid, the conclusion must also be true (Evans, 2005).

Eg:

Find out what conclusions can be drawn based on the statements.

Statements: A few plants are trees.

All plants are forests

Conclusions 1. All trees are plants

2. At least a few trees are forests

A) Conclusion (1) can be followed.

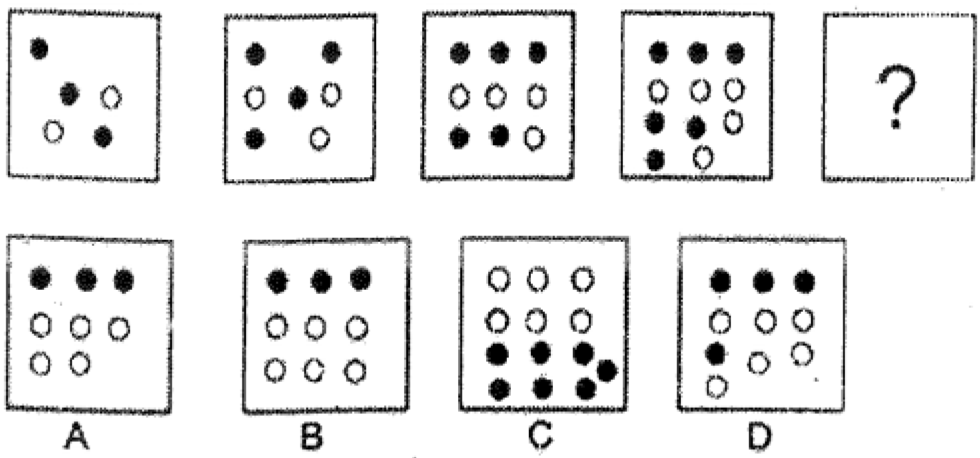
B) Conclusion (2) can be followed.

C) Conclusion (1) or Conclusion (2) can be followed.

D) Conclusion (1) or Conclusion (2) can be followed

Abstract Reasoning. Abstract reasoning is a mental skill that incorporates pattern recognition, relationship comprehension, and prediction-making without relying on language or past information and also referred to as non-verbal reasoning (Gust, 2008; Gentner & Smith, 2012). According to Gentner and Smith (2012) abstract reasoning evaluates a person's aptitude for problem solving and analysis utilizing spatial and visual reasoning.

Eg:



The dimension wise distribution of items in Logical Reasoning Test are given in Table 12.

Table 12

Dimension wise Distribution of Items in Logical Reasoning Test

Sl. No	Forms of reasoning	No. of questions
1.	Inductive Reasoning	10
2.	Analogical Reasoning	10
3.	Deductive Reasoning	10
4.	Abstract Reasoning	10

Scoring Procedure

The draft Logical Reasoning Test consisted of 40 multiple-choice items on the forms of logical reasoning such as inductive, analogical, deductive and abstract reasoning. Separate answer sheets were provided to the students for making their responses with alternatives A, B, C, and D. Students were required to choose the correct answers from four alternatives. Each correct response was assigned a score of '1' while each incorrect response assigned a score of '0'. The total score obtained for each student was then calculated to assess the Logical Reasoning of secondary school students. The draft Logical Reasoning Test is given in Appendix X.

Try Out

A sample of 390 secondary school students studying in standard VIII who follow Kerala State syllabus were selected to try out the developed Logical Reasoning Test. The draft Logical Reasoning Test was administered to the selected sample. Before administering the Logical Reasoning Test, the purpose of the test was briefed and necessary instructions were given to the students for filling the responses. The response sheets of 370 sample of secondary school students which are complete in all aspects were selected for item analysis.

Item Analysis

The investigator conducted item analysis to ensure the quality of the items and to determine which items should be included in the final Logical Reasoning Test. In order to conduct the item analysis, the researcher utilised the procedure outlined by Ebel and Frisbie (1991). The answer sheets of 370 students were thoroughly examined and organized in descending order based on students' overall scores on the Logical Reasoning Test. After arranging in descending order, the upper and lower groups of students were identified, specifically the top 27 percent and bottom 27 percent of the entire sample. The upper group consisted of the 27 percent of respondents with the highest total scores, i.e., 100 students, while the lower group consisted of the 27 percent of respondents with the lowest total scores, i.e. 100 students. Then the number of correct responses for each item within both the upper and the lower groups were identified and calculated the discriminating power of each item.

The discriminating power of an item is the power of that item to discriminate between the upper and lower group. The formula for calculating the discriminating power (DP) is:

$$DP = \frac{U - L}{N}$$

Where,

U is the number of right responses of an item in the upper group

L is the number of right responses of an item in the lower group

N is the size of the sample of the upper or lower group (N= 100)

The data and results of item analysis of items in Logical Reasoning Test are presented in Table 13.

Table 13

Data and Results of Item Analysis of Items in Logical Reasoning Test

Item No.	N	U	L	DP	Status
1	100	87	69	0.18	Rejected
2	100	87	63	0.24	Rejected
3	100	87	61	0.26	Rejected
4	100	88	39	0.49	Accepted
5	100	63	39	0.24	Rejected
6	100	77	34	0.43	Accepted
7	100	61	30	0.31	Accepted
8	100	70	40	0.30	Rejected
9	100	73	34	0.39	Accepted
10	100	64	32	0.32	Accepted

Item No.	N	U	L	DP	Status
II					
1	100	78	39	0.39	Accepted
2	100	61	25	0.36	Accepted
3	100	66	31	0.35	Accepted
4	100	52	27	0.25	Rejected
5	100	73	36	0.37	Accepted
6	100	73	31	0.42	Accepted
7	100	56	27	0.3	Rejected
8	100	79	29	0.5	Accepted
9	100	80	29	0.51	Accepted
10	100	81	50	0.41	Accepted
III					
1	100	74	42	0.32	Accepted
2	100	89	41	0.48	Accepted
3	100	78	35	0.43	Accepted
4	100	70	30	0.40	Accepted
5	100	73	29	0.44	Accepted
6	100	67	30	0.37	Accepted
7	100	72	26	0.46	Accepted
8	100	76	46	0.30	Rejected
9	100	75	35	0.39	Accepted
10	100	75	37	0.38	Accepted
IV					
1	100	86	47	0.39	Accepted
2	100	85	39	0.46	Accepted
3	100	77	45	0.32	Accepted
4	100	78	33	0.45	Accepted
5	100	90	44	0.46	Accepted
6	100	74	41	0.33	Accepted
7	100	78	45	0.33	Accepted
8	100	76	39	0.37	Accepted
9	100	90	49	0.41	Accepted
10	100	74	51	0.23	Rejected

Finalization of the Logical Reasoning Test

On the basis of the indices of discriminating power of each item, the items for the final Logical Reasoning Test were selected by the investigator. Items having discriminating power more than 0.40 a were selected initially. In order to give representation to all forms of logical reasoning those items having discriminating power more than 0.30 were also selected. The final version of the Logical Reasoning Test consisted of 31 multiple choice test items which includes five items on inductive reasoning, eight items on analogical reasoning, nine items on deductive, and nine items on abstract reasoning. The time limit fixed for completing the test is 40 minutes and the maximum score is 31. The final version of the Logical Reasoning Test (Malayalam & English), response sheet and scoring key are given in Appendix XI, XII, XIII and XIV respectively.

Establishing Validity and Reliability of the Logical Reasoning Test

The validity of the Logical Reasoning Test was established by face validity and content validity. Professionals in the field of teaching mathematics and mathematics education evaluated the items in the Logical Reasoning Test and attested the appropriateness of the test for measuring Logical Reasoning of standard VIII secondary school students. In addition to that the investigator ensured the comprehensiveness of the items with respect to the forms of logical reasoning. Thus, the investigator established the face validity and content validity of the Logical Reasoning Test.

The criterion related validity of the Logical Reasoning Test was established by correlating the scores of Logical Reasoning Test obtained from 30 secondary school students studying in VIII standard with that of the scores obtained by administering the Critical Thinking Skill Assessment Questionnaire (Sarigoz, 2012). The validity coefficient obtained for the Logical Reasoning Test is .96 (*N*= 30). This index shows that the Logical Reasoning Test is valid.

The test-retest method was utilized to determine the reliability of the developed Logical Reasoning Test. The same Logical Reasoning Test was administered to a sample of 30 students of VIII standard twice over a three week gap. After tabulating the two sets of scores so collected, the correlation coefficient was calculated and the results of Pearson's product moment coefficient of correlation is .79 (*N*= 30). In addition to that the Cronbach's alpha value obtained is .69. Thus, the Logical Reasoning Test is reliable.

Mathematics Anxiety Scale (Radhika & Niranjana, 2022)

In order to measure the Mathematics Anxiety of experimental and control groups of secondary school students before and after the experimentation, the investigator developed and standardized a Mathematics Anxiety Scale. The existence of learning anxiety can negatively affect students' capacity to understand mathematical concepts (Brady & Bowd, 2005). Various factors, including math learning anxiety (Evans & Mulvey, 2012), the ability of mathematical reasoning (Porru et al., 2019), and motivation to learn (Chen & Lin, 2020), significantly impact the trajectory of student problem-solving. According to Evans and Mulvey (2012), mathematics learning anxiety can arise from the complexity of math problems, potentially leading to increased apprehension and errors in problem-solving. Jiang et al., (2023) further emphasized the adverse effects of this anxiety on students' motivation to learn. This highlights the critical need to tackle learning anxiety in order to create a conducive learning environment and boost students' overall motivation. Gaining a deeper understanding of how learning anxiety interacts with cognitive processes like mathematical reasoning and problem-solving may offer valuable insights into its impact on learning motivation. Hence, measuring mathematics anxiety is a crucial aspect of understanding and improving students' experiences in learning mathematics The details of development and standardization of Mathematics Anxiety Scale are described in this section.

Planning of Mathematics Anxiety Scale

After analysing the existing literature and related studies in mathematics anxiety the investigator decided to develop a scale to test the Mathematics Anxiety of secondary school students. In addition to that it was also decided to develop the Mathematics Anxiety Scale on the dimensions of mathematics anxiety proposed by Yanez-Marquina and Villardon-Gallego (2017). The various dimensions of mathematics Anxiety are everyday life's math anxiety, learning mathematics anxiety, and test anxiety. Mathematics Anxiety Scale was planned with 22 items representing the dimensions of Mathematics Anxiety.

Preparation of Preliminary Mathematics Anxiety Scale

To measure Mathematics Anxiety of secondary school students, it was decided to use Mathematics Anxiety Scale with 22 items on the dimension of Mathematics

Anxiety such as everyday life's math anxiety, learning mathematics anxiety, and test anxiety (Yanez-Marquina & Villardon-Gallego, 2017). The draft scale on Mathematics Anxiety was constructed, which consisted of 25 statements, related to everyday lifes math anxiety, learning mathematics anxiety and test anxiety. The responses were given, viz, 'Always', 'Often', 'Sometimes', 'Rarely' and 'Never'. After consultation with experts, some items were omitted and the items in the draft Mathematics Anxiety Scale were confined to 22 items. The detailed description of dimensions of the Mathematics Anxiety Scale are given below.

Everyday Life's Math Anxiety. Everyday life's math anxiety encompasses a broad range of affective responses to students, everyday situations that require mathematical reasoning (Yanez-Marquina & Villardon-Gallego, 2017).

Eg: I find it difficult to calculate the total amount of purchase after buying items.

Learning Mathematics Anxiety. Math learning anxiety includes affective responses that a math student may experience during different situations of the maths learning process that take place in the scholar setting (Yanez-Marquina & Villardon-Gallego, 2017)

Eg: I feel panic while solving problems in mathematics class.

Math Test Anxiety. Test anxiety refers to feeling that a student has when either preparing or doing a math test. This dimension is considered different, though related to the previous one. In fact, It is conceivable that a student enjoys the subject of mathematics but feels nervous about doing a math problem during exams (Yanez-Marquina & Villardon-Gallego,2017).

Eg: I feel panic when mathematics test include different questions than what I have learned.

The dimension wise distribution of items in the Mathematics Anxiety Scale are presented in Table 14.

Table 14

Dimension wise Distribution of Items in Mathematics Anxiety Scale

Sl. No	Dimension of Mathematics Anxiety	Item No.
1.	Everyday life's math anxiety	1, 2, 3, 4, 5
2.	Learning mathematics anxiety	7, 9, 11, 12, 13, 15, 16, 17, 18, 19
3.	Test anxiety	6, 8, 10, 14, 20, 21, 22

Scoring Procedure

The Mathematics Anxiety Scale consisted of items that can be answered with the responses 'Always', 'Often', 'Sometimes', 'Rarely' and 'Never'. The respondent has to mark their responses to each item in the appropriate columns corresponding to any five alternatives. A score of '5' is given to the response of 'Always', '4' to the response of 'Often', '3' to the response of 'Sometimes' '2' to the response of 'Rarely' and '1' to the response of 'Never'. The total score obtained for items is calculated to identify the scores of mathematics anxiety of secondary school students.

Try Out

A sample of 390 secondary school students studying in standard VIII who follow Kerala State syllabus were selected to try out the developed Mathematics Anxiety Scale. The draft Mathematics Anxiety Scale was administered to the selected sample. Before administering the Mathematics Anxiety Scale, the purpose of the scale was briefed and necessary instructions were given to the students for filling the responses. The response sheets of 370 samples of secondary school students which are complete in all aspects were selected for item analysis.

Item Analysis

Item analysis was carried out to ensure the quality of items and for selecting items in the final Mathematics Anxiety Scale. The selection of items for the final Mathematics Anxiety Scale was done as per the procedure suggested by Edward (1969). The scores obtained for 370 students after try out were arranged in the descending order. The upper 27 percent and lower 27 percent of scores were identified and separated as upper group and lower group respectively. The scores obtained for each item by the upper group as well as the lower group were calculated separately. The *'t'* value was calculated by using the formula:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}}}$$

Where,

X_1 = The mean score on a given statement for the high group.

X_2 = The mean score on a given statement for the low group

S_2^2 = The variance of the distribution of responses of the high group to the statement.

S_1^2 = The variance of the distribution of responses of the low group to the statement.

N_2 = The number of subjects in the high group.

N_1 = The number of subjects in low group.

The data and results of item analysis of Items in Mathematics Anxiety Scale is given in the Table 15.

Table 15

Data and Results of Item Analysis is of Items in Mathematics Anxiety Scale

Item No.	Group	N	Mean	SD	t value
1	Upper	100	3.94	1.15	11.34**
	Lower	100	1.99	1.28	
2	Upper	100	4.30	0.95	12.98**
	Lower	100	2.24	1.27	
3	Upper	100	4.21	1.03	14.68**
	Lower	100	1.96	1.14	
4	Upper	100	3.96	1.11	11.28**
	Lower	100	2.09	1.23	
5	Upper	100	4.22	1.13	13.06**
	Lower	100	2.12	1.15	
6	Upper	100	3.92	1.30	9.02**
	Lower	100	2.35	1.16	
7	Upper	100	3.89	1.21	9.65**
	Lower	100	2.36	1.03	
8	Upper	100	4.54	0.98	18.15**
	Lower	100	1.87	1.10	
9	Upper	100	4.51	0.96	18.62**
	Lower	100	1.88	1.04	
10	Upper	100	4.13	1.19	12.04**
	Lower	100	2.16	1.13	
11	Upper	100	4.32	0.94	14.84**
	Lower	100	2.17	1.10	

Item No.	Group	N	Mean	SD	t value
12	Upper	100	3.86	1.21	9.63**
	Lower	100	2.21	1.22	
13	Upper	100	4.12	1.06	13.52**
	Lower	100	2.16	1.00	
14	Upper	100	3.83	1.30	8.80**
	Lower	100	2.25	1.23	
15	Upper	100	4.16	1.00	13.19**
	Lower	100	2.19	1.12	
16	Upper	100	3.95	1.20	10.90**
	Lower	100	2.18	1.10	
17	Upper	100	4.33	0.91	17.48**
	Lower	100	1.93	1.03	
18	Upper	100	4.10	1.07	12.25**
	Lower	100	2.16	1.17	
19	Upper	100	4.41	1.01	14.39**
	Lower	100	2.12	1.23	
20	Upper	100	4.09	1.04	11.90**
	Lower	100	2.11	1.29	
21	Upper	100	4.03	1.10	13.52**
	Lower	100	1.94	1.09	
22	Upper	100	4.17	1.18	11.30**
	Lower	100	2.20	1.27	

** selected items ($p \leq .01$)

Finalization of the Mathematics Anxiety Scale

Statements with *t* value greater than or equal to 1.96 were selected for the final version of Mathematics Anxiety Scale. Therefore, the final version of n Mathematics Anxiety Scale consists of 22 items. The final version of Mathematics Anxiety Scale (Malayalam and English) and it’s response sheet are presented in Appendix XV and XVI respectively.

Establishing Validity and Reliability of the Mathematics Anxiety Scale

The validity of the Mathematics Anxiety Scale is ensured through face validity and content validity by consulting with experts in the field of education and mathematics education. The criterion related validity of the tool was established by correlating the scores of Mathematics Anxiety Scale collected from 30 secondary school students studying in VIII standard with that of the scores obtained by administering Mathematics Anxiety Scale (Mahmood & Khatoon, 2011). The validity coefficient obtained for the Mathematics Anxiety Scale is .89 (*N*= 30). This index shows that the Mathematics Anxiety Scale is valid.

The reliability of the Mathematics Anxiety Scale was established with the help of the test- retest method. The same Mathematics Anxiety Scale was re- administered to the same sample of secondary school students after three weeks. Pearson's product moment coefficient of correlation is calculated for the two sets of scores to obtain the reliability of the Mathematics Anxiety Scale. The reliability coefficient obtained is .94 (*N*= 30). The index suggests that the Mathematics Anxiety Scale is reliable. The reliability of the Mathematics Anxiety Scale is also established by using Cronbach's alpha. The Cronbach's alpha coefficient obtained is .89 which ensures the reliability of Mathematics Anxiety Scale.

Scale on Achievement Motivation in Mathematics (Radhika & Niranjana, 2022)

In order to measure the Achievement Motivation in Mathematics of experimental and control groups of secondary school students before and after the experimentation, the investigator developed and standardized a Scale on Achievement

Motivation in Mathematics. The review of related literature emphasizes that the Achievement Motivation is a key factor in determining students' academic success, attitudes, persistence, and future aspirations in the field of mathematics and related disciplines (Baker, 2010; Awan, et al., 2011). The details of development and standardization of Scale on Achievement Motivation in Mathematics is explained in this section.

Planning of the Scale on Achievement Motivation in Mathematics

For identifying the components of Achievement Motivation in Mathematics, the investigator made extensive study of related literature. Different forms of motivation include extrinsic, intrinsic, psychological and achievement (Atkinson, 1964; Harackiewicz & Barron et al., 1997). After reviewing the literature, the investigator decided to develop the Scale on Achievement Motivation in Mathematics based on the components such as academic factors and social factors as suggested by Deo and Mohan (1985). Among the various academic and social factors as suggested by Deo and Mohan (1985) investigator decided to select the factors such as academic motivation, need for achievement, work method, importance of marks, need to excel, meaningfulness of daily school task, attitude towards teachers, interpersonal relationship, participation in school activities and social organization according to the nature of the present study. It was also decided to include 42 items in Scale on Achievement Motivation in Mathematics.

Preparation of Preliminary Scale on Achievement Motivation in Mathematics

To measure Achievement Motivation in Mathematics of secondary school students, it was decided to use a Scale on Achievement Motivation in Mathematics. The items were developed based on dimensions of achievement motivation proposed by Deo and Mohan (1985). The draft Scale on Achievement Motivation in Mathematics. was constructed, which consisted of 45 statements, related to the dimensions such as academic motivation, need for achievement, academic challenge, work method, importance of marks, need to excel, meaningfulness of daily school tasks, attitude towards teacher, interpersonal relationship, participation in school activities, and social organisation, The responses were given, viz, 'Always', 'Often', 'Sometimes', 'Rarely' and 'Never'. After consultation with experts, some items were omitted and the items in the draft inventory were confined to 42 items. The items in the tool were randomly arranged in the draft scale. The details of the category of academic factors and social factors included in the Scale on Achievement Motivation in Mathematics are given below.

Academic Motivation. Academic motivation, the key element of achievement motivation, focuses on students' drive, interest, and persistence in academic activities and tasks. It includes all of the internal and environmental variables that affect how engaged and successful students are in their academic success (Deo & Mohan,1992).

Eg: I try to learn more about tables and charts in Mathematics textbooks.

Need for Achievement. The need for achievement is a fundamental component of achievement motivation, reflecting individuals' inherent drive to succeed, accomplish goals, and demonstrate competence in challenging situations. Understanding and supporting the need for achievement can contribute to fostering motivation, enhancing performance, and promoting personal fulfilment and success (Deo & Mohan, 1992).

Eg: I am interested in having my own mathematics library.

Academic challenge. The obstacles and difficulties that are encounter by students in their academic work (Deo & Mohan, 1992)

Eg: I am interested to solve very tough mathematics problems.

Work Method. Work method can be considered as a component of achievement motivation, particularly in the context of individuals' approaches to tasks and their work habits (Deo & Mohan, 1992). While it may not be explicitly defined as a separate component in traditional theories of achievement motivation. It encompasses how individuals approach their work, the strategies they employ, and their overall work ethic.

Eg: I prepare for the next day's mathematics classes the day before.

Importance of Marks. Importance of marks can indeed be considered as a component of achievement motivation, particularly in educational contexts where academic performance is measured and evaluated through grades or marks (Deo &

Mohan, 1992). It reflects individuals' motivation to attain high academic marks or grades as a measure of their success and competence in academic pursuits.

Eg: I wish to make good mathematics achievements in mathematics

Need to Excel. Need to excel is a core component of achievement motivation, reflecting individuals' intrinsic drive and aspiration to achieve excellence in their endeavors (Deo & Mohan, 1992). Understanding and nurturing this component can empower individuals to pursue their goals with passion, determination, and a commitment to continuous improvement, ultimately leading to personal fulfilment and success in their chosen pursuits.

Eg: When I am studying mathematics I do not feel studying other subjects.

Meaningfulness of Daily School Tasks. The meaningfulness of daily school tasks is a vital component of achievement motivation, reflecting students' perceptions of the relevance, significance, and personal value they attribute to their academic activities and assignments. Fostering a sense of meaningfulness in daily school tasks can enhance students' intrinsic motivation, engagement, and academic success, ultimately contributing to their overall well-being and fulfillment as learners (Deo and Mohan, 1992).

Eg: I feel that success in life can be achieved through studying mathematics.

Attitude Towards Teacher. Attitude towards teachers is a critical component of Achievement Motivation, reflecting students' perceptions, feelings, and interactions with their teachers, which can profoundly influence their motivation, engagement, and academic success. Fostering positive teacher-student relationships, creating supportive learning environments, and providing effective feedback and encouragement are essential strategies for promoting a positive attitude towards learning and cultivating students' motivation to excel academically (Deo & Mohan, 1992).

Eg: I think my mathematics teachers are talented.

Interpersonal Relationship. Interpersonal relationship can indeed be considered as a component, reflecting the quality of relationships and interactions that students have with their peers, teachers, and other members of the academic community (Deo & Mohan, 1992).

Eg: I would like to be with people who excel in mathematics.

Participation in School Activities. Participation in school activities is a crucial component of achievement motivation, reflecting students' engagement, involvement, and investment in various extracurricular, co-curricular, and academic activities within the school community (Deo & Mohan, 1992)

Eg: I try to coordinate extracurricular activities with mathematics learning.

Social Organisation. Social organisation significantly influences individuals' motivation and behavior within social contexts. Positive social environments characterized by support, encouragement, collaboration, and recognition can enhance individuals' motivation to achieve their goals, while negative social dynamics may hinder motivation (Deo & Mohan, 1992).

Eg: I try to organize programmes related to mathematics.

The dimension wise distribution of items in Scale on Achievement Motivation in Mathematics are presented in Table 16.

Table 16

Dimension wise Distribution of Items in Scale on Achievement Motivation in Mathematics

Sl. No	Dimension of Mathematics Achievement Motivation	Item No.
Academic factors		
1.	Academic motivation	1,3,8,11, 18, 26, 32, 36, 41
2.	Need for achievement	4,5,9, 28,
3.	Academic challenge	6, 40,
4.	Work method	2,10, 12, 19, 20,21, 23, 24, 27,42
5.	Importance of marks	7,13,25, 33
6.	Need to excel	14,34,
7.	Meaningfulness of daily school tasks	15, 16, 35, 37
8.	Attitude towards teacher	29, 30, 31,
Social factors		
9.	Interpersonal relationship	17, 39,
10.	Participation in school activities	22
11.	Social organisation	38

Scoring Procedure

The Scale on Achievement Motivation in Mathematics consisted of items that can be answered with the responses 'Always', 'Often', 'Sometimes', 'Rarely' and ' Never'. The respondent has to mark their responses to each item in the appropriate columns corresponding to any five alternatives. A score of '5' is given to the response of 'Always', '4' to the response of 'Often', '3' to the response of 'Sometimes', '2' to the response of 'Rarely' and '1' to the response of 'Never'. The total score obtained for items is calculated to identify the scores of Achievement Motivation in Mathematics of secondary school students.

Try Out

A sample of 390 secondary school students studying in standard VIII who follow Kerala State syllabus were selected to try out the Scale on Achievement Motivation in Mathematics. The draft Scale on Achievement Motivation in Mathematics was administered to the selected sample. Before administering the tool, the investigator briefed the purpose of the study and necessary instructions to fill the responses were given to the students. The response sheets of 370 samples complete in all aspects were selected for item analysis.

Item Analysis

Item analysis was carried out to ensure the quality of items and for selecting items in the final Scale on Achievement Motivation in Mathematics. The selection of items for the final Scale on Achievement Motivation in Mathematics was done as per the procedure suggested by Edward (1969). The scores obtained for 370 secondary school students after pilot testing were arranged in the descending order. The upper 27 percent and lower 27 percent of scores were identified and separated as upper group and lower group respectively. The scores obtained for each item by the upper group as well as the lower group were calculated separately and the '*t*' value was calculated by using the formula:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}}}$$

Where,

X_1 = The mean score on a given statement for the high group.

X_2 = The mean score on a given statement for the low group

s_2^2 = The variance of the distribution of responses of the high group to the statement.

s_1^2 = The variance of the distribution of responses of the low group to the statement.

N_2 = The number of subjects in the high group.

N_1 = The number of subjects in low group.

The data and results of item analysis of items in Scale on Achievement Motivation in Mathematics is given in Table 17.

Table 17

Data and Results of Item Analysis of Items in Scale in Achievement Motivation in Mathematics

Item No.	Group	N	Mean	SD	t value
1	Upper	100	4.08	0.8	13.03**
	Lower	100	2.12	1.23	
2	Upper	100	4.57	0.70	9.22**
	Lower	100	3.37	1.09	
3	Upper	100	4.41	0.75	12.55**
	Lower	100	2.59	1.23	

Item No.	Group	N	Mean	SD	t value
4	Upper	100	4.26	0.79	10.71**
	Lower	100	2.68	1.23	
5	Upper	100	3.05	1.33	9.85**
	Lower	100	1.42	0.98	
6	Upper	100	4.63	0.56	10.68**
	Lower	100	3.22	1.19	
7	Upper	100	4.30	0.95	10.08**
	Lower	100	2.80	1.13	
8	Upper	100	4.2	0.93	9.82**
	Lower	100	2.71	1.25	
9	Upper	100	4.32	0.98	9.57**
	Lower	100	2.73	1.33	
10	Upper	100	4.21	1.01	11.56**
	Lower	100	2.26	1.35	
11	Upper	100	4.29	0.91	10.98**
	Lower	100	2.64	1.19	
12	Upper	100	4.41	0.79	11.74**
	Lower	100	2.63	1.29	
13	Upper	100	4.51	0.79	12.56**
	Lower	100	2.73	1.17	
14	Upper	100	3.52	1.50	4.53**
	Lower	100	2.59	1.40	
15	Upper	100	4.10	1.08	9.05**
	Lower	100	2.62	1.22	
16	Upper	100	4.20	0.87	9.43**
	Lower	100	2.69	1.33	
17	Upper	100	3.10	1.34	8.58**
	Lower	100	1.63	1.06	
18	Upper	100	3.57	1.81	4.28**
	Lower	100	2.60	1.35	
19	Upper	100	4.20	0.98	11.40**
	Lower	100	2.30	1.34	

Item No.	Group	N	Mean	SD	t value
20	Upper	100	4.64	0.67	13.74^{**}
	Lower	100	2.66	1.27	
21	Upper	100	4.83	5.01	4.03^{**}
	Lower	100	2.75	1.20	
22	Upper	100	4.56	0.57	14.02^{**}
	Lower	100	2.69	1.20	
23	Upper	100	4.55	0.66	11.35^{**}
	Lower	100	2.97	1.22	
24	Upper	100	4.71	0.67	9.09^{**}
	Lower	100	3.28	1.42	
25	Upper	100	4.61	0.79	6.09^{**}
	Lower	100	3.57	1.51	
26	Upper	100	3.70	1.20	10.99^{**}
	Lower	100	1.87	1.15	
27	Upper	100	3.83	1.18	10.45^{**}
	Lower	100	2.10	1.15	
28	Upper	100	4.16	0.84	11.56^{**}
	Lower	100	2.54	1.11	
29	Upper	100	4.73	0.63	6.13^{**}
	Lower	100	3.79	1.39	
30	Upper	100	4.69	0.61	9.33^{**}
	Lower	100	3.35	1.29	
31	Upper	100	4.70	0.70	8.70^{**}
	Lower	100	3.41	1.30	
32	Upper	100	4.28	0.91	10.68^{**}
	Lower	100	2.50	1.30	
33	Upper	100	4.39	0.87	10.06^{**}
	Lower	100	2.83	1.28	
34	Upper	100	4.67	0.69	7.28^{**}
	Lower	100	3.50	1.44	
35	Upper	100	4.21	0.90	6.92^{**}
	Lower	100	3.14	1.25	

Item No.	Group	N	Mean	SD	t value
36	Upper	100	4.32	0.81	11.73**
	Lower	100	2.70	1.11	
37	Upper	100	4.10	1.01	8.88**
	Lower	100	2.68	1.23	
38	Upper	100	3.78	1.05	8.67**
	Lower	100	2.42	1.15	
39	Upper	100	4.54	0.77	13.35**
	Lower	100	2.57	1.25	
40	Upper	100	4.33	0.81	10.57**
	Lower	100	2.70	1.30	
41	Upper	100	3.94	0.98	9.91**
	Lower	100	2.29	1.34	
42	Upper	100	4.10	0.98	11.84**
	Lower	100	2.23	1.25	

** selected items ($p \leq .01$)

Finalization of the Scale on Achievement Motivation in Mathematics

After the item analysis, the statements with *t* value greater than or equal to 1.96 were selected for the final version of Scale on Achievement Motivation in Mathematics. Therefore, the final version of Scale on Achievement Motivation in Mathematics consists of 42 items. The final version of the Scale on Achievement Motivation in Mathematics (Malayalam and English) and its response sheet are presented in Appendix XVII and XVIII respectively.

Establishing Validity and Reliability of the Scale on Achievement Motivation in Mathematics

The validity of the Scale on Achievement Motivation in Mathematics is ensured through face validity and content validity by consulting with experts in the field of education and mathematics education. The criterion related validity of the Scale on Achievement Motivation in Mathematics was established by correlating the scores of Scale on Mathematics Achievement motivation obtained from 30 secondary school students studying in VIII standard with that of the scores obtained by administering Scale of Achievement Motivation in Mathematics (Vijayakumari & Sumangala, 2000). The validity coefficient obtained for the Scale on Achievement Motivation in Mathematics is .89 (*N*= 30). This index shows that the Scale on Achievement Motivation in Mathematics is valid.

The reliability of the Scale on Achievement Motivation in Mathematics was established with the help of the test-retest method. The same scale was re-administered to the same sample after three weeks. Pearson's product moment coefficient of correlation is calculated for the two sets of scores to obtain the reliability of the Scale on Achievement Motivation in Mathematics. The reliability coefficient obtained is .73 (*N*= 30). The index suggests that the Scale on Achievement Motivation in Mathematics is reliable. The reliability of the instrument is also established by using Cronbach's alpha. The Cronbach's alpha coefficient obtained is .94 which ensures the reliability of Scale on Achievement Motivation in Mathematics.

Mathematical Beliefs Inventory (Radhika & Niranjana, 2022)

Research evidence supports that mathematics is a cornerstone of education, contributing to cognitive development, practical skills, and a deeper understanding of the world (Yadav, 2019).

Mathematical beliefs serve as a regulatory frame work that becomes clear when individual recognize that they shape an individual's knowledge structure. With in this framework, the individual is able to think and act in specific ways (Pehkonen & Torner, 1996). Recognizing and fostering positive mathematical beliefs is integral to creating a supportive and inclusive learning environment that promotes engagement, confidence, and achievement in mathematics (Alam & Mohanty, 2023). In order to measure the Mathematical Beliefs of experimental and control groups of secondary school students before and after the experimentation, the investigator developed and standardized Mathematical Beliefs Inventory. The detailed description of development and standardization of Mathematical Beliefs Inventory is given in this section.

Planning of Preliminary Mathematical Beliefs Inventory

The investigator had gone through the theoretical background and related studies in Mathematical Beliefs and decided to construct the Mathematical Beliefs Inventory on the dimensions, beliefs about the nature of mathematics, beliefs about mathematics in daily life, beliefs about mathematics teaching and learning, and beliefs about competence in Mathematics proposed by Grouws and Howald et al.,(1996), Zakaria and Musiran (2010) and Op't Eynde and De Cortes' (2004). It was also decided to incorporate 50 items in the draft Mathematical Beliefs Inventory.

Preparation of Preliminary Mathematical Beliefs Inventory

To measure the Mathematical Beliefs of secondary school students, it was decided to use Mathematical Beliefs Inventory with 50 statements, related to beliefs about the nature of mathematics, beliefs about mathematics in daily life, beliefs about mathematics teaching and learning, and beliefs about competence in mathematics. The responses were given viz, 'Agree' and 'Disagree' to mark the responses of students. The initial draft Mathematical Beliefs Inventory consisted of 50 items, after consultation with experts, some items were omitted and the items in the draft Mathematical Beliefs Inventory were confined to 44 items. The items were developed based on the dimensions of mathematical beliefs proposed by Grouws and Howald et al. (1996), Op't Eynde and De Cortes' (2004) and Zakaria and Musiran (2010). The items in the inventory were randomly arranged in the draft Mathematical Beliefs Inventory. Items related to naive beliefs and sophisticated beliefs were included in the inventory. The detailed description of dimensions of Mathematical Beliefs Inventory is given below.

Beliefs about the Nature of Mathematics. Individuals believe that mathematics subject is a key to scientific knowledge and there exists a meaningful connection between the mathematical concepts and study of mathematics helps to develop systematic, scientific, and logical thinking among individuals (Grouws & Howald et al., 1996, Zakaria & Musiran, 2010). Students believe that Mathematics is dynamic in nature, Mathematics is systematized, organised, and the exact branch of science deals with abstract concepts (Grouws & Howald et al., 1996, Zakaria & Musiran, 2010).

Eg: Mathematics helps in the development of logical thinking.

Beliefs about Mathematics in Daily Life. Individuals consider mathematics to be an undertaking science and as a subject that is highly valuable in daily life. Science mathematics is a formal representation of the real world, many individuals also think that Mathematics makes it easier for them to understand the world around them (Grouws & Howald et al., 1996).

Eg: Understanding of mathematics helps to earn for livelihood

Beliefs About Competency in Mathematics. In order to become proficient problem solvers in mathematics, students must cultivate a positive mathematical mindset, with a focus on affective factors such as emotions, motivations, and self-perceptions (Op't Eynde & De Corte, 2004). These beliefs encompass individuals' perceptions, attitudes, and self- evaluations regarding their own mathematical abilities, skills and potential for success in mathematical tasks and activities (Op't Eynde & De Corte, 2004).

Eg: It is highly challenging to find solutions for mathematics problems.

Beliefs about Mathematics Teaching and Learning. Students believe that learning mathematics is an active process and develops critical thinking, enabling them to find solutions to the problems of mathematics in their own way as well every problem in mathematics can be solved by adopting systematic methods (Zakaria & Musiran ,2010).

Eg: Different methods can be used to solve mathematics problems.

Thus, the draft Mathematical Beliefs Inventory consist of 44 items, in which 15 are naive belief items and 29 are sophisticated belief items. The dimension wise distribution of items in Mathematical Beliefs Inventory are presented in the Table 18.

Table 18

Dimension- wise Distribution of Items in Mathematical Beliefs Inventory

Sl. No.	Dimensions of mathematical beliefs	Item numbers
1.	Beliefs about the nature of mathematics	1, 2, 3, 4, 8, 11, 13, 14, 15, 22, 26, 27, 28, 35, 36, 43
2.	Beliefs about mathematics in daily life	5, 16, 17, 18, 19, 29, 38
3.	Beliefs about competence in mathematics	6, 7, 20, 21, 30, 31, 39, 40, 44
4.	Beliefs about mathematics teaching and learning	9, 10, 12, 23,24,25, 32, 33, 34, 37, 41, 42,

Scoring Procedure

The Mathematical Beliefs Inventory consisted of items that can be answered with the responses ‘Agree’ or ‘Disagree’. The respondent has to mark their responses to each item in the appropriate columns corresponding to any two alternatives. The naive belief item is scored ‘0’ for ‘Agree’ and ‘1’ for ‘disagree’. The sophisticated belief items scored ‘1’ for ‘Agree’ and ‘0’ for ‘Disagree’. The total score obtained for items is calculated to identify the scores of Mathematical Beliefs of secondary school students. The draft Mathematical Beliefs Inventory is presented in Appendix XIX.

Try Out

A sample of 390 secondary school students studying in standard VIII who follow Kerala State syllabus were selected to try out Mathematical Beliefs Inventory. The draft Mathematical Beliefs Inventory was administered to the selected sample. Before administering the inventory, the investigator briefed the purpose of the study and necessary instructions to fill the responses were given. The response sheets of 370 sample complete in all aspects were selected for item analysis.

Item Analysis

Item analysis was carried out to ensure the quality of items and for selecting items in the final Mathematical Beliefs Inventory. The selection of items for the final Mathematical Beliefs Inventory was done as per the procedure suggested by Edward (1969). The scores obtained for 370 students after try out were arranged in the descending order. The upper 27 percent and lower 27 percent of scores were identified and separated as upper group and lower group respectively. The scores obtained for each item by the upper group as well as the lower group were calculated separately. The *t* value was calculated by using the formula:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}}}$$

Where,

X_1 = The mean score on a given statement for the high group.

X_2 = The mean score on a given statement for the low group

s_2^2 = The variance of the distribution of responses of the high group to the statement.

s_1^2 = The variance of the distribution of responses of the low group to the statement.

N_2 = The number of subjects in the high group.

N_1 = The number of subjects in low group.

The data and results of item analysis of items in Mathematical Beliefs Inventory is given in the Table 19.

Table 19

Data and Results of Item Analysis of Items of Mathematical Belief Inventory

Item No.	Group	N	Mean	SD	t value
1	Upper	100	0.31	0.46	0.52
	Lower	100	0.28	0.45	
2	Upper	100	0.91	0.28	5.05**
	Lower	100	0.62	0.48	
3	Upper	100	0.18	0.39	1.58
	Lower	100	0.28	0.45	
4	Upper	100	0.95	0.21	5.94**
	Lower	100	0.63	0.48	
5	Upper	100	0.81	0.39	5.95**
	Lower	100	0.43	0.49	
6	Upper	100	0.53	0.50	3.72**
	Lower	100	0.28	0.45	
7	Upper	100	0.86	0.34	5.84**
	Lower	100	0.50	0.50	
8	Upper	100	0.44	0.50	0.59
	Lower	100	0.40	0.49	
9	Upper	100	0.86	0.34	5.19**
	Lower	100	0.54	0.59	

Item No.	Group	N	Mean	SD	t value
10	Upper	100	0.98	1.05	3.44**
	Lower	100	0.57	0.49	
11	Upper	100	0.78	0.41	4.56**
	Lower	100	0.48	0.50	
12	Upper	100	0.94	0.23	6.98**
	Lower	100	0.55	0.49	
13	Upper	100	0.66	0.47	3.94**
	Lower	100	0.39	0.49	
14	Upper	100	0.79	0.40	3.97**
	Lower	100	0.53	0.50	
15	Upper	100	0.39	0.49	0.31
	Lower	100	0.41	0.49	
16	Upper	100	0.80	0.40	2.64**
	Lower	100	0.63	0.48	
17	Upper	100	0.78	0.41	4.10**
	Lower	100	0.51	0.50	
18	Upper	100	0.91	0.28	6.35**
	Lower	100	0.54	0.50	
19	Upper	100	0.99	0.95	4.64**
	Lower	100	0.48	0.50	
20	Upper	100	0.82	0.38	4.85**
	Lower	100	0.51	0.50	
21	Upper	100	0.93	0.25	8.50**
	Lower	100	0.45	0.50	
22	Upper	100	0.95	0.21	6.76**
	Lower	100	0.58	0.49	
23	Upper	100	0.93	0.25	7.22**
	Lower	100	0.52	0.50	
24	Upper	100	0.87	0.33	3.52**
	Lower	100	0.66	0.47	
25	Upper	100	0.78	0.41	5.04**
	Lower	100	0.45	0.50	

Item No.	Group	N	Mean	SD	t value
26	Upper	100	0.53	0.50	0.15
	Lower	100	0.54	0.50	
27	Upper	100	0.88	0.32	5.75**
	Lower	100	0.57	0.49	
28	Upper	100	0.81	0.39	3.42**
	Lower	100	0.59	0.49	
29	Upper	100	0.81	0.39	5.13**
	Lower	100	0.48	0.50	
30	Upper	100	0.77	0.42	3.92**
	Lower	100	0.51	0.50	
31	Upper	100	0.90	0.30	7.85**
	Lower	100	0.44	0.49	
32	Upper	100	0.86	0.34	3.00**
	Lower	100	0.68	0.46	
33	Upper	100	0.77	0.42	5.18**
	Lower	100	0.43	0.49	
34	Upper	100	0.61	0.48	1.12
	Lower	100	0.53	0.50	
35	Upper	100	0.33	0.47	1.22
	Lower	100	0.41	0.49	
36	Upper	100	0.43	0.49	0.98
	Lower	100	0.50	0.50	
37	Upper	100	0.38	0.48	0.31
	Lower	100	0.41	0.50	
38	Upper	100	0.52	0.50	0.27
	Lower	100	0.50	0.50	
39	Upper	100	0.82	0.38	5.82**
	Lower	100	0.45	0.50	
40	Upper	100	0.88	0.32	6.98**
	Lower	100	0.46	0.50	
41	Upper	100	0.76	0.42	2.60**
	Lower	100	0.62	0.48	

Item No.	Group	N	Mean	SD	t value
42	Upper	100	0.84	0.36	4.93^{**}
	Lower	100	0.53	0.50	
43	Upper	100	0.91	0.28	3.30^{**}
	Lower	100	0.73	0.44	
44	Upper	100	0.97	0.17	8.80^{**}
	Lower	100	0.50	0.50	

Finalization of the Mathematical Beliefs Inventory

Statements with *t* value greater than or equal to 1.96 were selected for the final version of Mathematical Beliefs Inventory. Therefore, the final version of Mathematical Beliefs Inventory consists of 34 items, out of which 7 are naive belief items and 27 are sophisticated beliefs items. The final version of the Mathematical Beliefs Inventory (Malayalam and English) are presented in Appendix XX and XXI respectively.

Establishing Validity and Reliability of the Mathematical Beliefs Inventory

The validity of the Mathematical Beliefs Inventory is ensured through face validity and content validity by consulting with experts in the field of education and mathematics education. The criterion related validity of the Mathematical Beliefs Inventory was established by correlating the scores of Mathematical Beliefs Inventory obtained from 30 secondary school students studying in VIII standard with that of the scores obtained by administering the Mathematics Study Attitude and Belief Scale (Noushad & Joseph, 2022). The validity coefficient obtained for the Mathematical

Beliefs Inventory is 0.89 (*N*= 30). This index shows that the Mathematical Beliefs Inventory is valid.

The reliability of the Mathematical Beliefs Inventory was established with the help of test-retest method. The same Mathematical Beliefs Inventory was re-administered to the same sample after three weeks. Pearson's product moment coefficient of correlation is calculated for the two sets of scores to obtain the reliability of the scale. The reliability coefficient obtained is .89 (*N*= 30). The index suggests that the Mathematical Beliefs Inventory is reliable. The reliability of the Mathematical Beliefs Inventory is also established by using Cronbach's Alpha. The Cronbach's alpha coefficient obtained is .67 which ensures the reliability of Mathematical Beliefs Inventory.

Sample Selected for the Study

The population considered for the study is secondary school students studying in high schools of Kerala state who follow Kerala state syllabus. For conducting the first phase, survey phase, a sample of 600 students studying in VIII standard was selected from four districts of Kerala state Viz: from Thiuvananthapuram, Alappuzha, Palakkad, Kozhikode, Kannur and Kasargod. Districts of Kerala state. Simple random sampling technique was used while selecting the sample for survey and experiment. The details of final sample of the study are given in Table 20.

Table 20

Details of Final Sample used for the Study

SI. No.	Name of the school	District	No. of samples
1	Fort Girls Mission High School, Pazhavangadi.	Thivandram	100
2	Sree Vijayeswari High School, Cherianad, Chengannur	Alappuzha	100
3	GHSS, Pattambi.	Palakkad	50
4	GHSS, Kumaranellur	Palakkad	50
5	Malabar Christian College Hss, Vellayil	Kozhikode	50
6	GGVHSS, Feroke	Kozhikode	50
7	IMNS GHSS, Mayyil	Kannur	50
8	Parassinikadavu HSS	Kannur	50
9	GHSS, Udma	Kasargode	100
		TOTAL	600

During the second phase, for the experimentation, the sample comprised 62 secondary school students studying in VIII standard from two divisions of the same school, Aided Higher Secondary School, Peringode, in Palakkad district of Kerala state. The experimental group comprised of 31 secondary school students and the control group also comprised of 31 secondary school students of VIII standard. Intact class was used in both experimental and control groups.

Data Collection Procedure

The study was conducted in two phases, survey phase and experimentation phase. During the survey phase of the study, the data required for the study were collected from the selected sample of secondary school students studying in VIII standard of various schools in Kerala state. The investigator approached the headmasters of selected schools in order to get permission to collect the required data. After getting permission from the authorities, the required data were collected from students of selected schools in each district. Before administering the tool, the investigator briefed the purpose of the study and ensured the confidentiality of their responses as well as necessary directions were given to the students for filling the responses. The investigator administered the instrument, Mathematical Belief Inventory, for a time duration of 40 minutes and the duly filled response sheets were collected and considered for data analysis.

For phase II, experimental phase, the plan for experimental study was given in advance to the head of the selected school, Higher Secondary School, Peringode. As per the schedule planned, pre-test, experimental study, post-test were conducted. While administering the instruments, proper instructions were given to the experimental and control groups regarding the procedure of the study. Only after being sure that students had followed the instructions properly the instruments were administered during the pre-test and post-test. The instruments such as Achievement Test in Mathematics, Logical Reasoning Test, Mathematics Anxiety Scale, Scale on Achievement Motivation in Mathematics, and Mathematical Beliefs Inventory were administered during the pre-test and post-test in order to measure the variable before and after the experimentation for a time duration of 30 minutes, 40 minutes, 25 minutes, 45 minutes, 40 minutes respectively.

After collecting the response sheets from the students, the investigator scored them according to the scoring procedures of each instrument and tabulated. The tabulated data were analysed by using SPSS Version 27 as per objectives of the study.

Statistical Techniques Employed

The statistical techniques help the investigator to analyse the data quantitatively and interpret meaningfully on the basis of the analysed data. The study utilized several statistical techniques to achieve its objectives. The analysis procedures are classified under three major heads namely,

Descriptive statistics

Mean, median, mode, standard deviation, skewness and kurtosis of each dependent variable, Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs were calculated to know the basic properties of the distribution. Descriptive statistics were used to summarize, organize and simplify data which helped the investigator to describe the nature of the dependent variable, such as Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Mathematics Achievement Motivation, and Mathematical Beliefs, for the selected sample.

Probability-Probability Plot (P-P Plot)

P-P plots of the distribution of scores of the dependent variables, Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs, of secondary school students were calculated to know whether the distribution of scores of dependent variable follows normality for the pre-test and post-test scores of experimental and control groups.

Pearson's product moment coefficient of correlation

Pearson's correlation was calculated to obtain the reliability of the scales, Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs, It is also used to calculate the correlation between mean scores of pre-test and post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs of experimental and control groups. Product moment correlation was calculated to assess how much of variation in the post-test scores can be explained by pre-test scores of experimental and control groups. Pearson's product moment correlation between the covariate (pre-test scores of Mathematical Beliefs) and the dependent variable (post-test scores of Mathematical Beliefs) is calculated for controlling the initial differences in Mathematical Beliefs. It also used to ensure whether the assumptions of ANCOVA are met.

Levene's Test for Equality of Variance

Levene's test was conducted to confirm the homogeneity of variance before testing the significance of the difference between the mean scores of pre-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, Mathematical Beliefs of experimental and control groups. Significance of the difference between the mean scores of post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs of experimental and control groups and to confirm the homogeneity of variance before testing the significance of the difference between the mean scores of two groups.

One Sample t test

One Sample *t* test was used to test the significance of difference between the mean value obtained for Mathematical Beliefs and the test value of Mathematical Beliefs Inventory to analyze the level of Mathematical Beliefs of secondary school students.

The Test of Significance of Difference Between Means of Large Independent Sample (t-Test)

Large Independent sample *t*-test was conducted to compare mean scores of pre-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical beliefs for experimental and control groups. It also used to compare mean scores of post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs for experimental and control groups and to know the difference in the mean scores of gain scores on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, Mathematical Beliefs of secondary school students for experimental and control groups.

Test of Significance of Difference Between Mean of Large Dependent Sample (Paired Sample t-Test)

Paired sample *t*-test was conducted to compare pre-test and post-test mean scores on the dependent variables, Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs within the experimental and control groups.

Cohen's d

Cohen's *d* was used to find out the effectiveness of Process Stage Model through finding out the effect size of mean scores of post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs of the experimental and control groups, to find out the effectiveness of Process Stage Model. It also used to test the effect size of mean scores of pre-test and post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs of experimental group of secondary school students to find out the effectiveness of Process Stage Model.

Analysis of Covariance (ANCOVA)

Analysis of covariance is used to compare mean post-test scores of Mathematical Beliefs for experimental and control groups after controlling pre-test scores of Mathematical Beliefs.

Chapter IV

ANALYSIS AND INTERPRETATION

- Preliminary Analysis
- Analysis of the Level of Mathematical Beliefs of Secondary School Students
- Mean Difference Analysis
- Analysis of Covariance

ANALYSIS AND INTERPRETATION

The present study is envisaged to find out the effectiveness of the Process Stage Model on Learning Outcomes in Mathematics such as Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs among secondary school students. For the analysis of the collected data, relevant statistical techniques such as basic descriptive statistics, tests of significance of difference between means of large independent sample, and Cohen's *d* were used. The analysis of data was carried out on the basis of the objectives of the study and the formulated hypotheses were tested by using appropriate statistical techniques . The results of analysis and discussion are presented under the following headings.

- Preliminary Analysis
- Analysis of the Level of Mathematical Beliefs of Secondary School Students
- Mean Difference Analysis
- Analysis of Covariance (ANCOVA)

Preliminary Analysis

To determine the fundamental characteristics of the variables, preliminary analysis of the pre-test and post-test scores of the dependent variables such as Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs were done as a part of the statistical procedure. To determine whether the distribution of pre-test and post-test scores for Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs of secondary school students, are normally distributed, the distribution of the scores were examined by using statistical constants. Important statistical constants for the distribution of the scores for the variables mentioned above were found, including the mean, median, mode, standard deviation, skewness, and kurtosis. The important statistical constants for the distribution of pre-test and post-test scores for the variables, Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs are calculated and presented in Table 21.

Table 21

Statistical Constants Pre-test and Post-test of Scores of Dependent Variables

Variable	Sample		N	Mean	Median	Mode	Standard deviation	Skewness	Kurtosis
Achievement in Mathematics	Experimental Group	Pre-test	31	9.87	9.00	7.00	4.24	1.05	0.84
		Post-test	31	14.29	14.00	11.00	3.74	0.51	-0.45
	Control Group	Pre-test	31	9.74	9.00	8.00	3.53	1.50	3.57
		Post-test	31	9.98	9.00	7.00	3.64	1.26	1.49
Logical Reasoning	Experimental Group	Pre-test	31	12.81	12.00	11.00	3.67	-0.01	-0.47
		Post-test	31	14.94	16.00	15.00	4.01	-0.67	0.32
	Control Group	Pre-test	31	12.35	12.00	8.00	4.19	0.29	-1.08
		Post-test	31	12.52	12.00	11.00	3.27	-0.05	-0.14
Mathematics Anxiety	Experimental Group	Pre-test	31	81.32	84.00	83.00	16.80	-0.82	-0.26
		Post-test	31	52.26	54.00	55.00	7.64	-0.70	-0.23
	Control Group	Pre-test	31	54.97	56.00	62.00	10.04	0.03	-0.42
		Post-test	31	50.68	50.00	55.00	8.75	-0.19	0.21

Variable	Sample		N	Mean	Median	Mode	Standard deviation	Skewness	Kurtosis
Achievement Motivation in Mathematics	Experimental Group	Pre-test	31	142.06	150.00	136.00	36.42	-0.37	-1.04
		Post-test	31	163.74	169.00	169.00	18.06	-0.55	-0.83
	Control Group	Pre-test	31	132.77	133.00	121.00	10.42	-0.33	-0.38
		Post-test	31	137.42	136.00	128.00	28.44	-0.48	0.86
Mathematical Belief	Experimental Group	Pre-test	31	22.29	23.00	21.00	5.15	-0.49	0.04
		Post-test	31	25.00	26.00	28.00	2.95	-1.34	2.00
	Control Group	Pre-test	31	19.65	19.00	16.00	4.13	0.38	-0.12
		Post-test	31	22.03	22.00	18.00	3.99	-0.14	-0.69

Table 21 shows the important statistical constants for the distribution of the variables Achievement in Mathematics, Logical Reasoning, Mathematical Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs of secondary school students. The value of the mean, median, mode, and standard deviation of the pre-test and post-test scores of the experimental group of the variable Achievement in Mathematics are 9.87, 9.00, 7.00, 4.24, and 14.29, 14.00, 11.00, 3.74, respectively and that of the control group are 9.74, 9.00, 8.00, 3.53 and 9.98, 9.00, 7.00, and 3.64 respectively.

In the case of Logical Reasoning of secondary school students, the values of mean, median, mode, and standard deviation of the pre-test and post-test scores of the experimental group are 12.81, 12.00, 11.00, 3.67 and 14.94, 16.00, 15.00, 4.01 respectively and that of the control group are 12.35, 12.00, 8.00, 4.19 and 12.52, 12.00, 11.00 and 3.27 respectively.

While considering the scores of Mathematics Anxiety of secondary school students, the values of mean, median, mode, and standard deviation of the pre-test and post-test scores of the experimental group are 81.32, 84.00, 83.00, 16.80 and 52.26, 54.00, 55.00, 7.64 respectively, and the control group are 54.97, 56.00, 62.00, 10.04 and 50.68, 50.00, 55.00 and 8.75 respectively.

From Table 21 it is evident that for the scores of Achievement Motivation in Mathematics of secondary school students, the values of mean, median, mode, and standard deviation of the pre-test and post-test scores of the experimental group are 142.06, 150.00, 136.00, 36.42 and 163.74, 169.00, 169.00, 18.06 respectively and that of the control group are 132.77, 133.00, 121.00, 10.42 and 137.42, 136.00, 128.00, and 28.44 respectively.

In the case of Mathematical Beliefs, the values of mean, median, mode, and standard deviation of the pre-test and post-test scores of the experimental group are 22.29, 23.00, 21.00, 5.15 and 25.00, 26.00, 28.00, 2.95 respectively and that of the control group are 19.65, 19.00, 16.00, 4.13 and 22.03, 22.00, 18.00 and 3.99 respectively.

The indices of skewness of pre-test and post-test scores of Achievement in Mathematics of secondary school students for the experimental group are 1.05, 0.51 and the control group are 1.50, 1.26. It shows that the distribution of scores of the pre-test and post-test scores of Achievement in Mathematics for experimental and control groups are slightly positively skewed.

The indices of skewness of pre-test scores and post-test scores of Logical Reasoning of secondary school students for the experimental group are -0.01, and

-0.67 and the control group are 0.29 and -0.05 respectively. It shows that the distribution of pre-test scores of Logical Reasoning for experimental group is slightly negatively skewed, the distribution of post-test scores of Logical Reasoning is slightly positively skewed, the distribution of pre-test scores of Logical Reasoning for control group is slightly positively skewed and the distribution of post-test scores of Logical Reasoning for control group is slightly negatively skewed.

The indices of skewness of pre-test and post-test scores of Mathematics Anxiety of secondary school students for experimental group are -0.82, and -0.70 respectively and the control group are 0.03 and -0.19 respectively. It shows that the distribution of pre-test and post-test scores of Mathematics Anxiety for experimental group is slightly negatively skewed, the distribution of pre-test scores of Mathematics Anxiety for control group is slightly positively skewed and the distribution of post-test scores of Mathematics Anxiety for control group is slightly negatively skewed.

The indices of skewness of pre-test and post-test scores of Achievement Motivation in Mathematics of secondary school students for the experimental group are -0.37, and-0.55 and the control group are -0.33 and-0.48 respectively. It shows that the distribution of pre-test and post-test scores of Achievement Motivation in mathematics for experimental group is slightly negatively skewed and the distribution of pre-test and post-test scores of Achievement Motivation in mathematics for control group is also slightly negatively skewed.

The indices of skewness of pre-test and post-test scores of Mathematical Beliefs of secondary school students for the experimental group are -0.49, and-1.34 and the control group are 0.38 and -0.14 respectively. It shows that the distribution of pre-test and post-test scores of Mathematical Beliefs for experimental group is slightly negatively skewed, the distribution of pre-test scores of Mathematical Beliefs for control group is slightly positively skewed and the distribution of post-test scores of Mathematical Beliefs for control group is slightly negatively skewed.

The index of kurtosis for pre-test and post-test scores of Achievement in Mathematics of secondary school students for the experimental group are 0.84 and -0.45 and that of the control group are 3.57 and 1.49 respectively. It indicates that pre-test scores of the experimental group for the variable, Achievement in Mathematics of secondary school students are slightly leptokurtic and post-test scores are slightly platykurtic and that of the control group is slightly leptokurtic in nature. The distribution of scores of Achievement in Mathematics of secondary school students for pre-test and post-tests scores shows that the distribution is approximately normal.

The index of kurtosis of pre-test and post-test scores of Logical Reasoning of secondary school students for the experimental group are -0.47 and 0.32 and that of the control group are -1.08 and -0.14 respectively. The pre-test scores of Logical Reasoning of the experimental group of secondary school students shows that the distribution is platykurtic in nature and follows normal distribution approximately. The post-test scores of Logical Reasoning for experimental group indicates that the distribution is leptokurtic in nature. The pre-test and post-test scores of Logical Reasoning of the control group suggest that the distribution is platykurtic in nature and the distribution of scores of Logical Reasoning of secondary school students follows normal distribution approximately for control group.

The index of kurtosis of Mathematics Anxiety of secondary school students for the pre-test and post-test scores are -0.26 and -0.23 and that of the control group are -0.42 and 0.22 respectively. The pre-test and post-test scores of Mathematics

Anxiety of the experimental group indicate that the distribution is slightly platykurtic in both cases. The pre-test scores of Mathematics Anxiety of control group shows that the distribution is platykurtic and that of the post-test scores is leptokurtic. Thus, the distribution of scores of Mathematics Anxiety of secondary school students follows an almost normal distribution.

The index of kurtosis of Achievement Motivation in Mathematics of secondary school students for pre-test and post-test scores are -1.04 and -0.83 and that of the control group is -0.38 and 0.86 respectively. The pre-test and post-test scores of Achievement Motivation in Mathematics for experimental group and pre-test and post-test scores of the control group indicate that the distribution is slightly platykurtic. Whereas the post-test scores of the experimental group show that the distribution is slightly leptokurtic. Thus, it is evident from the analysis of distribution of scores of Achievement Motivation in Mathematics that the distribution is almost normal in nature.

The index of kurtosis of Mathematical Beliefs of secondary school students for pre-test and post-test scores are 0.04 and 2.00 and that of the control group are -0.12 and -0.69 respectively. The pre-test scores of the experimental group, and the pre-test and post-test scores of control group shows that the distributions are slightly platykurtic in nature. Whereas, the post test scores of experimental group indicate that the distribution is slightly leptokurtic in nature. Thus, it is evident that the distribution of scores of Mathematical Beliefs follow approximately a normal distribution.

Discussion

Thus, from the results of preliminary analysis of the basic properties of the distribution of scores of dependent variables i.e., Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs, it is evident that the mean, median and mode coincide approximately and the distribution of scores of pre-test and post-test for dependent variables follow a normal distribution approximately. Hence, the further analysis was carried out with the help of the inferential statistics.

P-P Plot of the Variables

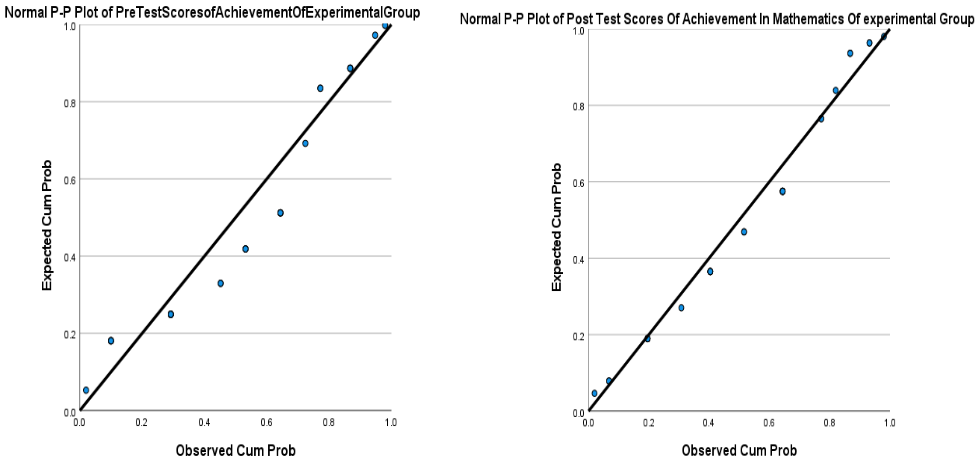
Using P-P plots, the distribution of scores of the dependent variables, Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs, of secondary school students were further examined. P-P plots indicate the cumulative probability of the variables against the cumulative probability of the normal distribution. The P-P plots of the distribution of the scores of the dependent variables, Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs, of secondary school students for experimental group are presented in Figure 9, Figure 10, Figure 11, Figure 12, Figure 13 respectively and for control group are presented in Figure 14, Figure 15, Figure 16, Figure 17 and Figure 18 respectively.

P-P plot of the Variables of the Experimental Group

The p-p plots of the distribution of the pre-test and post-test scores of Achievement in Mathematics of experimental group are presented in Figure 9.

Figure 9

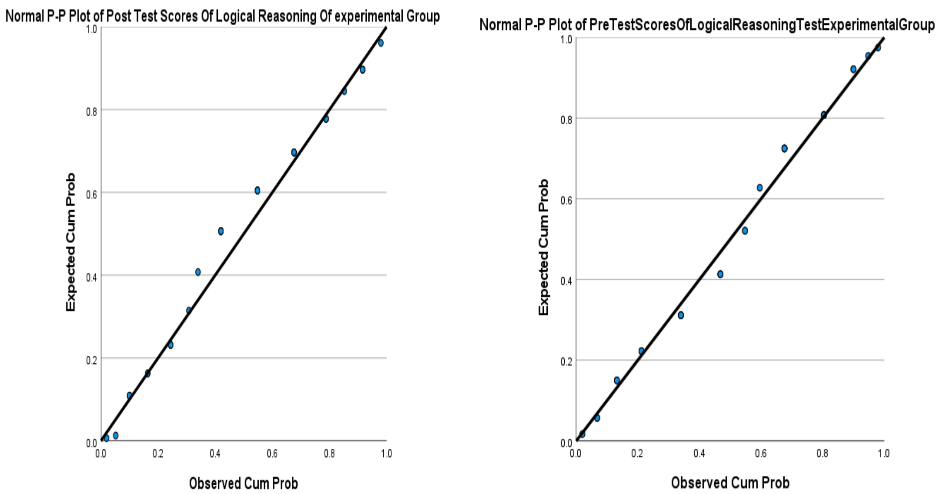
P-P Plot of Achievement in Mathematics of Experimental Group



The p-p plots of the distribution of the pre-test and post-test scores of Logical Reasoning of experimental group are presented in Figure 10.

Figure 10

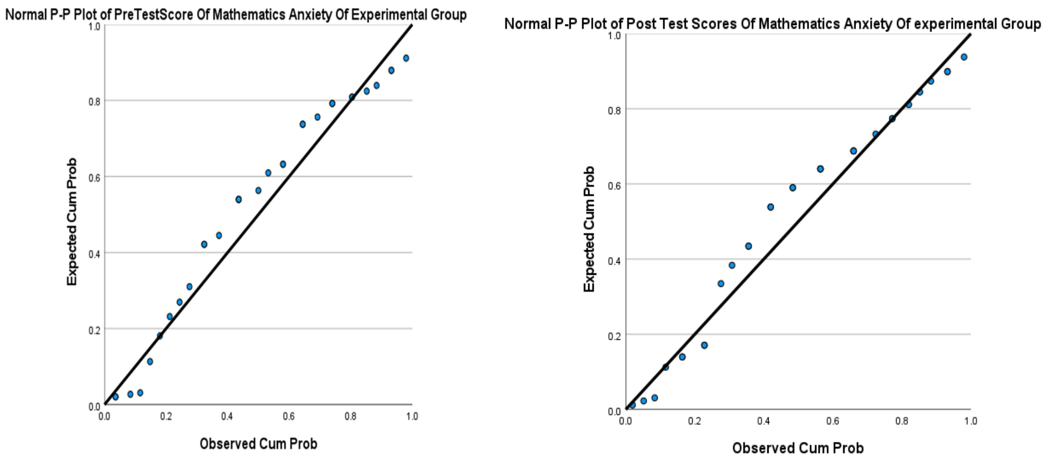
P-P Plot of Logical Reasoning of Experimental Group



The p-p plots of the distribution of the pre-test and post-test scores of Mathematics Anxiety of experimental group are presented in Figure 11.

Figure 11

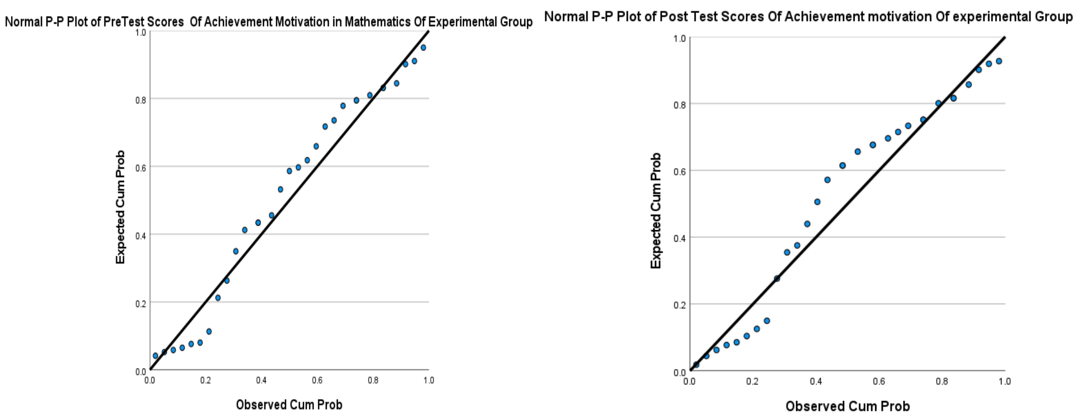
P-P Plot of Mathematics Anxiety of Experimental Group



The p-p plots of the distribution of the pre-test and post-test scores of Achievement Motivation in Mathematics of experimental group are presented in Figure 12.

Figure 12

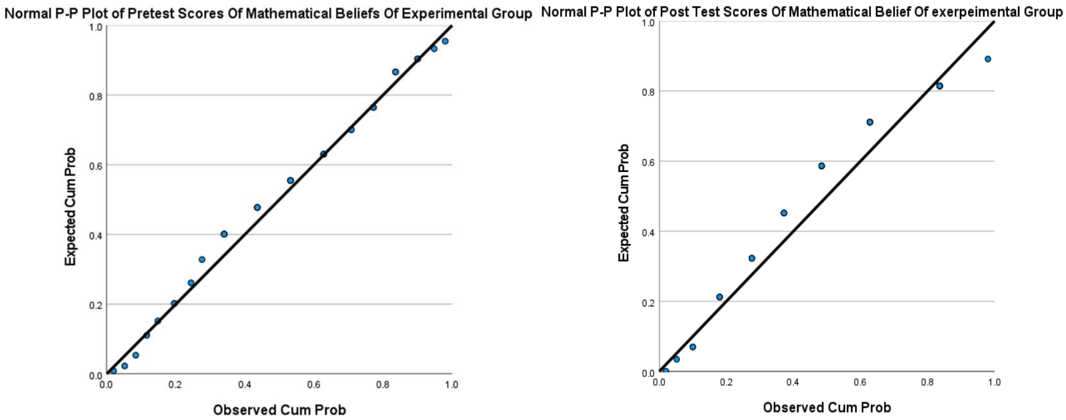
P-P Plot of Achievement Motivation in Mathematics of Experimental Group



The p-p plots of the distribution of the pre-test and post-test scores of Mathematical Beliefs of experimental group are presented in Figure 13.

Figure 13

P-P Plot of Mathematical Beliefs of Experimental Group

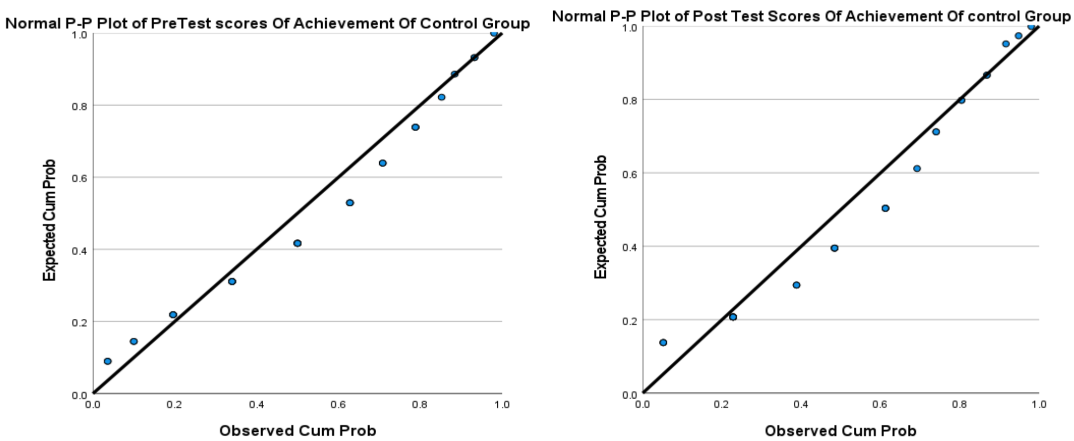


P-P plot of the Variables of the control Group

The p-p plots of the distribution of the pre-test and post-test scores of Achievement in Mathematics of control group are presented in Figure 14.

Figure 14

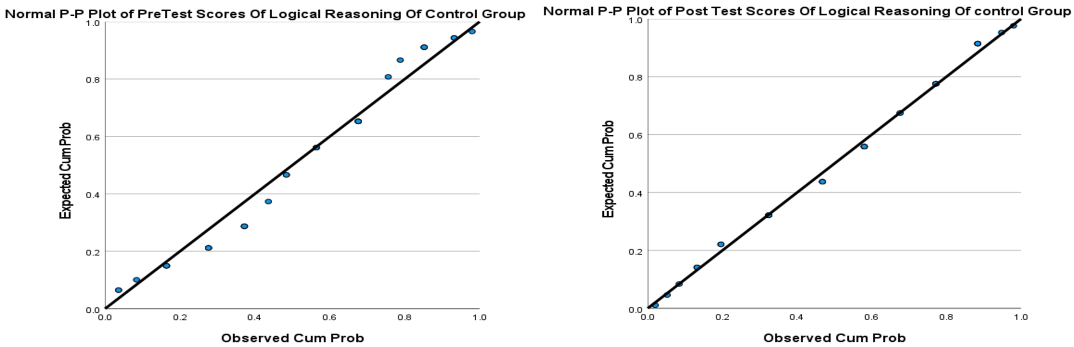
P-P Plot of Achievement in Mathematics of Control Group



The p-p plots of the distribution of the pre-test and post-test scores of Logical Reasoning of control group are presented in Figure 15.

Figure 15

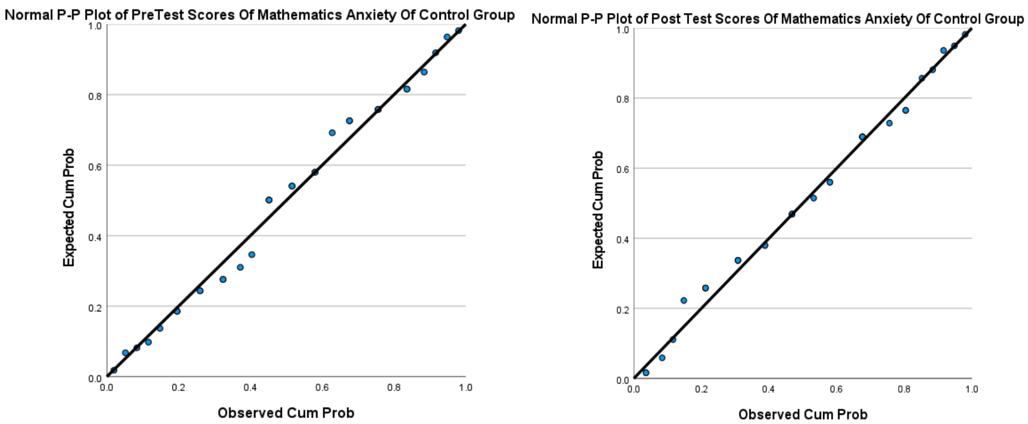
P-P Plot of Logical Reasoning of Control Group



The p-p plots of the distribution of the pre-test and post-test scores of Mathematical Beliefs of control group are presented in Figure 16.

Figure 16

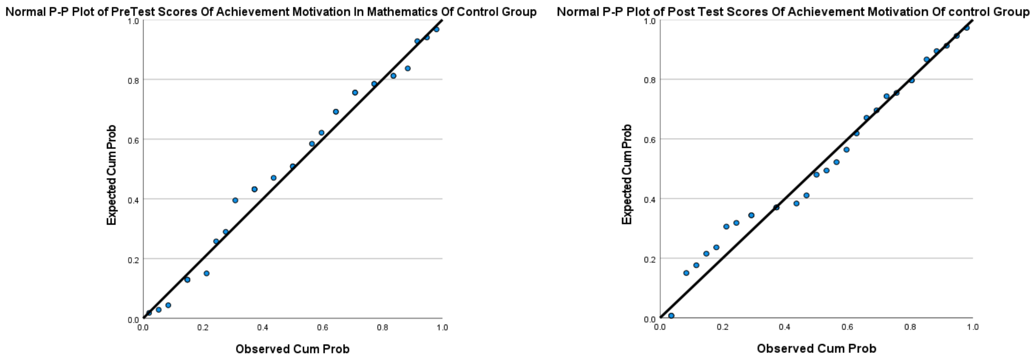
P-P Plot of Mathematics Anxiety of Control Group



The p-p plots of the distribution of the pre-test and post-test scores of Mathematics Anxiety of control groups are presented in Figure 17.

Figure 17

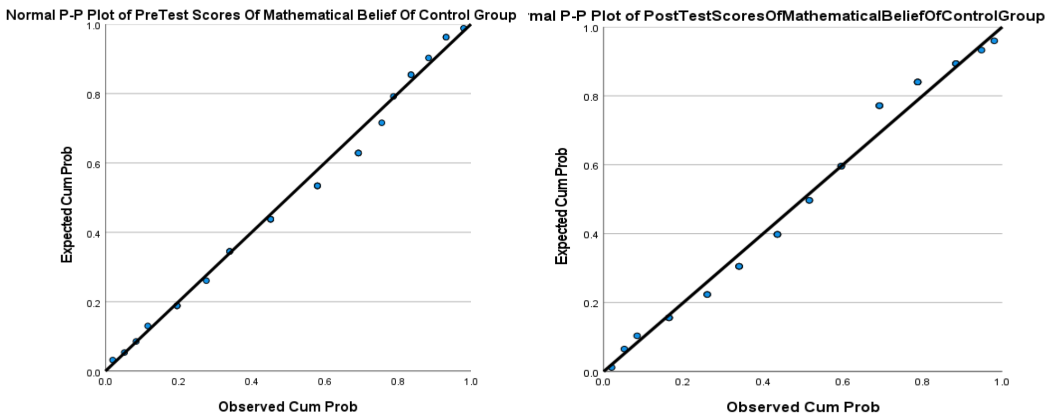
P-P Plot of Achievement Motivation in Mathematics of Control Group



The p-p plots of the distribution of the pre-test and post-test scores of Achievement Motivation in Mathematics of control groups are presented in Figure 18.

Figure 18

P-P Plot of Mathematical Beliefs of Control Group



Discussion. The normal Probability-Probability of pre-test and post-test scores of Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs of the experimental and control groups show that the scores of dependent variables follow normal distribution approximately. Since this dependent variable follows near normality, it can be concluded that the sample selected for the study is a true representative of the population.

As it is clear from the preliminary analysis that the distribution of scores of Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs for the experimental and control groups are approximately normal, further analysis of the objectives was carried out. The mean difference analysis was carried out to find out whether there exists any significant difference in the mean scores of pre-test and post-test scores of dependent variables for the experimental and control groups.

Analysis of the Level of Mathematical Beliefs of Secondary School Students

The first specific objective of the study is to analyze the level of Mathematical Beliefs of secondary school students. To analyze the level of Mathematical Beliefs of secondary school students the researcher used descriptive analysis, one sample t-test, and Cohen's d to find out the effect size, which is the first phase of the study. The descriptive statistics for the scores of Mathematical Beliefs of secondary school students were calculated and are presented in the Table 22.

Table 22

Descriptive Statistics for the Scores of Mathematical Beliefs of Secondary School Students.

Variable	N	Mean	Median	Mode	Standard Deviation	Skewness	Kurtosis
Mathematical Beliefs	600	23.52	24.00	22.00	4.72	-0.33	-0.27

Discussion

Table 22 shows that the mean score of Mathematical Beliefs of secondary school students is 23.52 and the standard deviation is 4.72. The maximum and minimum scores obtainable for Mathematical Belief Inventory are 0 and 34 respectively and the mid value is 17. The obtained mean score of the Mathematical Beliefs of secondary school students is 23.52 which is higher than the mid value (17) of the Mathematical Belief Inventory as well less than the maximum value (34) of the Mathematical Beliefs Inventory. Thus, it can be concluded that secondary school students are having moderate level of Mathematical Beliefs.

In order to verify whether the difference in obtained mean score of Mathematical Beliefs and the mid value is significant, one sample t-test was carried out by considering the mid value of the Mathematical Beliefs Inventory as test value i.e. 17. One sample t-test was conducted to find out the significant difference between the obtained mean (M = 23.52) for the scores on Mathematical Beliefs of secondary school students and the test value (Mid Value = 17) which is the mid value of the Mathematical Beliefs Inventory. Data and the results of one sample t-test of

Mathematical Beliefs of secondary school students and effect size are presented in Table 23.

Table 23

Data and Results of One sample t test for Mathematical Beliefs of Secondary School Students and Effect Size

Variable	N	M	SD	Test Value	Critical Ratio t -value	df	Cohen's d	Effect Size
Mathematical Beliefs	600	23.52	4.72	17	33.84**	599	1.38	High

**p < .01

Discussion

Table 23 indicates that the mean value of Mathematical Beliefs of secondary school students is 23.52 and standard deviation is 4.72. The obtained critical ratio of Mathematical Beliefs of secondary school students is t = 33.84, p< .01, which is greater than the tabled value of t (2.33) at .01 level of significance. Thus, it is evident that there is a significant difference between the mean scores of Mathematical Beliefs of secondary school students and the test value of the Mathematical Beliefs. In addition to this, the effect size as measured by Cohen's d (d =1.38) also indicates a high effect size. Hence, it can be concluded that the secondary school students are having a moderate level of Mathematical Beliefs.

Mean Difference Analysis

The mean difference analysis was carried out to find out whether there exists any significant difference in the pre-test scores, post-test scores, and gain scores of

Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety. Achievement Motivation in Mathematics and Mathematical Beliefs of secondary school students for the experimental and control groups. The results and discussion of mean difference analysis are presented under the following sections.

- Comparison of Mean Scores of Pre-test
- Comparison of Mean Scores of Post-test
- Comparison of Mean Scores of Pre-test and Post-test
- Comparison of Means Scores of Gain Scores

Comparison of Mean Scores of Pre-test

The second specific objective of the study is to compare the mean scores of pre-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs for experimental and control groups of secondary school students. Under this section, the mean difference analysis of pre-test scores of Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety. Achievement Motivation in Mathematics and Mathematical Beliefs of secondary school students for the experimental and control groups were carried out. The results and discussion of mean difference analysis of pre-test scores of Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety. Achievement Motivation in Mathematics and Mathematical Beliefs of secondary school students for the experimental and control groups are presented in the following sub sections.

- Comparison of Mean Scores of Pre-test on Achievement in Mathematics for Experimental and Control Groups
- Comparison of Mean Scores of Pre-test on Logical Reasoning for Experimental and Control Groups
- Comparison of Mean Scores of Pre-test on Mathematics Anxiety for Experimental and Control Groups
- Comparison of Mean Scores of Pre-test on Achievement Motivation in Mathematics for Experimental and Control Groups
- Comparison of Mean Scores of Pre-test on Mathematical Beliefs for Experimental and Control Groups

Comparison of Mean Scores of Pre-Test on Achievement in Mathematics for Experimental and Control Groups

Both experimental and control groups were subjected to pre-test before providing treatment to find out the existing level of Achievement in Mathematics among the secondary school students and to compare the mean scores of pre-test scores on Achievement in Mathematics for both groups.

Pre-test scores of Achievement in Mathematics of experimental and control groups of secondary school students were calculated and analysis of descriptive statistics revealed that the distribution of pre-test scores of Achievement in Mathematics of secondary school students follow normal distribution approximately.

As pre-test scores of Achievement in Mathematics are normally distributed in both experimental and control groups, further analysis was done with parametric tests.

Test of significance of difference between means of large independent sample (*t*-test) was done to know the difference in mean scores of pre-test on Achievement in Mathematics of secondary school students for experimental and control groups. To confirm the homogeneity of variance before testing the significance of the difference between the mean scores of pre-test on Achievement in Mathematics of two groups, Levene's test was conducted. The details of data and results of Levene's Test for equality of variance of pre-test scores on Achievement in Mathematics for experimental and control groups are given in Table 24.

Table 24

Data and Results of Levene's Test for Equality of Variance of Pre-test Scores of Achievement in Mathematics for Experimental and Control Groups

Variable	Condition	Levene's Test F	Degrees of Freedom	Equality of Variance Significance Level
Pre-test Scores of Achievement in Mathematics	Equal Variance Assumed	1.64	$df_1 = 1$ $df_2 = 60$	0.21

Discussion. Table 24 shows that the Levene's test for equality of variance of pre-test scores on Achievement in Mathematics is satisfied F (1,60) =1.64, $p = 0.21$. Hence, the variance does not differ significantly for experimental and control groups of secondary school students for the pre-test scores of Achievement in Mathematics. As the homogeneity assumption of the variance was met, *t*-test was carried out to test the significance of difference between mean scores of pre-test scores of Achievement in Mathematics for experimental and control groups. The data and results of the test of significance of difference between means of large independent sample for pre-test scores of Achievement in Mathematics of secondary school students for experimental and control groups are given in Table 25.

Table 25

Data and Results of Test of Significance of Difference between Means of Large Independent Sample for Scores of Pre-test on Achievement in Mathematics of Experimental and Control Groups

Variable	Group	N	M	SD	Critical Ratio (t-value)
Pre-test scores of Achievement in Mathematics	Experimental Group	31	9.87	4.24	0.23
	Control Group	31	9.65	3.42	

Discussion. Table 25 shows that the critical ratio obtained, t = 0.23, p > .05, for pre-test scores of Achievement in Mathematics of secondary school students for experimental and control groups. The t value obtained is less than the tabled value of t (1.96) indicating that it is not significant even at .05 level of significance. Thus, it can be concluded that there is no significant difference in the mean scores of pre-test on Achievement in Mathematics of secondary school students between the experimental and control groups. Hence, both the participants in the experimental and control group are having the same level of Achievement in Mathematics in pre-test scores.

Comparison of Mean Scores of Pre-test on Logical Reasoning for Experimental and Control Groups

Both experimental and control groups were subjected to pre-test on Logical Reasoning before providing treatment to find out the existing level of Logical

Reasoning among the secondary school students and to compare the mean scores of pre-test on Logical Reasoning for both groups.

Pre-test scores of Logical Reasoning of experimental and control groups of secondary school students were calculated and analysis of descriptive statistics revealed that the distribution of pre-test scores of Logical Reasoning of secondary school students follow normal distribution approximately.

As pre-test scores of Logical Reasoning are normally distributed in both experimental and control groups, further analysis was done with parametric tests. Test of significance of difference between means of large independent sample(t-test) was done to know the difference in mean scores of pre-test on Logical Reasoning of secondary school students for experimental and control groups. To confirm the homogeneity of variance before testing the significance of the difference between the mean scores of pre-test on Logical Reasoning of two groups, Levene's test was conducted. The details of data and results of Levene's Test for equality of variance of pre-test scores on Logical Reasoning for experimental and control groups are given in Table 26.

Table 26

Data and Results of Levene's Test for Equality of Variance Pre-test scores on Logical Reasoning for Experimental and Control Groups

Variable	Condition	Levene's Test F	Degrees of Freedom	Equality of Variance Significance Level
Pre-test Scores of Logical Reasoning	Equal Variance Assumed	0.89	$df_1 = 1$ $df_2 = 60$	0.35

Discussion. Table 26 shows that the Levene's test for equality of variance of pre-test scores on Logical Reasoning is satisfied F (1,60) =0.89, p = 0.35. Hence, the variance does not differ significantly for experimental and control groups of secondary school students for the pre-test scores of Logical Reasoning. As the homogeneity assumption of the variance was met, t-test was carried out to test the significance of difference between mean scores of pre-test on Logical Reasoning for experimental and control groups. The data and results of the test of significance of difference between means of large independent sample for pre-test scores of Logical Reasoning of secondary school students for experimental and control groups are given in Table 27.

Table 27

Data and Results of Test of Significance of Difference Between Means of Large Independent Sample for Scores of Pre-test on Logical Reasoning of Experimental and Control Groups

Variable	Group	N	M	SD	Critical Ratio (t-value)
Pre-test Scores of Logical Reasoning	Experimental Group	31	12.81	3.67	0.45
	Control Group	31	12.35	4.19	

Discussion. Table 27 shows that the critical ratio obtained, t = 0.45, p > .05, for pre-test scores on Logical Reasoning of secondary school students for experimental and control groups. The t value obtained is less than the tabled value of t (1.96) indicating that it is not significant even at .05 level of significance. Thus, it can be concluded that there is no significant difference in the mean scores of pre-test on Logical Reasoning of secondary school students between the experimental and control groups. Hence, both the participants in the experimental and control group are having the same level of Logical Reasoning in pre-test scores.

Comparison of Mean Scores of Pre-test on Mathematics Anxiety for Experimental and Control Groups

Both experimental and control groups were subjected to pre-tests before providing treatment to find out the existing level of Mathematics Anxiety among the secondary school students and to compare the mean scores of pre-test on Mathematics Anxiety for both groups.

Pre-test scores of Mathematics Anxiety of experimental and control groups of secondary school students were calculated and descriptive statistics of the scores of Mathematics Anxiety indicated that the distribution of pre-test scores of Mathematics Anxiety of secondary school students follows normal distribution approximately.

As pre-test scores of Mathematics Anxiety are normally distributed in both experimental and control groups, further analysis was done with parametric tests. Test of significance of difference between means of large independent sample (t-test) was done to know the difference in mean scores of pre-test on Mathematics Anxiety of secondary school students for experimental and control groups. To confirm the homogeneity of variance before testing the significance of the difference between the mean scores of pre-test on Mathematics Anxiety of two groups, Levene's test was conducted. The details of data and results of Levene's Test for equality of variance of pre-test of Mathematics Anxiety for experimental and control groups are given in Table 28.

Table 28

Data and Results of Levene's Test for Equality of Variance of Pre-test Scores of Mathematics Anxiety of Experimental and Control Groups

Variable	Condition	Levene's Test F	Degrees of Freedom	Equality of Variance Significance Level
Pre-test Scores of Mathematics Anxiety	Equal Variance Assumed	6.65	$df_1 = 1$ $df_2 = 60$	0.012

Discussion. From Table 28 it is evident that the Levene's test for equality of variance of pre-test scores of Mathematics Anxiety is satisfied F (1,60) = 6.65, p = 0.012. Hence, the variance does not differ significantly for experimental and control groups of secondary school students for the pre-test scores of Mathematics Anxiety. As the homogeneity assumption of the variance was met, t-test was carried out to test the significance of difference between mean scores of pre-test on Mathematics Anxiety for experimental and control groups. The data and results of the test of significance of difference between means of large independent sample for pre-test scores of Mathematics Anxiety of secondary school students for experimental and control groups and effect size are given in Table 29.

Table 29

Data and Results of the Test of Significance of Difference between Means of Large Independent Sample for Scores of Pre-test on Mathematics Anxiety of Experimental and Control Groups and Effect Size

Variable	Group	N	M	SD	Critical Ratio (t-value)	Cohen's *d*	Effect size
Pre-test scores of Mathematics Anxiety	Experimental Group	31	81.32	16.80	7.47**	1.38	High
	Control Group	31	54.98	10.34			

**p < .01

Discussion. Table 29 indicates that the critical ratio obtained, $t = 7.47$, $p < .01$, for pre-test scores on Mathematics Anxiety of secondary school students for experimental and control groups is greater than the tabled value of t (2.58) which is significant at .01 level of significance. Hence, it is evident that there exists a significant difference between the experimental and control groups in the pre-test scores of Mathematics Anxiety of secondary school students.

In order to know which group is having higher Mathematics Anxiety, the mean scores obtained for pre-test scores of Mathematics Anxiety of secondary school students of experimental and control groups were analyzed. The mean score for pre-test scores of Mathematics Anxiety of the experimental group ($M = 81.32$, $SD = 16.80$) is higher than that of the control group ($M = 54.98$, $SD = 10.34$). The calculated Cohen's d value (d = 1.38) indicates the effect between the two groups is large. Therefore, it can be concluded that the experimental group is having higher Mathematics Anxiety than the control group of secondary school students.

Comparison of Mean Scores of Pre-test on Achievement Motivation in Mathematics for Experimental and Control Groups

Both experimental and control groups were subjected to pre-test before providing treatment to find out the existing level of Achievement Motivation in Mathematics among the secondary school students and to compare the mean scores of pre-test on Achievement Motivation in Mathematics for both groups.

Pre-test scores of Achievement Motivation in Mathematics of experimental and control groups of secondary school students were calculated and descriptive statistics of the scores of Achievement Motivation in Mathematics indicated that the distribution of pre-test scores of Achievement Motivation in Mathematics of secondary school students follows normal distribution approximately.

As pre-test scores of Achievement Motivation in Mathematics are normally distributed in both experimental and control groups, further analysis was done with parametric tests. Test of significance of difference between means of large independent sample (t-test) was done to know the difference in mean scores of pre-test on Achievement Motivation in Mathematics of secondary school students for experimental and control groups. To confirm the homogeneity of variance before testing the significance of the difference between the mean scores of pre-test on Achievement Motivation in Mathematics of two groups, Levene's test was conducted. The details of data and results of Levene's Test for equality of variance of pre-test scores of Achievement Motivation in Mathematics for experimental and control groups are given in Table 30.

Table 30

Data and Results of Levene's Test for Equality of Variance of Pre-test Scores on Achievement Motivation in Mathematics for Experimental and Control Groups

Variable	Condition	Levene's Test F	Degrees of Freedom	Equality of Variance Significance Level
Pre-test Scores of Achievement Motivation in Mathematics	Equal Variance Assumed	37.66	$df_1 = 1$ $df_2 = 60$	0.18

Discussion. Table 30 shows that the Levene's test for equality of variance of pre-test scores of Achievement Motivation in Mathematics is satisfied F (1,60) =37.66, p = 0.18. Hence, the variance does not differ significantly for experimental and control groups of secondary school students for the pre-test scores of Achievement Motivation in Mathematics. As the homogeneity assumption of the variance was met, t-test was carried out to test the significance of difference between mean scores of pre-test on Achievement Motivation in Mathematics for experimental and control groups. The data and results of the test of significance of difference between means of large independent sample for pre-test scores on Achievement Motivation in Mathematics of secondary school students for experimental and control groups are given in Table 31.

Table 31

Data and Results of Test of Significance of Difference Between Means of Large Independent Sample for Scores of Pre-test on Achievement Motivation in Mathematics of Experimental and Control Groups

Variable	Group	N	M	SD	Critical Ratio (t-value)
Pre-test scores of Achievement Motivation in Mathematics	Experimental Group	31	142.06	36.46	1.37
	Control Group	31	132.77	0.42	

Discussion. Table 31 shows that the critical ratio obtained, t = 1.37, p>.05, for pre-test scores of Achievement Motivation in Mathematics of secondary school students for experimental and control groups. The t value obtained is less than the tabled value of t (1.96) indicating that it is not significant even at .05 level of significance. Thus, it can be concluded that there is no significant difference in the mean scores of pre-test on Achievement Motivation in Mathematics of secondary school students between the experimental and control groups. Hence, both the participants in the experimental and control group are having the same level of Achievement Motivation in Mathematics in pre-test scores.

Comparison of Mean Scores of Pre-test on Mathematical Beliefs for Experimental and Control Groups

Both experimental and control groups were subjected to pre-test before providing treatment to find out the existing level of Mathematical Beliefs among the secondary school students and to compare the mean scores of pre-test on Mathematical Beliefs for both groups.

Pre-test scores of Mathematical Beliefs of experimental and control groups of secondary school students were calculated and descriptive statistics of the scores of Mathematical Beliefs indicated that the distribution of pre-test scores of Mathematical Beliefs of secondary school students follows normal distribution approximately.

As pre-test scores of Mathematical Beliefs are normally distributed in both experimental and control groups, further analysis was done with parametric tests. Test of significance of difference between means of large independent sample (t-test) was done to know the difference in mean scores of pre-test on Mathematical Beliefs of secondary school students for experimental and control groups. To confirm the homogeneity of variance before testing the significance of the difference between the mean scores of pre-test on Mathematical Beliefs of two groups, Levene's test was conducted. The details of data and results of Levene's Test for equality of variance of pre-test scores of Mathematical Beliefs for experimental and control groups are given in Table 32.

Table 32

Data and Results of Levene's Test for Equality of Variance of Pre-test Scores of Mathematical Beliefs of Experimental and Control Groups

Variable	Condition	Levene's Test F	Degrees of Freedom	Equality of Variance Significance Level
Pre-test Scores of Mathematical Beliefs	Equal Variance Assumed	1.11	$df_1 = 1$ $df_2 = 60$	0.30

Discussion. From Table 32 it is evident that the Levene's test for equality of variance of pre-test scores of Mathematical Beliefs is satisfied F (1,60) = 1.11, p = 0.30. Hence, the variance does not differ significantly for experimental and control groups of secondary school students for the pre-test scores of Mathematical Beliefs. As the homogeneity assumption of the variance was met, t-test was carried out to test the significance of difference between mean scores of pre-test on Mathematical Beliefs for experimental and control groups. The data and results of the test of significance of difference between means of large independent sample for pre-test scores of Mathematical Beliefs of secondary school students for experimental and control groups and effect size are given in Table 33.

Table 33

Data and Results of Test of Significance of Difference Between Means of Large Independent Sample for Scores of Pre-test on Mathematical Beliefs of Experimental and Control Groups and Effect Size

Variable	Group	N	M	SD	Critical Ratio (t-value)	Cohen's d	Effect Size
Pre-test scores of Mathematical Beliefs	Experimental Group	31	22.29	5.15	2.23*	0.57	Moderate
	Control Group	31	19.64	4.12			

*p < .05

Discussion. Table 33 shows that the critical ratio obtained, t = 2.23, p < .05, for pre-test scores of Mathematical Beliefs of secondary school students for experimental and control groups. The t value obtained is greater than the tabled value of t (1.96) indicating that it is significant at .05 level of significance. Thus, it can be concluded that there is significant difference in the mean scores of pre-test on Mathematical Beliefs of secondary school students between the experimental and control groups. In order to know which group is having higher mathematical beliefs the mean scores obtained for pre-test scores of mathematical beliefs of secondary school students of experimental and control groups where analyzed. The mean scores for pre-test scores of mathematical beliefs of the experimental group (M = 22.29, SD = 5.15) is higher than that of the control group (M = 19.64, SD = 4.12). The calculated Cohen's d value (d = .57) indicates the effect size between the two group is moderate. Hence, both the participants in the experimental and control group are different in their level of Mathematical Beliefs.

Comparison of Mean Scores of Post-test

The third specific objective of the study is to compare the mean scores of post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs for experimental and control groups of secondary school students. Under this section, the mean difference analysis of post-test scores of Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety. Achievement Motivation in Mathematics and Mathematical Beliefs of secondary school students for the experimental and control groups were carried out. The results and discussion of mean difference analysis of post-test scores of Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety. Achievement Motivation in Mathematics and Mathematical Beliefs of secondary school students for the experimental and control groups are presented in the following sub sections.

- Comparison of Mean Scores of Post-test on Achievement in Mathematics for Experimental and Control Groups
- Comparison of Mean Scores of Post-test on Logical Reasoning for Experimental and Control Groups
- Comparison of Mean Scores of Post-test on Mathematics Anxiety for Experimental and Control Groups
- Comparison of Mean Scores of Post-test on Achievement Motivation in Mathematics for Experimental and Control Groups
- Comparison of Mean Scores of Post-test on Mathematical Beliefs for Experimental and Control Groups

Comparison of Mean Scores of Post-test on Achievement in Mathematics for Experimental and Control Groups

The experimental and control groups were subjected to post-tests, by using the same instruments administered for the pre-test, to find out the level of Achievement in Mathematics among the secondary school students and to compare the mean scores of post-test on Achievement in Mathematics for both groups after providing treatment.

The post-test scores of Achievement in Mathematics of experimental and control groups of secondary school students were calculated and descriptive statistics of the post-test scores of Achievement in Mathematics indicated that the distribution of post-test scores of Achievement in Mathematics of secondary school students follow normal distribution approximately. Since the post-test scores on Achievement in Mathematics are normally distributed in experimental and control groups, further analysis was done with parametric tests.

Test of significance of difference between means of large independent sample (*t*-test) was done to know the difference in mean scores of post-test on Achievement in Mathematics of secondary school students for experimental and control groups. The data were examined to determine the effectiveness of the Process Stage Model on Achievement in Mathematics for the experimental group. To confirm the homogeneity of variance before testing the significance of the difference between the mean scores of post-test on Achievement in Mathematics of two groups, Levene's test was conducted. The details of data and results of Levene's Test for equality of variance of post-test scores of Achievement in Mathematics for experimental and control groups are given in Table 34.

Table 34

Data and Results of Levene's Test for Equality of Variance of Post-test Scores of Achievement in Mathematics for Experimental and Control Groups

Variable	Condition	Levene's Test F	Degrees of Freedom	Equality of Variance Significance Level
Post-test Scores of Achievement in Mathematics	Equal Variance Assumed	0.47	$df_1 = 1$ $df_2 = 60$	0.017

Discussion. Table 34 shows that the Levene's test for equality of variance of pre-test scores on Achievement in Mathematics is satisfied F (1,60) =0.47, $p = 0.017$. Hence, the variance does not differ significantly for experimental and control groups of secondary school students for the post-test scores ofAchievement in Mathematics.

As the homogeneity assumption of the variance was met, t-test was carried out to test the significance of difference between mean scores of post-test on Achievement in Mathematics for experimental and control groups. The data and results of the test of significance of difference between means of large independent sample for post-test scores of Achievement in Mathematics of secondary school students for experimental and control groups and effect size of post-test mean scores are given in Table 35.

Table 35

Data and Results of Test of Significance of Difference between Means of Large Independent Sample for Scores of Post-test on Achievement in Mathematics of Experimental and Control Groups and Effect Size

Variable	Group	N	M	SD	Critical Ratio (t-value)	Cohen's d	Effect Size
Post-test scores of Achievement in Mathematics	Experimental Group	31	14.29	3.74	4.61**	1.02	High
	Control Group	31	9.98	3.64			

**p < .01

Discussion. Table 35 shows that the critical ratio obtained, $t = 4.61$, $p<0.01$, for post-test scores of Achievement in Mathematics of secondary school students for experimental and control groups. The t value obtained is greater than the tabled value of t (2.58) indicating that it is significant at .01 level of significance. Thus, it can be concluded that there is significant difference in the mean scores of post-test on Achievement in Mathematics of secondary school students between the experimental and control groups. Hence, both the participants in the experimental and control groups of secondary school students differ significantly in post-test scores of

Achievement in Mathematics. Thus, it is evident that the experimental group and control group of secondary school students are different in their level of Achievement in Mathematics in post-test scores.

Further analysis of the mean scores of post-test on Achievement in Mathematics of secondary school students for experimental and control groups were carried out to know which group is having higher level of Achievement in Mathematics. The results indicate that the experimental group (M = 14.29, SD = 3.74) is having higher Achievement in Mathematics than the control group (M = 9.98, SD =3.64) of secondary school students. In addition to this, the effect size of mean scores of post-test of Achievement in Mathematics of the experimental and control groups as measured by Cohen's d (d = 1.02) indicates high effect size. Hence, it can be concluded that for the post-test scores of Achievement in Mathematics of secondary school students, the experimental group is higher in Achievement in Mathematics than the control group.

Comparison of Mean Scores of Post-test on Logical Reasoning for Experimental and Control Groups

The experimental and control groups were subjected to post-tests, by using the same instruments administered for the pre-test, to find out the level of Logical Reasoning among the secondary school students and to compare the mean scores of post-test on Logical Reasoning for both groups after providing treatment.

The post-test scores of Logical Reasoning of experimental and control groups of secondary school students were calculated and descriptive statistics of the scores of Logical Reasoning indicated that the distribution of post-test scores on Logical Reasoning of secondary school students follow normal distribution approximately. Since the post-test scores on Logical Reasoning are normally distributed in experimental and control groups, further analysis was done with parametric tests.

Test of significance of difference between means of large independent sample (*t*-test) was done to know the difference in mean scores of post-test on Logical Reasoning of secondary school students for experimental and control groups. The data were examined to determine the effectiveness of the Process Stage Model on Logical Reasoning for the experimental group. To confirm the homogeneity of variance before testing the significance of the difference between the mean scores of post-test on Logical Reasoning of two groups, Levene's test was conducted. The details of data and results of Levene's Test for equality of variance of post-test scores of Logical Reasoning for experimental and control groups are given in Table 36.

Table 36

Data and Results of Levene's Test for Equality of Variance of Post-test Scores of Logical Reasoning for Experimental and Control Groups

Variable	Condition	Levene's Test F	Degrees of Freedom	Equality of Variance Significance Level
Post-test Scores of Logical Reasoning	Equal Variance Assumed	0.85	df1=1 df2=60	0.012

Discussion. Table 36 shows that the Levene's test for equality of variance of post-test scores of Logical Reasoning is satisfied F (1,60) =0.85, p = 0.012. Hence, the variance does not differ significantly for experimental and control groups of secondary school students for the post-test scores of Logical Reasoning. As the homogeneity assumption of the variance was met, t-test was carried out to test the significance of difference between mean scores of post-test on Logical Reasoning for experimental and control groups. The data and results of the test of significance of difference between means of large independent sample for post-test scores of Logical Reasoning of secondary school students for experimental and control groups are given in Table 37.

Table 37

Data and Results of Test of Significance of Difference between Means of Large Independent Sample for Scores of Post-test on Logical Reasoning of Experimental and Control Groups and Effect Size

Variable	Group	N	M	SD	Critical Ratio (t-value)	Cohen's d	Effect size
Post-test scores of Logical Reasoning	Experimental Group	31	14.94	4.01	2.60**	0.63	Moderate
	Control Group	31	12.52	3.27			

**p < .01

Discussion. Table 37 shows that the critical ratio obtained, $t = 2.60$, $p < .01$, for post-test scores of Logical Reasoning of secondary school students for experimental and control groups. The t value obtained is greater than the tabled value of t (2.58) indicating that it is significant at .01 level of significance. Thus, it can be concluded that there is significant difference in the mean scores of post-test on Logical Reasoning of secondary school students between the experimental and control groups.

Hence, both the participants in the experimental and control groups of secondary school students differ significantly in post-test scores of Logical Reasoning. Thus, it is evident that the experimental group and control group of secondary school students are different in their level of Logical Reasoning in post-test scores.

Further analysis of the mean scores of post-test scores of Logical Reasoning of secondary school students for experimental and control groups were carried out to know which group is having higher level of Logical Reasoning. The results indicate that the experimental group (M = 14.94, SD = 4.01) is having higher Logical Reasoning than the control group (M = 12.52, SD =3.27) of secondary school students. In addition to this, the effect size of mean scores of post-test on Logical Reasoning of the experimental and control groups as measured by Cohen's d (d = 0.63) indicates moderate effect size. Hence, it can be concluded that for the post-test scores of Logical Reasoning of secondary school students, the experimental group is higher than the control group.

Comparison of Mean Scores of Post-test on Mathematics Anxiety for Experimental and Control Group

The experimental and control groups were subjected to post-tests, by using the same instruments administered for the pre-test to find out the level of Mathematics Anxiety among the secondary school students and to compare the mean scores of post-test scores on Mathematics Anxiety for both groups after providing treatment.

The post-test scores of Mathematics Anxiety of experimental and control groups of secondary school students were calculated and descriptive statistics of the post-test scores of Mathematics Anxiety indicated that the distribution of post-test scores of Mathematics Anxiety of secondary school students follow normal distribution approximately. Since the post-test scores of Mathematics Anxiety are normally distributed in experimental and control groups, further analysis can be done with parametric tests.

Test of significance of difference between means of large independent sample (*t*-test) was done to know the difference in mean scores of post-test on Mathematics Anxiety of secondary school students for experimental and control groups. The data were examined to determine the effectiveness of the Process Stage Model on Mathematics Anxiety for the experimental group. To confirm the homogeneity of variance before testing the significance of the difference between the mean scores of post-test on Mathematics Anxiety of two groups, Levene's test was conducted. The details of data and results of Levene's Test for equality of variance of post-test scores of Mathematics Anxiety for experimental and control groups are given in Table 38.

Table 38

Data and Results of Levene's Test for Equality of Variance of Post-test Scores of Mathematics Anxiety for Experimental and Control Groups

Variable	Condition	Levene's Test F	Degrees of Freedom	Equality of Variance Significance Level
Post-test Scores of Mathematics Anxiety	Equal Variance Assumed	0.82	$df_1 = 1$ $df_2 = 60$	0.17

Discussion. Table 38 shows that the Levene's test for equality of variance of post-test scores on Logical Reasoning is satisfied, F (1,60) =0.82, p = 0.17. Hence, the variance does not differ significantly for experimental and control groups of secondary school students for the post-test scores of Mathematics Anxiety. As the homogeneity assumption of the variance was met, t-test was carried out to test the significance of difference between mean scores of post-test on Mathematics Anxiety for experimental and control groups. The data and results of the test of significance of difference between means of large independent sample for post-test scores of Mathematics Anxiety of secondary school students for experimental and control groups are given in Table 39.

Table 39

Data and Results of Test of Significance of Difference Between Means of Large Independent Sample for Scores of Post-test on Mathematics Anxiety of Experimental and Control Groups

Variable	Group	N	M	SD	Critical Ratio (t-value)
Post-test scores of Mathematics Anxiety	Experimental Group	31	52.26	7.64	1.40
	Control Group	31	50.67	8.75	

Discussion. Table 39 shows that the critical ratio obtained, t = 1.40, p > .05, for post-test scores of Mathematics Anxiety of secondary school students for experimental and control groups. The t value obtained is less than the tabled value of t (1.96) indicating that it is not significant even at .05 level of significance. Thus, it can be concluded that there is no significant difference in the mean scores of post-test on Mathematics Anxiety of secondary school students between the experimental and control groups. Hence, both the participants in the experimental and control groups of secondary school students do not differ significantly in the post-test scores of Mathematics Anxiety.

Comparison of Mean Scores of Post-test on Achievement Motivation in Mathematics for Experimental and Control Group

The experimental and control groups were subjected to post-tests, by using the same instruments administered for the pre-test, to find out the level of Achievement Motivation in Mathematics among the secondary school students and to compare the mean scores of post-test on Achievement Motivation in Mathematics for both groups after providing treatment.

The post-test scores of Achievement Motivation in Mathematics of experimental and control groups of secondary school students were calculated and descriptive statistics of the post-test scores of Achievement Motivation in Mathematics indicated that the distribution of post-test scores of Achievement Motivation in Mathematics of secondary school students follow normal distribution approximately. Since the post-test scores of Achievement Motivation in Mathematics are normally distributed in experimental and control groups, further analysis was done with parametric tests.

Test of significance of difference between means of large independent sample (t-test) was done to know the difference in mean scores of post-test on Achievement Motivation in Mathematics of secondary school students for experimental and control groups. The data were examined to determine the effectiveness of the Process Stage Model on Achievement Motivation in Mathematics for the experimental group. To confirm the homogeneity of variance before testing the significance of the difference between the mean scores of post-test on Achievement Motivation in Mathematics of two groups, Levene's test was conducted. The details of data and results of Levene's Test for equality of variance of post-test scores of Achievement Motivation in Mathematics for experimental and control groups are given in Table 40.

Table 40

Data and Results of Levene's Test for Equality of Variance of Post-test Scores of Achievement Motivation in Mathematics for Experimental and Control Groups

Variable	Condition	Levene's Test F	Degrees of Freedom	Equality of Variance Significance Level
Post-test Scores of Achievement Motivation in Mathematics	Equal Variance Assumed	2.96	$df_1 = 1$ $df_2 = 60$	0.01

Discussion. Table 40 shows that the Levene's test for equality of variance of post-test scores of Achievement Motivation in Mathematics is not satisfied, F (1,60) =2.96, $p < .01$. Hence, the variance differs significantly for experimental and control groups of secondary school students for the post-test scores on Achievement Motivation in Mathematics. Even though, the variance differ significantly, the variance of post-test scores of Achievement Motivation in Mathematics between the experimental and control groups are assumed to be equal and *t*-test was carried out to test the significance of difference between mean scores of post-test on Achievement Motivation in Mathematics for experimental and control groups. The data and results of the test of significance of difference between means of large independent sample for post-test scores of Achievement Motivation in Mathematics of secondary school students for experimental and control groups are given in Table 41.

Table 41

Data and Results of Test of Significance of Difference Between Means of Large Independent Sample for Scores of Post-test on Achievement Motivation in Mathematics of Experimental and Control Groups and Effect Size

Variable	Group	N	M	SD	Critical Ratio (t-value)	Cohen's d	Effect size
Post-test scores Achievement Motivation in Mathematics	Experimental Group	31	163.74	18.06	4.35**	1.96	High
	Control Group	31	137.42	28. 44			

**p < .01

Discussion. Table 41 shows that the critical ratio obtained, *t* = 4.35, *p* <.01, for post-test scores of Achievement Motivation in Mathematics of secondary school students for experimental and control groups. The *t* value obtained is greater than the tabled value of *t* (2.58) indicating that it is significant at .01 level of significance. Thus, it can be concluded that there is significant difference in the mean scores of post-test on Achievement Motivation in Mathematics of secondary school students between the experimental and control groups. Hence, both the participants in the experimental and control groups of secondary school students differ significantly in post-test scores of Achievement Motivation in Mathematics. Thus, it is evident that the experimental group and control group of secondary school students are different in their level of Achievement Motivation in Mathematics in post-test scores.

Further analysis of the mean scores of post-test scores on Achievement Motivation in Mathematics of secondary school students for experimental and control groups were carried out to know which group is having higher level of Achievement Motivation in Mathematics. The results indicate that the experimental group (*M* = 163.74, *SD* = 18.06) is having higher Achievement Motivation in Mathematics than the control group (*M* = 137.42, *SD* =28.44) of secondary school students. In addition to this, the effect size of mean scores of post-test on Achievement Motivation in Mathematics of the experimental and control groups as measured by Cohen's *d* (*d* = 1.96) indicates high effect size. Hence, it can be concluded that for the post-test scores of Achievement Motivation in Mathematics of secondary school students, the experimental group is higher than the control group.

Comparison of Mean Scores of Post-test on Mathematical Beliefs for Experimental and Control Group

The experimental and control groups were subjected to post-tests, by using the same instruments administered for the pre-test, to find out the level of Mathematical Beliefs among the secondary school students and to compare the mean scores of post-test on Mathematical Beliefs for both groups after providing treatment.

The post-test scores of Mathematical Beliefs of experimental and control groups of secondary school students were calculated and descriptive statistics of the post-test scores of Mathematical Beliefs indicated that the distribution of post-test scores of Mathematical Beliefs of secondary school students follow normal distribution approximately. Since the post-test scores of Mathematical Beliefs are normally distributed in experimental and control groups, further analysis was done with parametric tests.

Test of significance of difference between means of large independent sample (*t*-test) was done to know the difference in mean scores of post-test on Mathematical Beliefs of secondary school students for experimental and control groups. The data were examined to determine the effectiveness of the Process Stage Model on Mathematical Beliefs for the experimental group. To confirm the homogeneity of variance before testing the significance of the difference between the mean scores of post-test on Mathematical Beliefs of two groups, Levene's test was conducted. The details of data and results of Levene's Test for equality of variance of post-test scores of Mathematical Beliefs for experimental and control groups are given in Table 42.

Table 42

Data and Results of Levene's Test for Equality of Variance of Post-test Scores of Mathematical Belief in Mathematics for Experimental and Control Groups

Variable	Condition	Levene's Test F	Degrees of Freedom	Equality of Variance Significance Level
Post-test Scores of Mathematical Beliefs	Equal Variance Assumed	4.25	$df_1 = 1$ $df_2 = 60$	0.04

Discussion. Table 42 shows that the Levene's test for equality of variance of post-test scores on Mathematical Beliefs is satisfied F (1,60) = 4.25, p = 0.04. Hence, the variance does not differ significantly for experimental and control groups of secondary school students for the post-test scores of Mathematical Beliefs. As the homogeneity assumption of the variance was met, t-test was carried out to test the significance of difference between mean scores of post-test on Mathematical Beliefs for experimental and control groups. The data and results of the test of significance of difference between means of large independent sample for post-test scores of Mathematical Beliefs of secondary school students for experimental and control groups are given in Table 43.

Table 43

Data and Results of Test of Significance of Difference Between Means of Large Independent Sample for Scores of Post-test on Mathematical Beliefs of Experimental and Control Groups and Effect Size

Variable	Group	N	M	SD	Critical Ratio (t-value)	Cohen's d	Effect size
Post-test Scores of Mathematical Beliefs	Experimental Group	31	25.35	2.95	3.73**	0.95	High
	Control Group	31	22.03	3.99			

**p < .01

Discussion. Table 43 shows that the critical ratio obtained, $t = 3.73$, $p < 0.01$, for post-test scores on Mathematical Beliefs of secondary school students for experimental and control groups. The *t* value obtained is greater than the tabled value of *t* (2.58) indicating that it is significant at .01 level of significance. Thus, it can be concluded that there is significant difference in the mean scores of post-test on Mathematical Beliefs of secondary school students between the experimental and control groups. Hence, both the participants in the experimental and control groups of secondary school students differ significantly in post-test scores of Mathematical

Beliefs. Thus, it is evident that the experimental group and control group of secondary school students are different in their level of Mathematical Beliefs in post-test scores.

Further analysis of the mean scores of post-test on Mathematical Beliefs of secondary school students for experimental and control groups were carried out to know which group is having higher level of Mathematical Beliefs. The results indicate that the experimental group (M = 25.35, SD = 2.95) is having higher Mathematical Beliefs than the control group (M = 22.03, SD =3.99) of secondary school students. In addition to this, the effect size of mean scores of post-test on Mathematical Beliefs of the experimental and control groups as measured by Cohen's d (d = 0.95) indicates high effect size. Hence, it can be concluded that for the post-test scores on Mathematical Beliefs of secondary school students, the experimental group is higher than the control group.

Comparison of Mean Scores of Pre-test and Post-test

The fourth and fifth specific objectives of the study is to compare the mean scores of pre-test and post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs for experimental and control groups of secondary school students. Under this section, the mean difference analysis of pre-test and post-test scores of Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs of secondary school students for the experimental and control groups were carried out. The results and discussion of mean difference analysis of pre-test and post-test scores of Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs of secondary school students for the experimental and control groups are presented in the following sub sections.

- Comparison of Mean Scores of Pre-test and Post-test on Achievement in Mathematics for Experimental Group
- Comparison of Mean Scores of Pre-test and Post-test on Logical Reasoning for Experimental Group
- Comparison of Mean Scores of Pre-test and Post-test on Mathematics Anxiety for Experimental Group
- Comparison of Mean Scores of Pre-test and Post-test on Achievement Motivation in Mathematics for Experimental Group
- Comparison of Mean Scores of Pre-test and Post-test on Mathematical Beliefs for Experimental Group
- Comparison of Mean Scores of Pre-test and Post-test on Achievement in Mathematics for Control Group
- Comparison of Mean Scores of Pre-test and Post-test on Logical Reasoning for Control Group
- Comparison of Mean Scores of Pre-test and Post-test on Mathematics Anxiety for Control Group

- Comparison of Mean Scores of Pre-test and Post-test on Achievement Motivation in Mathematics for Control Group
- Comparison of Mean Scores of Pre-test and Post-test on Mathematical Beliefs for Control Group

Comparison of Mean Scores of Pre-test and Post-test on Achievement in Mathematics for Experimental Group

The pre-test and post-test scores of Achievement in Mathematics of experimental group of secondary school students were calculated and descriptive statistics of scores of Achievement in Mathematics indicated that the distribution of pre-test and post-test scores of Achievement in Mathematics of secondary school students follow normal distribution approximately. Since, the pre-test and post-test scores of Achievement in Mathematics of the experimental group are normally distributed, further analysis was done with parametric tests.

Paired sample *t*-test was conducted to compare pre-test and post-test mean scores of Achievement in Mathematics within the experimental group. The data were examined to determine the effectiveness of the Process Stage Model on Achievement in Mathematics for the experimental group. Data and results of the test of significance of difference between mean scores of pre-test and post-test on Achievement in Mathematics of experimental group and effect size are given in Table 44.

Table 44

Data and Result of the Test of Significance of Difference Between Mean Scores of Pre-test and Post-test Scores of Achievement in Mathematics of Experimental group and Effect Size

Group	Variable	N	M	SD	Correlation	Critical Ratio (t-value)	Cohen's d	Effect size
Experimental group	Pre-test scores of Achievement in Mathematics	31	9.87	4.24	0.64	7.23**	1.02	High
	Post-test scores of Achievement in Mathematics	31	14.29	3.74				

**p < .01

Discussion. Table 44 shows that the critical ratio obtained, $t = 7.23$, $p < .01$, for pre-test and post-test scores on Achievement in Mathematics of secondary school students for the experimental group. The *t* value obtained is greater than the tabled value of *t* (2.58) indicating that it is significant at .01 level of significance. Thus, it can be concluded that there is significant difference in the mean scores of pre-test and post-test on Achievement in Mathematics of secondary school students for the experimental group. Hence, the participants in the experimental group of secondary school students are different in the scores of Achievement in Mathematics in pre-test and post-test.

Further analysis of the mean scores of pre-test and post-test on Achievement in Mathematics of secondary school students for the experimental group were carried out to know whether secondary school students of experimental group are having higher scores for Achievement in Mathematics either in pre-test scores or in post-test scores of Achievement in Mathematics. The results indicate that the post-test scores

(*M* = 14.29, *SD* = 3.74) of Achievement in Mathematics are having higher mean scores than the pre-test scores (*M* = 9.87, *SD* =4.24) of secondary school students in the experimental group. In addition to this, the effect size of mean scores of pre-test and post-test scores of Achievement in Mathematics of the experimental group as measured by Cohen's *d* (*d* = 1.02) indicates high effect size. Hence, it can be concluded that the Achievement in Mathematics of secondary school students of the experimental group is higher in post-test scores than pre-test scores of Achievement in Mathematics of secondary school students of the experimental group.

Comparison of Mean Scores of Pre-test and Post-test on Logical Reasoning for Experimental Group

The pre-test and post-test scores of Logical Reasoning of experimental group of secondary school students were calculated and descriptive statistics of scores of Logical Reasoning indicated that the distribution of pre-test and post-test scores of Logical Reasoning of secondary school students follow normal distribution approximately. Since the pre-test and post-test scores of Logical Reasoning of the experimental group are normally distributed, further analysis was done with parametric tests.

Paired sample t-test was conducted to compare mean scores of pre-test and post-test scores of Logical Reasoning within the experimental group. The data were examined to determine the effectiveness of the Process Stage Model on Logical Reasoning for the experimental group. Data and results of the test of significance of difference between mean scores of pre-test and post-test on Logical Reasoning of experimental group and effect size are given in Table 45.

Table 45

Data and result of the Test of Significance of Difference Between Mean Scores of Pre-test and Post-test scores of Logical Reasoning of Experimental Group and Effect Size

Group	Variable	N	M	SD	Correlation	Critical Ratio (t-value)	Cohen's d	Effect size
Experimental group	Pre-test scores of Logical Reasoning	31	12.81	3.67	0.48	3.03**	0.45	Moderate
	Post-test scores of Logical Reasoning	31	14.94	4.01				

**p < .01

Discussion. Table 45 shows that the critical ratio obtained, $t = 3.03$, $p < .01$, for pre-test and post-test scores of Logical Reasoning of secondary school students for the experimental group. The *t* value obtained is greater than the tabled value of *t* (2.58) indicating that it is significant at .01 level of significance. Thus, it can be concluded that there is significant difference in the mean scores of pre-test and post-test on Logical Reasoning of secondary school students for the experimental group. Thus, it is evident that the scores of Logical Reasoning for the experimental group of secondary school students are different in pre-test and post-test.

Further analysis of the mean scores of pre-test and post-test on Logical Reasoning of secondary school students for the experimental group were carried out to know whether pre-test scores on Logical Reasoning or post-test scores of Logical Reasoning of the participants are higher. The results indicate that the secondary school students show higher mean scores of Logical Reasoning in the post-test scores (*M* = 14.94, *SD* = 4.01) of the experimental group than the pre-test scores (*M* = 12.81, SD =3.67) of Logical Reasoning. In addition to this, the effect size of mean scores of pre-test and post-test scores of Logical Reasoning of the experimental group as measured by Cohen's *d* (*d* = 0.45) indicates moderate effect size. Hence, it can be concluded that the post-test scores of Logical Reasoning of secondary school students of the experimental group is higher than pre-test scores of Logical Reasoning of secondary school students of the experimental group.

Comparison of Mean Scores of Pre-test and Post-test on Mathematics Anxiety for Experimental Group

The pre-test and post-test scores of Mathematics Anxiety of the experimental group of secondary school students were calculated and descriptive statistics of scores of Mathematics Anxiety indicated that the distribution of pre-test and post-test scores of Mathematics Anxiety of secondary school students follow normal distribution approximately. Since the pre-test and post-test scores of Mathematics Anxiety of the experimental group are normally distributed, further analysis was done with parametric tests.

Paired sample *t*-test was conducted to compare mean scores of pre-test and post-test on Mathematics Anxiety within the experimental group. The data were examined to determine the effectiveness of the Process Stage Model on reducing the Mathematics Anxiety of the experimental group. Data and result of the test of significance of difference between mean scores of pre-test and post-test on Mathematics Anxiety of experimental group and effect size are given in Table 46.

Table 46

Data and Result of the Test of Significance of Difference Between Mean Scores of Pre-test and Post-test Scores of Mathematics Anxiety of Experimental Group and Effect Size

Group	Variable	N	M	SD	Correlation	Critical Ratio (t-value)	Cohen's d	Effect size
Experimental group	Pre-test scores of Mathematics Anxiety	31	81.32	16.81	0.90	15.48**	1.49	High
	Post-test scores of Mathematics Anxiety	31	52.26	7.64				

**p < .01

Discussion. Table 46 shows that the critical ratio obtained, $t = 15.48$, $p < .01$, for pre-test and post-test scores on Mathematics Anxiety of secondary school students for the experimental group. The *t* value obtained is greater than the tabled value of *t* (2.58) indicating that it is significant at .01 level of significance Thus, it can be concluded that there is significant difference in the mean scores of pre-test and post-test scores on Mathematics Anxiety of secondary school students for the experimental group. Thus, it is evident that the scores of Mathematics Anxiety of secondary school students of the experimental group differ in pre-test and post-test.

Further analysis of the mean scores of pre-test and post-test on Mathematics Anxiety of secondary school students for the experimental group were carried out to know whether the pre-test scores or post-test scores of Mathematics Anxiety is having a low level of Mathematics Anxiety. The results indicate that the post-test scores (*M* = 52.26, *SD* = 7.64) of Mathematics Anxiety is lower than the pre-test scores (*M* =

81.32, *SD* =6.81) of secondary school students in the experimental group. In addition to this, the effect size of mean scores of pre-test and post-test on Mathematics Anxiety of the experimental group as measured by Cohen's *d* (*d* = 1.49) indicates high effect size. Hence, it can be concluded that the post-test scores of Mathematics Anxiety of secondary school students of the experimental group is lower than pre-test scores of Mathematics Anxiety of secondary school students of the experimental group.

Comparison of Mean Scores of Pre-test and Post-test on Achievement Motivation in Mathematics for Experimental Group

The pre-test and post-test scores of Achievement Motivation in Mathematics of experimental group of secondary school students were calculated and descriptive statistics of scores of Achievement Motivation in Mathematics indicated that the distribution of pre-test and post-test scores of Achievement Motivation in Mathematics of secondary school students follow normal distribution approximately. Since the pre-test and post-test scores of Achievement Motivation in Mathematics of the experimental group are normally distributed, further analysis was done with parametric tests.

Paired sample *t*-test was conducted to compare pre-test and post-test mean scores of Achievement Motivation in Mathematics within the experimental group. The data were examined to determine the effectiveness of the Process Stage Model on Achievement Motivation in Mathematics of the experimental group. Data and results of the test of significance of difference between mean scores of pre-test and post-test on Achievement Motivation in Mathematics of experimental group and effect size are given in Table 47.

Table 47

Data and Results of the Test of Significance of Difference Between Mean Scores of Pre-test and Post-test Scores of Achievement Motivation in Mathematics of Experimental Group and Effect Size

Group	Variable	N	M	SD	Correlation	Critical Ratio (t-value)	Cohen's d	Effect size
Experimental group	Pre-test scores of Achievement Motivation in Mathematics	31	142.06	18.06	0.91	5.82**	1.04	High
	Post-test scores of Achievement Motivation in Mathematics	31	163.74	36.42				

**p < .01

Discussion. Table 47 shows that the critical ratio obtained, $t = 5.82$, $p < 0.01$, for pre-test and post-test scores of Achievement Motivation in Mathematics of secondary school students for the experimental group. The *t* value obtained is greater than the tabled value of *t* (2.58) indicating that it is significant at .01 level of significance. Thus, it can be concluded that there is significant difference in the mean scores of pre-test and post-test scores of Achievement Motivation in Mathematics of secondary school students for the experimental group. Thus, it is evident that the secondary school students of experimental group differ in Achievement Motivation in Mathematics in the pre-test and post-test scores.

Further analysis of the mean scores of pre-test and post-test scores of Achievement Motivation in Mathematics of secondary school students for the experimental group were carried out to know whether the pre-test scores or post-test scores of Achievement Motivation in Mathematics of secondary school students in experimental group is having high Achievement Motivation in Mathematics. The results indicate that the post-test scores (M = 163.74, SD = 36.42) of Achievement Motivation in Mathematics of the experimental group are higher than the pre-test scores (M = 142.06, SD =18.06) of secondary school students in the experimental group. In addition to this, the effect size of mean scores of pre-test and post-test of Achievement Motivation in Mathematics of the experimental group as measured by Cohen's d (d = 1.04) indicates high effect size. Hence, it can be concluded that the post-test scores of Achievement Motivation in Mathematics of secondary school students of the experimental group is higher than pre-test scores of Achievement Motivation in Mathematics of secondary school students of the experimental group.

Comparison of Mean Scores of Pre-test and Post-test on Mathematical Beliefs for Experimental Group

The pre-test and post-test scores of Mathematical Beliefs of the experimental group of secondary school students were calculated and descriptive statistics of scores of Mathematical Beliefs indicated that the distribution of pre-test and post-test scores of Mathematical Beliefs of secondary school students follow normal distribution approximately. Since the pre-test and post-test scores of Mathematical Beliefs of the experimental group are normally distributed, further analysis was done with parametric tests.

Paired sample *t*-test was conducted to compare the mean scores of pre-test and post-test of Mathematical Beliefs within the experimental group. The data were examined to determine the effectiveness of the Process Stage Model on Mathematical Beliefs of the experimental group. Data and results of the test of significance of difference between mean scores of pre-test and post-test on Mathematical Beliefs of experimental group and effect size are given in Table 48.

Table 48

Data and Results of the Test of significance of Difference Between Mean Scores of Pre-test and Post-test Scores on Mathematical Beliefs of Experimental Group and Effect Size

Group	Variable	N	M	SD	Correlation	Critical Ratio (t-value)	Cohen's d	Effect size
Experimental group	Pre-test scores of Mathematical Beliefs	31	22.29	15.15	0.72	4.70**	0.85	High
	Post-test scores of Mathematical Beliefs	31	25.35	2.90				

**p< .01

Discussion. Table 48 shows that the critical ratio obtained, $t = 4.70$, $p < 0.01$, for pre-test and post-test scores of Mathematical Beliefs of secondary school students for the experimental group. The *t* value obtained is greater than the tabled value of *t* (2.58) indicating that it is significant at .01 level of significance. Thus, it can be concluded that there is significant difference in the mean scores of pre-test and post-test on Mathematical Beliefs of secondary school students for the experimental group. Thus, it is evident that the secondary school students in the experimental group are different in the scores of Mathematical Beliefs in pre-test and post-test.

Further analysis of the mean scores of pre-test and post-test on Mathematical Beliefs of secondary school students for the experimental group were carried out to know whether secondary school students are having high Mathematical Beliefs either in pre-test scores or in post-test scores of Mathematical Beliefs. The results indicate that the post-test scores (M =25.35, SD = 2.90) of Mathematical Beliefs are higher than the pre-test scores (M = 22.29, SD =5.15) of secondary school students in the experimental group. In addition to this, the effect size of mean scores of pre-test and post-test on Mathematical Beliefs of the experimental group as measured by Cohen's d (d = 0.85) indicates high effect size. Hence, it can be concluded that the post-test scores of Mathematical Beliefs of secondary school students of the experimental group is higher than pre-test scores on Mathematical Beliefs.

Comparison of Mean Scores of Pre-test and Post-test on Achievement in Mathematics for Control Group

The pre-test and post-test scores of Achievement in Mathematics of control group of secondary school students were calculated and descriptive statistics of scores of Achievement in Mathematics indicated that the distribution of pre-test and post-test scores of Achievement in Mathematics of secondary school students follow normal distribution approximately. Since the pre-test and post-test scores of Achievement in Mathematics of the control group are normally distributed, further analysis was done with parametric tests.

Paired sample t-test was conducted to compare mean scores of pre-test and post-test on Achievement in Mathematics within the control group. Data and result of the test of significance of difference between mean scores of pre-test and post-test scores of Achievement in Mathematics of control group is given in Table 49.

Table 49

*Data and Result of the Test of Significance of Difference Between Mean Scores of Pre-test and Post-test Scores o*f *Achievement in Mathematics of Control Group*

Group	Variable	N	M	SD	Correlation	Critical Ratio (t-value)
Control group	Pre-test scores of Achievement in Mathematics	31	9.65	3.42	0.89	-1.11
	Post-test scores of Achievement in Mathematics	31	9.97	3.64		

Discussion. Table 49 shows that the critical ratio obtained, t = -1.11, p > .05, for pre-test and post-test scores on Achievement in Mathematics of secondary school students for the control group. The t value obtained is less than the tabled value of t (1.96) indicating that it is not significant even at the .05 level of significance. Thus, it can be concluded that there is no significant difference in the mean pre-test and post-test scores of Achievement in Mathematics of secondary school students for the control group. Hence, the participants in the control group of secondary school students are having same level of Achievement in Mathematics for pre-test and post-test scores.

Comparison of Mean Scores of Pre-test and Post-test on Logical Reasoning for Control Group

The pre-test and post-test scores of Logical Reasoning of the control group of secondary school students were calculated and descriptive statistics of scores of

Logical Reasoning indicated that the distribution of pre-test and post-test scores on Logical Reasoning of secondary school students follow normal distribution approximately. Since the pre-test and post-test scores of Logical Reasoning of the control group are normally distributed, further analysis was done with parametric tests.

Paired sample *t*-test was conducted to compare mean scores of pre-test and post-test scores on Logical Reasoning within the control group. Data and result of the test of significance of difference between mean scores of pre-test and post-test scores of Logical Reasoning of the control group is given in Table 50.

Table 50

Data and Result of the Test of Significance of Difference Between Mean Pre-test and Post-test Scores of Logical Reasoning of Control Group

Group	Variable	N	M	SD	Correlation	Critical Ratio (t-value)
Control group	Pre-test scores of Logical Reasoning	31	12.35	4.19	0.83	-0.38
	Post-test scores of Logical Reasoning	31	12.52	3.27		

Discussion. Table 50 shows that the critical ratio obtained, t = -0.38, p >.05, for pre-test and post-test scores of Logical Reasoning of secondary school students for the control group. The t value obtained is less than the tabled value of t (1.96) indicating that it is not significant even at .05 level of significance. Thus, it can be concluded that there is no significant difference in the mean pre-test and post-test scores of Logical Reasoning of secondary school students for the control group.

Hence, the secondary school students of the control group are having the same level of Logical Reasoning for pre-test and post-test scores.

Comparison of Mean Scores of Pre-test and Post-test on Mathematics Anxiety for Control Group

The pre-test and post-test scores of Mathematics Anxiety of the control group of secondary school students were calculated and descriptive statistics of scores of Mathematics Anxiety indicated that the distribution of pre-test and post-test scores of Mathematics Anxiety of secondary school students follow normal distribution approximately. Since the pre-test and post-test scores of Mathematics Anxiety of the control group are normally distributed, further analysis was done with parametric tests.

Paired sample *t*-test was conducted to compare the mean scores of pre-test and post-test on Mathematics Anxiety within the control group. Data and results of the Test of significance of difference between mean scores of pre-test and post-test scores on Mathematics Anxiety of control group and effect size is given in Table 51.

Table 51

Data and Results of the Test of Significance of Difference Between Mean Scores of Pre-test and Post-test scores on Mathematics Anxiety of Control Group

Group	Variable	N	M	SD	Correlation	Critical Ratio (t-value)
Control group	Pre-test scores on Mathematics Anxiety	31	54.97	10.04	0.87	4.83**
	Post-test scores on Mathematics Anxiety	31	50.68	8.75		

**p < .01

Discussion. Table 51 shows that the critical ratio obtained, $t = 4.83$, $p < .01$, for pre-test and post-test scores on Mathematics Anxiety of secondary school students for the control group. The t value obtained is greater than the tabled value of t (2.58) indicating that it is significant at .01 level of significance Thus, it can be concluded that there is significant difference in the mean pre-test and post-test scores of Mathematics Anxiety of secondary school students for the control group. Hence, the control group of secondary school students differ in pre-test and post-test scores on Mathematics Anxiety.

Comparison of Mean Scores of Pre-test and Post-test on Achievement Motivation in Mathematics for Control Group

The pre-test and post-test scores of Achievement Motivation in Mathematics of control group of secondary school students were calculated and descriptive statistics of scores of Achievement Motivation in Mathematics indicated that the distribution of pre-test and post-test scores of Achievement Motivation in Mathematics of secondary school students follow normal distribution approximately. Since the pre-test and post-test scores of Achievement Motivation in Mathematics of the control group are normally distributed, further analysis was done with parametric tests.

Paired sample t-test was conducted to compare the mean scores of pre-test and post-test scores on Achievement Motivation in Mathematics within the control group. Data and results of the test of significance of difference between mean scores of pre-test and post-test scores on Achievement Motivation in Mathematics of control group is given in Table 52.

Table 52

Data and Results of the Test of Significance of Difference Between Mean Scores of Pre-test and Post-test on Achievement Motivation in Mathematics of Control Group

Group	Variable	N	M	SD	Correlation	Critical Ratio (t-value)
Control group	Pre-test scores of Achievement Motivation in Mathematics	31	132.77	10.42	0.23	-0.93
	Post-test scores of Achievement Motivation in Mathematics	31	137.49	28.44		

Discussion. Table 52 shows that the critical ratio obtained, $t = -0.93$, $p < 0.05$, for pre-test and post-test scores on Achievement Motivation in Mathematics of secondary school students for the control group. The t value obtained is less than the tabled value of t (1.96) indicating that it is not significant even at .05 level of significance. Thus, it can be concluded that there is no significant difference in the mean pre-test and post-test scores of Achievement Motivation in Mathematics of secondary school students for the control group. Hence, the control group of secondary school students on pre-test and post-test scores on Achievement Motivation in Mathematics are at the same level.

Comparison of Mean Scores of Pre-test and Post-test on Mathematical Beliefs for Control Group

The pre-test and post-test scores of Mathematical Beliefs of the control group of secondary school students were calculated and descriptive statistics of scores of Mathematical Beliefs indicated that the distribution of pre-test and post-test scores of

Mathematical Beliefs of secondary school students follow normal distribution approximately. Since the pre-test and post-test scores of Mathematical Beliefs of the control group are normally distributed, further analysis was done with parametric tests.

Paired sample *t*-test was conducted to compare pre-test and post-test mean scores of Mathematical Beliefs within the control group. Data and results of the test of significance of difference between mean scores of pre-test and post-test on Mathematical Beliefs of control group is given in Table 53.

Table 53

Data and Results of the Test of Significance of Difference Between Mean Scores of Pre-test and Post-test on Mathematical Beliefs of Control Group

Group	Variable	M	SD	Correlation	Critical Ratio (t-value)
Control Group	Pre-test scores of Mathematical Beliefs	19.65	14.12	0.72	4.37**
	post-test scores of Mathematical Beliefs	22.03	3.98		

**p < .01

Discussion. Table 53 shows that the critical ratio obtained, $t = 4.37$, $p < 0.01$, for pre-test and post-test scores of Mathematical Beliefs of secondary school students for the control group. The *t* value obtained is greater than the tabled value of t (2.58) indicating that it is significant at the .01 level of significance. Thus, it can be concluded that there is significant difference in the mean pre-test and post-test scores of Mathematical Beliefs of secondary school students for the control group. Hence, the participants in the control group of secondary school students on pre-test and post-test scores for Mathematical Beliefs differ significantly.

Comparison of Mean Scores of Gain Scores

The sixth specific objective of the study is to compare the mean scores of gain scores on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs for experimental and control groups of secondary school students. Under this section, the mean difference analysis of gain scores of Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety. Achievement Motivation in Mathematics and Mathematical Beliefs of secondary school students for the experimental and control groups were carried out. The results and discussion of mean difference analysis of gain scores of Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs of secondary school students for the experimental and control groups are presented in the following sub sections.

- Comparison of Mean Scores of Gain Scores on Achievement in Mathematics for Experimental and Control Groups
- Comparison of Mean Scores of Gain Scores on Logical Reasoning for Experimental and Control Groups
- Comparison of Mean Scores of Gain Scores on Mathematics Anxiety for Experimental and Control Groups

- Comparison of Mean Scores of Gain Scores on Achievement Motivation in Mathematics for Experimental and Control Groups
- Comparison of Mean Scores of Gain Scores on Mathematical Beliefs for Experimental and Control Groups

Comparison of Mean Scores of Gain Scores on Achievement in Mathematics for Experimental and Control Groups

The comparison of post-test scores of Achievement in Mathematics of experimental and control groups revealed the difference between the two groups is significant. After comparing post-test scores of Achievement in Mathematics of experimental and control groups, a comparison of gain scores was also conducted to ensure whether there exist any significant difference in the gain scores on Achievement in Mathematics of experimental and control groups.

Gain scores on Achievement in Mathematics of experimental and control groups of secondary school students were calculated and analysis of descriptive statistics revealed that the distribution of gain scores on Achievement in Mathematics of secondary school students follow normal distribution approximately.

As gain scores on Achievement in Mathematics are normally distributed in both experimental and control groups, further analysis was done with parametric tests. Test of significance of difference between means of large independent sample (*t*-test) was done to know the difference in mean scores of gain scores on Achievement in Mathematics of secondary school students for experimental and control groups. To confirm the homogeneity of variance before testing the significance of the difference between the mean scores of gain scores on Achievement in Mathematics of two groups, Levene's test was conducted. The details of data and results of Levene's Test for equality of variance of gain scores on Achievement in Mathematics for experimental and control groups are given in Table 54.

Table 54

Data and Results of Levene's Test for Equality of Variance of Gain Scores on Achievement in Mathematics for Experimental and Control Groups

Variable	Condition	Levene's Test F	Degrees of Freedom	Equality of Variance Significance Level
Gain Scores on Achievement in Mathematics	Equal Variance Assumed	9.45	$df_1 = 1$ $df_2 = 60$	0.003

Discussion. Table 54 shows that the Levene's test for equality of variance of pre-test scores on Achievement in Mathematics is not satisfied F (1,60) = 9.45, $p < 0.003$. Hence, the variance differs significantly for experimental and control groups of secondary school students for the gain scores on Achievement in Mathematics. Further analysis was carried out by assuming an equal variance and *t*-test was carried out to test the significance of difference between mean scores of gain scores on Achievement in Mathematics for experimental and control groups. The data and results of the test of significance of difference between means of large independent sample for gain scores on Achievement in Mathematics of secondary school students for experimental and control groups and effect size are given in Table 55.

Table 55

Data and Results of Test of Significance of Difference between Means of Large Independent Sample for Mean Scores of Gain Scores on Achievement in Mathematics of Experimental and Control Groups and Effect size

Variable	Group	N	M	SD	Critical Ratio (t-value)	Cohen's d	Effect size
Gain Scores of Achievement in Mathematics	Experimental Group	31	4.42	3.40	3.19**	0.76	High
	Control Group	31	0.41	6.09			

**p < .01

Discussion. Table 55 shows that the critical ratio obtained, t = 3.19, p < .01, for gain scores on Achievement in Mathematics of secondary school students for experimental and control groups. The t value obtained is greater than the tabled value of t (2.58) indicating that it is significant at .01 level of significance. Thus, it can be concluded that there is significant difference in the mean scores of gain scores on Achievement in Mathematics of secondary school students for experimental and control groups. Thus, it is evident that the secondary school students differ in their gain scores on Achievement in Mathematics for experimental and control groups.

Further analysis of the mean scores of gain scores on Achievement in Mathematics of secondary school students for experimental and control groups were carried out to know which group is having higher Achievement in Mathematics. The results indicate that the experimental group (M = 4.42, SD = 3.40) is having higher Achievement in Mathematics than the control group (M = 0.41, SD = 6.09) in gain scores on Achievement in Mathematics of secondary school students. In addition to this, the effect size of mean scores of gain scores on Achievement in Mathematics of secondary school students for experimental and control groups as measured by Cohen's *d* (*d* = 0.76) indicates high effect size. Hence, it can be concluded that for the gain scores on Achievement in Mathematics of secondary school students, the experimental group is higher in Achievement in Mathematics than the control group. Therefore, it can be concluded that the Process Stage Model is effective for enhancing Achievement in Mathematics of secondary school students. The study supports the findings that learning strategies are a significant predictor of students' academic achievement (Pennequin et al., 2010; Muelas & Navarro, 2015; Almoslaman, 2022). Similarly, research studies reported that instructional strategies such as cooperative learning models (Pandy, 2011), inquiry training model (Bhatt, 2020) and blended learning model (Indrapangastyi et al., 2021) are effective in enhancing academic performance of students.

Comparison of Mean Scores of Gain Scores on Logical Reasoning for Experimental and Control Groups

The comparison of post-test scores of Logical Reasoning of experimental and control groups revealed the difference between the two groups is significant. After comparing post-test results of Logical Reasoning of experimental and control groups, a comparison of gain scores was also conducted to ensure whether there exist any significant difference in the gain scores on Logical Reasoning of experimental and control groups.

Gain scores on Logical Reasoning of experimental and control groups of secondary school students were calculated and analysis of descriptive statistics revealed that the distribution of gain scores on Logical Reasoning of secondary school students follow normal distribution approximately.

As gain scores on Logical Reasoning are normally distributed in both experimental and control groups, further analysis was done with parametric tests. Test of significance of difference between means of large independent sample (*t*-test) was done to know the difference in mean scores of gain scores on Logical Reasoning of secondary school students for experimental and control groups. To confirm the homogeneity of variance before testing the significance of the difference between the mean scores of gain scores on Logical Reasoning of two groups, Levene's test was conducted. The details of data and results of Levene's Test for equality of variance of gain scores on Logical Reasoning for experimental and control groups are given in Table 56.

Table 56

Data and Results of Levene's Test for Equality of Variance of gain scores on Logical Reasoning for Experimental and Control Groups

Variable	Condition	Levene's Test F	Degrees of Freedom	Equality of Variance Significance Level
Gain Scores on Logical Reasoning	Equal Variance Assumed	4.43	$df_1 = 1$ $df_2 = 60$	0.04

Discussion. Table 56 shows that the Levene's test for equality of variance of gain scores on Logical Reasoning is satisfied F (1,60) =4.43, p = 0.04. Hence, the variance does not differ significantly for experimental and control groups of secondary school students for the gain scores on Logical Reasoning. As the homogeneity assumption of the variance was met, *t*-test was carried out to test the significance of difference between mean scores of gain scores on Logical Reasoning for experimental and control groups. The data and results of the test of significance of difference between means of large independent sample for gain scores on Logical Reasoning of secondary school students for experimental and control groups and effect size are given in Table 57.

Table 57

Data and Results of Test of Significance of Difference between Means of Large Independent Sample for Scores of Gain Scores on Logical Reasoning of Experimental and Control Groups and Effect size

Variable	Group	N	M	SD	Critical Ratio (*t*-value)	Cohen's *d*	Effect size
Gain Scores of Logical Reasoning	Experimental Group	31	2.12	3.91	2.40*	0.59	Moderate
	Control Group	31	0.16	2.35			

*p < .05

Discussion. Table 57 shows that the critical ratio obtained, $t = 2.40$, $p < .05$, for gain scores on Logical Reasoning of secondary school students for experimental and control groups. The *t* value obtained is greater than the tabled value of *t* (1.96) indicating that it is significant at .05 level. Thus, it can be concluded that there is significant difference in the mean scores of gain scores on Logical Reasoning of secondary school students for experimental and control groups. Thus, it is evident that the secondary school students are different in gain scores on Logical Reasoning of experimental and control groups.

Further analysis of the mean gain scores on Logical Reasoning of secondary school students for experimental and control groups were carried out to know which group is having higher level of gain scores on Logical Reasoning. The results indicate that the experimental group (M = 2.12, SD = 3.91) is having higher gain scores on Logical Reasoning than the control group (M = 0.16, SD =2.35) of secondary school students. In addition to this, the effect size of mean gain scores on Logical Reasoning of secondary school students for experimental and control groups as measured by Cohen's d (d = 0.59) indicates moderate effect size. Hence, it can be concluded that for the gain scores on Logical Reasoning of secondary school students, the experimental group is higher than the control group. Thus, it is evident that the Process Stage Model is effective for enhancing Logical Reasoning of secondary school students. Similarly, Ovchinnikova (2020) noted that the use of methods and laws of formal and dialectical logic, method of scientific thinking allows students to form a style of verbal and logical thinking. The result of the study also supports the findings that problem based learning (Anwar et al., 2020), play based learning (Fathima et al., 2021) and higher order thinking model (Khan & Rana, 2021) enhanced the logical reasoning of students.

Comparison of Mean Scores of Gain Scores on Mathematics Anxiety for Experimental and Control Groups

The comparison of post-test scores of Mathematics Anxiety of experimental and control groups revealed the difference between the two groups is not significant. It indicates the effectiveness of the Process Stage Model in reducing the Mathematics Anxiety of secondary school students. After comparing post-test results of Mathematics Anxiety of experimental and control groups, a comparison of gain scores was also conducted to ensure whether there exist any significant difference between gain scores on Mathematics Anxiety of experimental and control groups.

Gain scores on Mathematics Anxiety of experimental and control groups of secondary school students were calculated and analysis of descriptive statistics revealed that the distribution of gain scores on Mathematics Anxiety of secondary school students follow normal distribution approximately.

As gain scores on Mathematics Anxiety are normally distributed in both experimental and control groups, further analysis was done with parametric tests. Test of significance of difference between means of large independent sample (*t*-test) was done to know the difference in mean scores of gain scores on Mathematics Anxiety of secondary school students for experimental and control groups. To confirm the homogeneity of variance before testing the significance of the difference between the mean scores of gain scores on Mathematics Anxiety of two groups, Levene's test was conducted. The details of data and results of Levene's Test for equality of variance of gain scores on Logical Reasoning for experimental and control groups are given in Table 58.

Table 58

Data and Results of Levene's Test for Equality of Variance of Gain scores on Logical Reasoning for Experimental and Control Groups

Variable	Condition	Levene's Test F	Degrees of Freedom	Equality of Variance Significance Level
Gain Scores on Mathematics Anxiety	Equal Variance Assumed	12.29	df1=1 df2=60	<0.001

Discussion. Table 58 shows that the Levene's test for equality of variance of gain scores on Mathematics Anxiety is not satisfied *F* (1,60) =12.29, $p < .001$. Hence, the variance differs significantly for experimental and control groups of secondary school students for the gain scores on Mathematics Anxiety. Further analysis was carried out by assuming an equal variance and *t*-test was carried out to test the significance of difference between mean scores of gain scores on Mathematics Anxiety for experimental and control groups. The data and results of the test of significance of difference between means of large independent sample for gain scores on Mathematics Anxiety of secondary school students for experimental and control groups are given in Table 59.

Table 59

Data and Results of Test of Significance of Difference between Means of Large Independent Sample for Scores of Gain Scores on Mathematics Anxiety of Experimental and Control Groups

Variable	Group	N	M	SD	Critical Ratio (t-value)	Cohen's d	Effect size
Gain Scores on Mathematics Anxiety	Experimental Group	31	-29.06	10.45	-11.93**	-1.63	High
	Control Group	31	-4.29	4.95			

** p < .01

Discussion. Table 59 shows that the critical ratio obtained, $t = -11.93$, $p < .01$, for gain scores on Mathematics Anxiety of secondary school students for experimental and control groups. This suggests that there is a substantial difference between gain scores on Mathematics Anxiety of secondary school students for experimental and control groups at .01 level of significance. The negative *t*-value suggests that the mean gain score (reduction in Mathematics Anxiety) for experimental group is significantly lower than that for the control group.

Further analysis of the mean gain scores on Mathematics Anxiety of secondary school students for experimental and control groups were carried out to know the difference in gain scores on Mathematics Anxiety. The results indicate that the experimental group (M = -29.06, SD = 10.45) is having less gain scores on Mathematics Anxiety than the control group (M = -4.26, SD =4.95) of secondary school students. In addition to this, the effect size of mean gain scores on Mathematics Anxiety of secondary school students for experimental and control groups as measured by Cohen's d (d = -1.63) indicates high effect size. Hence, it can be concluded that for the gain scores on Mathematics Anxiety of secondary school students, the experimental group is less than the control group. Thus, it is evident that the Process Stage Model is effective for reducing Mathematics Anxiety of secondary school students. Similarly, the study conducted by Atoyebi and Atoyebi (2022) supported that mathematics teaching strategies correlated with students' mathematics anxiety. In addition to that the studies conducted by Niaci et al. (2021), Tsegaw et al. (2021), and Yaftin and Baughamadi (2022) reported that flipped classroom, pedagogic practices and multimedia approach reduced mathematics anxiety of students.

Comparison of Mean Scores of Gain Scores on Achievement Motivation in Mathematics for Experimental and Control Groups

The comparison of post-test scores of Achievement Motivation in Mathematics of experimental and control groups revealed the difference between the two groups is significant. After comparing post-test results of Achievement

Motivation in Mathematics of experimental and control groups, a comparison of gain scores was also conducted to ensure whether there exist any significant difference in the gain scores on Achievement Motivation in Mathematics of experimental and control groups.

Gain scores of Achievement Motivation in Mathematics of experimental and control groups of secondary school students were calculated and analysis of descriptive statistics revealed that the distribution of gain scores on Achievement Motivation in Mathematics of secondary school students follow normal distribution approximately.

As gain scores on Achievement Motivation in Mathematics are normally distributed in both experimental and control groups, further analysis was done with parametric tests. Test of significance of difference between means of large independent sample (*t*-test) was done to know the difference in mean scores of gain on Achievement Motivation in Mathematics of secondary school students for experimental and control groups. To confirm the homogeneity of variance before testing the significance of the difference between the mean scores of gain on Achievement Motivation in Mathematics of two groups, Levene's test was conducted. The details of data and results of Levene's Test for equality of variance of gain scores on Achievement Motivation in Mathematics for Experimental and Control Groups are given in Table 60.

Table 60

Data and Results of Levene's Test for Equality of Variance of Gain Scores on Achievement Motivation in Mathematics for Experimental and Control Groups

Variable	Condition	Levene's Test F	Degrees of Freedom	Equality of Variance Significance Level
Gain Scores on Achievement Motivation in Mathematics	Equal Variance Assumed	0.33	$df_1 = 1$ $df_2 = 60$	0.57

Discussion. Table 60 shows that the Levene's test for equality of variance of gain scores on Logical Reasoning is satisfied F (1,60) = 0.33, p = 0.57. Hence, the variance does not differ significantly for experimental and control groups of secondary school students for the gain scores on Achievement Motivation in Mathematics. As the homogeneity assumption of the variance was met, t-test was carried out to test the significance of difference between mean gain scores on Achievement Motivation in Mathematics for experimental and control groups. The data and results of the test of significance of difference between means of large independent sample for gain scores on Achievement Motivation in Mathematics of secondary school students for experimental and control groups and effect size are given in Table 61.

Table 61

Data and Results of Test of Significance of Difference between Means of Large Independent Sample for Scores of Gain Scores on Achievement Motivation in Mathematics of Experimental and Control Groups and Effect Size

Variable	Group	N	M	SD	Critical Ratio (*t*-value)	Cohen's *d*	Effect size
Gain Scores on Achievement Motivation in Mathematics	Experimental Group	31	21.68	20.67	2.78**	0.66	Moderate
	Control Group	31	4.65	27.94			

**p < .01

Discussion. Table 61 shows that the critical ratio obtained, $t = 2.78$, $p < 0.01$, for gain scores on Achievement Motivation in Mathematics of secondary school students for experimental and control groups. The *t* value obtained is greater than the tabled value of *t* (2.58) indicating that it is significant at .01 level of significance. Thus, it can be concluded that there is significant difference in the mean scores of gain scores on Achievement Motivation in Mathematics of secondary school students between the experimental and control groups. Thus, it is evident that the secondary school students are different in their gain scores on Achievement Motivation in Mathematics for experimental and control groups.

Further analysis of the mean gain scores on Achievement Motivation in Mathematics of secondary school students for experimental and control groups were carried out to know which group is higher in gain scores on Achievement Motivation in Mathematics. The results indicate that the experimental group ($M = 21.68$, $SD = 20.67$) is having higher gain scores on Achievement Motivation in Mathematics than the control group ($M = 4.65$, $SD = 27.94$) of secondary school students. In addition to this, the effect size of mean gain scores on Achievement Motivation in Mathematics of secondary school students for experimental and control groups as measured by Cohen's *d* (*d* = 0.66) indicates moderate effect size. Hence, it can be concluded that for the gain scores on Achievement Motivation in Mathematics of secondary school students, the experimental group is higher than the control group. Therefore, it can be concluded that the Process Stage Model is effective for enhancing Achievement Motivation in Mathematics of secondary school students. Kaur and Sankhian (2017) reported that the activity based method has been found to enhance achievement motivation and academic performance in Mathematics, in contrast to traditional approach. Similarly, Mohanty (2016) reported that inquiry training model is effective in enhancing achievement motivation.

Comparison of Mean Scores of Gain Scores on Mathematical Beliefs for Experimental and Control Groups

The comparison of post-test scores of Mathematical Beliefs of experimental and control groups revealed the difference between the two groups is significant. After comparing post-test results of Mathematical Beliefs of experimental and control groups, a comparison of gain scores was also conducted to ensure whether there exist any significant difference in the gain scores on Mathematical Beliefs of experimental and control groups.

Gain scores of Mathematical Beliefs of experimental and control groups of secondary school students were calculated and analysis of descriptive statistics revealed that the distribution of gain scores of Mathematical Beliefs of secondary school students follow normal distribution approximately.

As gain scores on Mathematical Beliefs are normally distributed in both experimental and control groups, further analysis was done with parametric tests. Test of significance of difference between means of large independent sample (*t*-test) was done to know the difference in mean scores of gain scores on Mathematical Beliefs of secondary school students for experimental and control groups. To confirm the homogeneity of variance before testing the significance of the difference between the mean scores of gain on Mathematical Beliefs of two groups, Levene's test was conducted. The details of data and results of Levene's Test for equality of variance of gain scores on Mathematical Beliefs for experimental and control groups are given in Table 62.

Table 62

Data and Results of Levene's Test for Equality of Variance of Gain Scores on Mathematical Beliefs for Experimental and Control Groups

Variable	Condition	Levene's Test F	Degrees of Freedom	Equality of Variance Significance Level
Gain Scores of Mathematical Beliefs	Equal Variance Assumed	0.49	$df_1 = 1$ $df_2 = 60$	0.49

Discussion. Table 62 shows that the Levene's test for equality of variance of gain scores on Mathematical Beliefs is satisfied, $F\,(1,60) = 0.49$, $p = 0.49$. Hence, the variance does not differ significantly for experimental and control groups of secondary school students for the gain scores on Mathematical Beliefs. As the homogeneity assumption of the variance was met, *t*-test was carried out to test the significance of difference between mean gain scores on Mathematical Beliefs for experimental and control groups. The data and results of the test of significance of difference between means of large independent sample for gain scores on Mathematical Beliefs of secondary school students for experimental and control groups are given in Table 63.

Table 63

Data and Results of Test of Significance of Difference Between Means of Large Independent Sample for Scores of Gain Scores on Mathematical Beliefs of Experimental and Control Groups

Variable	Group	N	M	SD	Critical Ratio (t-value)
Gain Scores of Mathematical Beliefs	Experimental Group	31	3.06	3.63	0.8
	Control Group	31	2.39	3.04	

Discussion. Table 63 shows the critical ratio obtained, $t = 0.8$, $p > 0.05$, for gain scores on Mathematical Beliefs of secondary school students for experimental and control groups. The *t* value obtained is less than the tabled value of *t* (1.96) indicating that it is not significant even at .05 level. Thus, it can be concluded that there is no significant difference in the mean scores of gain scores on Mathematical Beliefs of secondary school students between the experimental and control groups. Hence, both the experimental and control group of secondary school students are same in Mathematical Beliefs while comparing the gain scores after treatment. Therefore, Process Stage Model is less effective in enhancing the Mathematical Beliefs of Secondary School students.

Analysis of Covariance (ANCOVA)

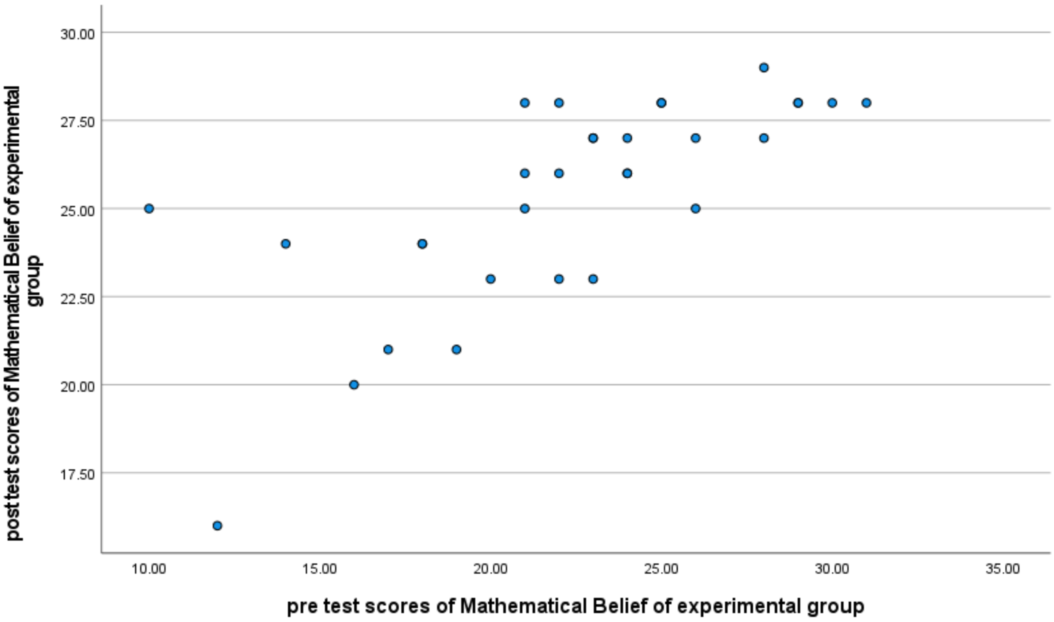
During the initial stage of analysis, the mean pre-test score comparison of experimental and control groups regarding the variable Mathematical Beliefs shows significant difference (t = 2.23, p < .05). The results of comparison of post-test scores on Mathematical Beliefs for experimental and control groups also exhibited significant differences in mean scores of post-test scores on Mathematical Beliefs for experimental and control groups (t = 3.73, p < .01). Hence it is mandatory to find out the difference in Mathematical Beliefs found during the post-test scores of experimental and control groups by limiting the effect of pre-test scores on Mathematical Beliefs. To ensure the precision of the difference, by controlling the effect of pre-experimental status of Mathematical Beliefs the statistical procedure ANCOVA is used. Before carrying out the ANCOVA, it investigator checked whether the assumptions of ANCOVA were met. The assumption check of ANCOVA are described below.

Linear Relationship Between Covariate and Dependent Variable of Experimental Group

The relationship between the covariate (pre-test scores on Mathematical Beliefs) and the dependent variable (post- test scores on Mathematical Beliefs) of the experimental group are tested with scatter-plots. The Figure 19 represents the scatterplots of experimental group.

Figure 19

Scatter plot of pre-test scores of Mathematical Beliefs and post-test scores of Mathematical Beliefs of experimental group



Discussion

The scatter plot exhibits the linear relationship between the covariate (pre-test scores on Mathematical Beliefs) and the dependent variable (post- test scores on Mathematical Beliefs) of the experimental group. The correlation between the covariate (pre-test scores on Mathematical Beliefs) and the dependent variable (post-test scores on Mathematical Beliefs) are shown below in Table 64.

Table 64

Pearson's Correlation between the Covariate (Pre-test Scores on Mathematical Beliefs) and the Dependent Variable (Post test Scores on Mathematical Beliefs) of the Experimental Group.

Variable	Group	N	Pearson's correlation
Pre-test scores of Mathematical Beliefs	Experimental	31	0.73
Post-test scores of Mathematical Beliefs		31	

Discussion

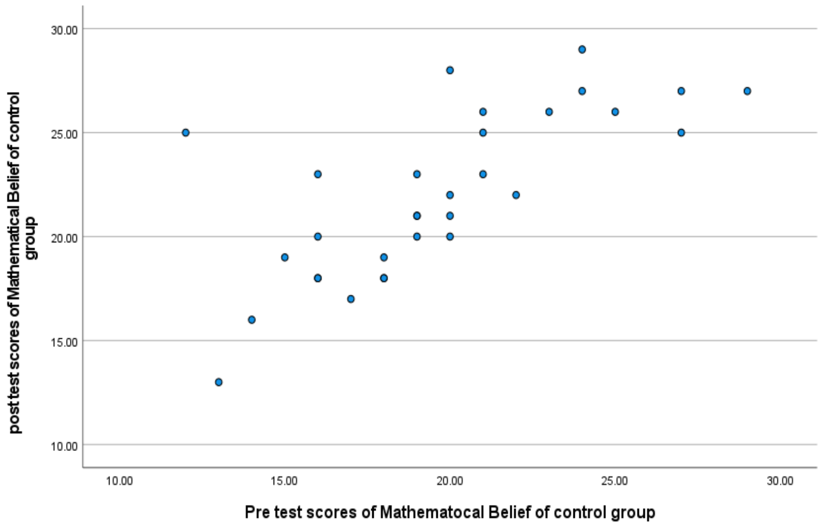
Table 64 shows that the Pearson's correlation between the covariate (pre-test scores on Mathematical Beliefs) and the dependent variable (post-test scores on Mathematical Beliefs) of the experimental group is r = .73. Hence, it can be concluded that covariate (pre-test scores on Mathematical Beliefs) and the dependent variable (post test scores on Mathematical Beliefs) of the experimental group have positive linear relationship.

Linear Relationship between Covariate and Dependent Variable of Control Group

The relationship between the covariate (pre-test scores on Mathematical Beliefs) and the dependent variable (post- test scores on Mathematical Beliefs) are tested with scatter-plots. The Figure 20 represents the Scatter plots of the control group.

Figure 20

Scatter plot of pre-test scores of Mathematical Beliefs and post-test scores of Mathematical Beliefs of control group.



The scatter plot exhibits the linear relationship between the covariate (pre-test scores on Mathematical Beliefs) and the dependent variable (post- test scores on Mathematical Beliefs) of the control group. The correlation between the covariate (pre-test scores on Mathematical Beliefs) and the dependent variable (post-test scores on Mathematical Beliefs) of control group are shown below in Table 65.

Table 65

Pearson's Correlation Between the Covariate (Pre-test Scores on Mathematical Beliefs) and the Dependent variable (Post-test Scores on Mathematical Beliefs) of the Control Group

Variable	Group	N	Pearson's correlation
Pre-test scores of Mathematical Beliefs	Control	31	0.72
Post-test scores of Mathematical Beliefs		31	

Discussion

Table 65 shows Pearson's correlation between the covariate (pre-test scores on Mathematical Beliefs) and the dependent variable (post test scores on Mathematical Beliefs) of the control group is r = .72. Hence, it can be concluded that covariate (pre-test scores on Mathematical Beliefs) and the dependent variable (post test scores on Mathematical Beliefs) of the control group have positive linear relationship.

To confirm the homogeneity of variance before testing the Univariate Analysis of covariance with pre-test scores on Mathematical Beliefs as covariate of two groups, Levene's test was conducted. The details of data and results of Levene's Test for Equality of Variance of covariate (pre-test scores on Mathematical Beliefs) and dependent variable (post-test scores on Mathematical Beliefs) for Experimental and Control Groups are given in Table 66.

Table 66

Data and results of Levene's Test for Equality of Variance of Covariate (Pre-test Scores on Mathematical Beliefs) and Dependent Variable (Post-test scores on Mathematical Beliefs) for Experimental and Control Groups

Covariate	Dependent Variable	Levene's Test F	Degrees of Freedom	Equality of Variance Significance Level
Pre-test scores of Mathematical Beliefs	post-test scores of Mathematical Beliefs	2.17**	df1=1 df2=60	0.15

Discussion

Table 66 shows that the Levene's test for equality of variance of covariate (pre-test scores on Mathematical Beliefs) and dependent variable (post-test scores on Mathematical Beliefs) for experimental and control Groups is satisfied, F (1,60) = 2.17, $p = 0.15$. Hence, the variance does not differ significantly for experimental and control groups of secondary school students for the pre-test and post-test scores on Mathematical Beliefs. As the homogeneity assumption of the variance was met, Univariate Analysis of Covariance was carried out. Data and result of one-way ANCOVA with covariate (pre-test scores on Mathematical Beliefs) and the dependent variable (post-test scores on Mathematical Beliefs) for pre-test scores on Mathematical Beliefs of secondary school students for experimental and control groups are given in Table 67.

Table 67

Data and result of one-way ANCOVA with Covariate (Pre-test Scores on Mathematical Beliefs) and the Dependent Variable (Post-test Scores on Mathematical Beliefs) for Pre-test Scores of Mathematical Beliefs of Secondary School Students for Experimental and Control groups

Source of Variance	Sum of squares	df	Mean square	Critical Ratio F-value	Partial Eta Squared
Pre-test scores of Mathematical Beliefs	359.60	1	359.60	56.06**	0.49
Groups	53.55	1	53.55	8.35**	0.12
Error	378.47	59	6.42		

**p < .01

Discussion

Table 67 shows that the critical ratio, F (1,59) = 8.35, p < .01, η_2 = 0.12, the difference between the experimental group and control group on post-test scores on Mathematical Beliefs is significant while adjusting the pre-test scores on Mathematical Beliefs. It reveals that there was statistically significant difference between the experimental and control groups in post-test scores on Mathematical Beliefs when controlling for the covariate. So, the covariate (pre-test scores on Mathematical Beliefs) significantly adjusts the association between the predictor and dependent variable. Therefore, it can be concluded that Process Stage Model has a significant effect on post-test scores of Mathematical beliefs of experimental group. The partial Eta squared value (0.12) indicates that the effect size is small. One way ANCOVA showed the difference between experimental and control group is significant while considering the effect of covariate. In order to find the group which shows more Mathematical Beliefs, the comparison of estimated marginal means was used. Data and result of comparison of estimated marginal means of experimental and control groups are shown in Table 68.

Table 68

Data and result of comparison of Estimated Marginal Means of Experimental and Control groups

Dependent variable	Estimated Marginal Means	
	Experimental group	Control group
Post-test scores of Mathematical Beliefs	24.66	22.73

Discussion

Table 68 shows that the estimated marginal means of experimental and control groups are 24.66 and 22.73 respectively. The marginal means of the experimental group (M = 24.66) is greater than the marginal means of the control group (M = 22.73). Thus, it is evident that the experimental group shows better Mathematical Beliefs than the control group considering pre-test scores on Mathematical Belief as covariate. Therefore, it can be concluded that the Process stage Model is effective in enhancing Mathematical Beliefs of secondary school students. Similarly, Cormas (2022) concluded that educational methods course on early childhood preservice teachers' instructional beliefs, significantly changed perspective teachers beliefs, increasing their constructivist views and making these beliefs more concreate and coherent. The findings of the study supported the results that innovate strategies are helpful in enhancing Mathematical Beliefs of students (Rahayu & Kurniasih, 2014; Abebe et al., 2023),

Conclusion

By analyzing the results of the study, the investigator arrived at the following conclusions. The findings of the study indicated the effectiveness of the Process Stage Model in improving cognitive and affective outcomes related to mathematics learning. The comparison between the experimental and control groups revealed that the Process Stage Model significantly enhanced students Achievement in Mathematics, Logical Reasoning and Achievement Motivation in Mathematics. These improvements highlighted the Process Stage Model’s success in fostering both cognitive skills and Achievement Motivation in Mathematics of secondary school students, surpassing the existing constructivist model of teaching.

Additionally, the use of Process Stage Model resulted in substantial reduction in Mathematics Anxiety of secondary school students, suggesting its potential to alleviate negative emotions associated with the subject. Furthermore, when considering pre-test scores on Mathematical Beliefs as covariate, the estimated marginal means of the experimental group were found to be higher than those of the control group of secondary school students. This indicated that the Process Stage Model is also effective in enhancing students' Mathematical Beliefs. Overall, the results supported the notion that the Process Stage Model is an effective instructional strategy in improving both cognitive abilities and emotional well-being in mathematics education, with particular benefits in reducing Mathematics Anxiety and fostering Mathematical Beliefs among secondary school students.

Chapter 5

SUMMARY, FINDINGS AND CONCLUSIONS

SUMMARY, FINDINGS AND CONCLUSIONS

The mathematics education aims at enhancing essential competencies among the students such as conceptual understanding, procedural fluency in computation, and problem-solving skills (Ministry of Education, 2011; NCTM, 2000). The relationship between these three facets of mathematical competence is often characterized by bidirectional and iterative nature (Hallett et al., 2010; Rittle-Johnson, 2015). However, a noticeable disconnect between these areas frequently arises in classroom teaching and student achievement in mathematics (Hallet et al., 2010; Lefevre et al., 2006). As a result, the curriculum places a stronger emphasis on problem-solving skills, which involve the application of acquired mathematical concepts and procedures to real-world situations. According to Brenner et al. (1997) connecting different representations is instrumental in achieving a deeper insight into the learning concepts and facilitates the interpretation of complex interdependencies among mathematical concepts, promoting abstraction and generalization. Research has shown that linking multiple representations of a mathematical idea contributes significantly to the development of conceptual understanding and enhances problem-solving abilities (Brenner et al., 1997; Carbonneau et al., 2013). High cognitive-demand instructional tasks are intended to establish connections between mathematical methods and their foundational concepts, moving beyond mere mechanical execution. Studies have shown that such tasks correlate and enhance students' understanding and proficiency in procedural skills (Hiebert & Wearne 1993; Stain & Wearne, 1996).

The learning of mathematics is significantly influenced by affective connections, which provide a sense of meaning for individuals (De Bellis & Goldin, 2006). According to Gagatsis et al. (2009) middle school students exhibiting higher levels of self-efficacy in mathematics are more likely to express positive beliefs about their skills in employing different types of representations. Encouraging students to explore various methods for solving mathematical problems seems to enhance their interest in mathematics (Schukajilow & Krug, 2014). Research studies indicate that when students engage with real-world mathematical problems that offer multiple solutions and representations, they tend to shift their prior beliefs such that mathematics as merely a subject for memorizing algorithms, with little relevance beyond passing examinations (Mason & Scrivani, 2004). Several research studies showed that students were more motivated to solve problems through their strategies and share their thoughts with peers, had greater readiness to express their opinions and heightened enthusiasm for learning, even if their ideas were not always correct (Kosko, 2012; Patrick et al., 2003). Affective learning outcomes are essential components of the mathematics curriculum along with the cognitive outcomes, as the positive emotional experiences foster a sense of personal relevance in learning mathematics, which in turn deepens their understanding of the mathematical concepts (Linnenbrink & Pintrich, 2004).

Selecting appropriate teaching strategies is crucial for enhancing student performance (Tomlinson, 2001). Student centered approaches promote critical thinking and foster respectful classroom environments (Xhomara,2022). Implementing teaching strategies and active participation facilitated interaction among students which helps in enhancing course performance and results in a positive impact on student achievement in the classroom (Freeman et al., 2014). Thus, it is evident that teaching approaches and strategies have a positive impact on enhancing the cognitive outcomes and affective outcomes of various subjects, as well helps in removing undesirable affective factors of learning. Therefore, the investigator decided to find out the effectiveness of the Process Stage Model on learning outcomes in mathematics such as Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical beliefs among secondary school students.

Hence the research question framed for the study are;

1. What is the level of Mathematical Beliefs of secondary school students?
2. Does the Process Stage Model enhances the Achievement in Mathematics of secondary school students?
3. Does the Process Stage Model enhances Logical Reasoning of secondary school students?
4. Does the Process Stage Model reduces Mathematics Anxiety of secondary school students?
5. Does the Process Stage Model enhances Achievement Motivation in Mathematics of secondary school students?

6. Does the Process Stage Model helps in developing Mathematical Beliefs of secondary school students?

Study in Retrospect

The various stages of the study such as restatement of the problem, variables, hypotheses, design of the study, sample selected for the study, instruments used and statistical techniques employed are viewed retrospectively in this section.

Restatement of the problem

National Education Policy, 2020 visualizes that India's future leadership in disciplines such as artificial intelligence, machine learning, and data science will rely heavily on mathematical skills and reasoning. Thus, mathematics and computing thinking will be given more priority throughout the school years by using a variety of innovative approaches, strategies and techniques that make mathematical thinking more fun and interesting (Ministry of Human Resource and Development, Government of India, 2020). Across the various stages of school education, mathematics has the ability to develop problem solving skills, logical reasoning, creativity and objectivity. Hence, it is essential to use innovative pedagogies that make learning of mathematics at the secondary stage of education enjoyable and meaningful by connecting mathematics with day-to-day living and engaging students in reflective learning. Therefore, the investigator decided to use a model of teaching which incorporates values and beliefs developed through processes as stages which is based on reflective and active learning principles for enhancing both cognitive and affective learning outcomes in mathematics. The use of such innovative pedagogies will be helpful in making learning of mathematics enjoyable and a lifelong passion by understanding fundamental concepts of mathematics connecting with the real world. Thus, the present study is entitled as "EFFECTIVENESS OF PROCESS STAGE MODEL ON SELECT LEARNING OUTCOMES IN MATHEMATICS AMONG SECONDARY SCHOOL STUDENTS"

Variables

The independent and dependent variables adopted in the study are

Independent Variables

The independent variables in the study are two types of Instructional Strategies

a) Process Stage Model as Instructional Strategy for Experimental Group

b) Constructivist Model as Instructional Strategy for Control Group

Dependent Variables

The dependent variables in the study are select Cognitive and Affective Learning Outcomes in Mathematics.

Cognitive Learning Outcomes

- Achievement in Mathematics
- Logical Reasoning

Affective Learning Outcomes

- Mathematics Anxiety
- Achievement Motivation in Mathematics
- Mathematical Beliefs

Objectives

The objectives framed for the study are:

Major Objective

- To find out the effectiveness of the Process Stage Model on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs of secondary school students.

Specific Objectives

The specific objectives are

1. To analyze the level of Mathematical Beliefs of secondary school students.
2. To compare the mean scores of pre-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs for experimental and control groups of secondary school students.
3. To compare the mean scores of post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs for experimental and control groups of secondary school students.
4. To compare the mean scores of pre-test and post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement

Motivation in Mathematics and Mathematical Beliefs for experimental group of secondary school students.

5. To compare the mean scores of pre-test and post-test on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs for control group of secondary school students.

6. To compare the mean scores of gain scores on Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics, and Mathematical Beliefs for experimental and control groups of secondary school students.

Hypotheses

The hypotheses framed for the study are;

1. Secondary school students are having moderate level of Mathematical Beliefs

2. There exists no significant difference in the mean scores of pre-test on Achievement in Mathematics for experimental and control groups of secondary school students.

3. There exists no significant difference in the mean scores of pre-test on Logical Reasoning for experimental and control groups of secondary school students.

4. There exists no significant difference in the mean scores of pre-test on Mathematics Anxiety for experimental and control groups of secondary school students.

5. There exists no significant difference in the mean scores of pre-test on Achievement Motivation in Mathematics for experimental and control groups of secondary school students.

6. There exists no significant difference in the mean scores of pre-test on Mathematical Beliefs for experimental and control groups of secondary school students.

7. There exists significant difference in the mean scores of post-test on Achievement in Mathematics for experimental and control groups of secondary school students.

8. There exists significant difference in the mean scores of post-test on Logical Reasoning for experimental and control groups of secondary school students.

9. There exists significant difference in the mean scores of Post-test on Mathematics Anxiety for experimental and control groups of secondary school students.

10. There exists significant difference in the mean scores of post-test on Achievement Motivation in Mathematics for experimental and control groups of secondary school students.

11. There exists significant difference in the mean scores of post-test on Mathematical Beliefs for experimental and control groups of secondary school students.

12. There exists significant difference in the mean scores of pre-test and post-test on Achievement in Mathematics for experimental group of secondary school students.

13. There exists significant difference in the mean scores of pre-test and post-test on Logical Reasoning for experimental group of secondary school students.

14. There exists significant difference in the mean scores of pre-test and post-test on Mathematics Anxiety for experimental group of secondary school students.

15. There exists significant difference in the mean scores of pre-test and post-test on Achievement Motivation in Mathematics for experimental group of secondary school students.

16. There exists significant difference in the mean scores of pre-test and post-test on Mathematical Beliefs for experimental group of secondary school students.

17. There exists significant difference in the mean scores of pre-test and post-test on Achievement in Mathematics for control group of secondary school students.

18. There exists significant difference in the mean scores of pre-test and post-test on Logical Reasoning for control group of secondary school students.

19. There exists significant difference in the mean scores of pre-test and post-test on Mathematics Anxiety for control group of secondary school students.

20. There exists significant difference in the mean scores of pre-test and post-test on Achievement Motivation in Mathematics for control group of secondary school students.

21. There exists significant difference in the mean scores of pre-test and post-test on Mathematical Beliefs for control group of secondary school students.

22. There exists significant difference in the mean scores of gain scores on Achievement in Mathematics for experimental and control groups of secondary school students.

23. There exists significant difference in the mean scores of gain scores on Logical Reasoning for experimental and control groups of secondary school students.

24. There exists significant difference in the mean scores of gain scores on Mathematics Anxiety for experimental and control groups of secondary school students.

25. There exists significant difference in the mean scores of gain scores on Achievement Motivation in Mathematics for experimental and control groups of secondary school students.

26. There exists significant difference in the mean scores of gain scores on Mathematical Beliefs for experimental and control groups of secondary school students.

27. The Process Stage Model is effective for enhancing Achievement in Mathematics of secondary school students.

28. The Process Stage Model is effective for enhancing Logical Reasoning of secondary school students.

29. The Process Stage Model is effective for reducing Mathematics Anxiety of secondary school students.

30. The Process Stage Model is effective for enhancing Achievement Motivation in Mathematics of secondary school students.

31. The Process Stage Model is effective for enhancing Mathematical Beliefs of secondary school students.

Design of the Study

The study adopted multi-methodology by incorporating both survey and experimental method. The survey method was adopted to analyze the level of Mathematical Beliefs of secondary school students and experimental method was used to study the effectiveness of the Process Stage Model on select learning outcomes in mathematics such as Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs among secondary school students.

Design of Experimentation

In order to know the effectiveness of the Process Stage Model on select learning outcomes in mathematics such as Achievement in Mathematics, Logical Reasoning, Mathematics Anxiety, Achievement Motivation in Mathematics and Mathematical Beliefs among secondary school students, the investigator required two groups of participants, one group who taught with the Process Stage Model, and another group with the Constructivist model. Two group pre-test post-test non-equivalent group design is selected for conducting the study. Intact class was used both in experimental and control groups. The design of the experimentation is;

$$G_1: O_1 \text{ x } O_2$$

$$G_2: O_3 \text{ c } O_4$$

Where,

G1 is the experimental group with pre-test O1 and post-test O2 and

G2 is the control group with pre-test O3 and post-test O4

Sample Selected for the Study

The population considered for the study is secondary school students studying in high schools of Kerala state who follow the Kerala state syllabus. A sample of 600 secondary school students studying in VIII standard was selected for the first phase during survey and for the experimentation, sample comprised of 62 secondary school students studying in VIII standard selected from two divisions of Higher Secondary School, Peringode in Palakkad district of Kerala state. Intact class was selected both for experimental group and control group which comprised of 31 students of VIII standard in both groups.

Instruments Used

The instruments used in the study are;

- Lesson Transcript on Process Stage Model (Radhika & Niranjana, 2022)
- Lesson Transcript on Constructivist Model
- Achievement Test in Mathematics (Radhika & Niranjana, 2022)
- Logical Reasoning Test (Radhika & Niranjana, 2022)
- Mathematics Anxiety Scale (Radhika & Niranjana,2022)
- Scale on Achievement Motivation in Mathematics (Radhika & Niranjana, 2022)
- Mathematical Beliefs Inventory (Radhika & Niranjana, 2022)

Statistical Techniques Employed

The statistical techniques used for the analyzing the data are;

- Descriptive Statistics
- Probability-Probability Plot
- Pearson's Product Moment Correlation
- Levene's Test for Equality of Variance
- One Sample *t* test
- Test of Significance of Difference Between Means of Large Independent Sample *(t*-test)
- Test of Significance of Difference Between Means of Large Dependent Sample (Paired Sample *t*-Test)

- Cohen's d
- Analysis of Covariance (ANCOVA)

Major Findings of the Study

The major findings of the study are:

1. Analysis of the level of Mathematical Beliefs of secondary school students indicated a significant difference between the mean score (M = 23.52, SD = 4.72) of mathematical beliefs of secondary school students and the test value (mid value of scale = 17) of the Mathematical Beliefs Inventory. Hence, the secondary school students are having a moderate level of Mathematical Beliefs. Results of one sample t test also confirmed that the secondary school students are having moderate level (t = 33.84, p < .01) of Mathematical Beliefs.

2. Comparison of mean scores of pre-test on Achievement in Mathematics for experimental and control groups does not indicate significant difference (t = 0.23, p > .05). Therefore, the two groups - experimental and control groups are equal in the scores of Achievement in Mathematics in the pre-experimental status.

3. Comparison of mean scores of pre-test on Logical Reasoning for experimental and control groups of secondary school students does not indicate significant difference (t = 0.45, p > .05). Thus, the two groups - experimental and control groups are equal in the scores of Logical Reasoning in the pre-experimental status.

4. Comparison of mean scores of pre-test on Mathematics Anxiety for experimental and control groups of secondary school students indicated significant difference (t = 7.47, p < .01). Therefore, the two groups - experimental and control groups are not equal in the scores of Mathematics Anxiety in the pre-experimental status. The mean scores of pre-test on Mathematics Anxiety of experimental group (M = 81.32, SD = 16.80) is greater than the mean scores of pre - test on Mathematics Anxiety of control group (M = 54.98, SD = 10.34). Hence, the experimental group has greater Mathematics Anxiety in pre-experimental status than the control group.

5. Comparison of mean pre-test scores on Achievement Motivation in Mathematics of secondary school students does not indicate significant difference (t = 1.37, $p > .05$). Thus, the two groups - experimental and control groups are equal in the scores of Achievement Motivation in Mathematics in the pre-experimental status.

6. Comparison of mean scores of pre-test on Mathematical Beliefs for experimental and control groups of secondary school students indicated a significant difference (t = 2.23, p < .05). Hence, the two groups - experimental and control groups are not equal in terms of the pre-experimental status in the scores of Mathematical Beliefs. The mean scores of pre-test on Mathematical Beliefs for experimental group (M = 22.29, SD = 5.15) is greater than the mean scores of pre-test on Mathematical Beliefs for control group (M = 19.64, SD = 4.12). Therefore, the experimental group has greater Mathematical Beliefs in the pre-experimental status than the control group.

7. Comparison of mean scores of post-test on Achievement in Mathematics for experimental and control groups indicated a significant difference (t = 4.61, p < .01). Thus, the two groups - experimental and control groups are different in the scores of Achievement in Mathematics in the post - experimental status. The performance of students in the experimental group in the post-test on Achievement in Mathematics (M = 14.29, SD = 3.74) is greater than that of the students in the control group (M = 9.98, SD = 3.64).

8. Comparison of mean scores of post-test on Logical Reasoning for experimental and control groups of secondary school students indicated significant difference (t = 2.60, p < .01). Thus, the two groups - experimental and control groups are different in mean scores of post-test on Logical Reasoning. The performance of students in the experimental group in the post-test on Logical Reasoning (M = 14.94, SD = 4.01) is greater than that of the students in the control group (M = 12.52, SD = 3.27).

9. Comparison of mean scores of post-test on Mathematics Anxiety for experimental and control groups of secondary school students indicated no significant differences (t = 1.40, p > .05). Thus, the two groups - experimental and control groups are equal in the scores of Mathematics Anxiety in the post-experimental status.

10. Comparison of mean scores of post-test on Achievement Motivation in Mathematics for experimental and control groups of secondary school students indicated significant difference (t = 4.35, p < .01). Hence, the two groups - experimental and control groups are different in the scores of Achievement

Motivation in Mathematics in post experimental status. The performance of students in the experimental group in the post-test on Achievement Motivation in Mathematics (M = 163.74, SD = 18.06) is greater than that of the students in the control group (M = 137.42, SD = 28.44).

11. Comparison of mean scores of post-test on Mathematical Beliefs for experimental and control groups of secondary school students indicated significant difference (t = 3.73, p < .01). Thus, the two groups - experimental and control groups are different in scores on Mathematical Beliefs in the post-experimental status. The performance of students in the experimental group in the post-test on Mathematical Beliefs (M = 25.35, SD = 2.95) is greater than that of the students in the control group (M = 22.03, SD = 3.99).

12. Comparison of mean scores of pre-test and post-test on Achievement in Mathematics for the experimental group of secondary school students indicated significant difference (t = 7.23, p < .01). Thus, there exists significant difference in the pre-test and post-test status on Achievement in Mathematics of secondary school students. The performance of students in post-test on Achievement in Mathematics (M = 14.29, SD = 3.74) of the experimental group is greater than the performance of students in pre-test on Achievement in Mathematics (M = 9.87, SD = 4.24).

13. Comparison of mean scores of pre-test and post-test on Logical Reasoning for the experimental group of secondary school students indicates significant difference (t = 3.03, p < .01). Thus, the experimental group is different in terms of pre-test and post-test status on Logical Reasoning. The performance

of students in post-test on Logical Reasoning *(M* = 14.94, *SD* = 4.01) of the experimental group is greater than the performance of students in pre-test on Logical Reasoning *(M* = 12.81, *SD* = 3.67).

14. Comparison of mean scores of pre-test and post-test on Mathematics Anxiety for the experimental group of secondary school students indicated significant difference (t = 15.48, p < .01). Hence, the experimental group is different in terms of pre-test and post-test status on Mathematics Anxiety. The performance of students in pre-test on Mathematics Anxiety (*M* = 81.32, *SD* = 16.81) of the experimental group is greater than the performance of students in post-test on Mathematics Anxiety *(M* = 52.26, *SD* = 7.64).

15. Comparison of mean scores of pre-test and post-test on Achievement Motivation in Mathematics for the experimental group of secondary school students indicated significant difference (t = 5.82, p < .01). Thus, the experimental group is different in terms of pre-test and post-test status on Achievement Motivation in Mathematics. The performance of students in post-test on Achievement Motivation in Mathematics *(M* = 163.74, *SD* = 36.42) of the experimental group is greater than the performance of students in pre-test on Achievement Motivation in Mathematics *(M* = 142.06, *SD* = 18.06).

16. Comparison of mean scores of pre-test and post-test on Mathematical Beliefs for the experimental group of secondary school students indicated significant difference (t = 4.70, p < .01). Thus, the experimental group is different in terms of pre-test and post-test status on Mathematical Beliefs. The performance of

students in post-test on Mathematical Beliefs (*M* = 25.35, *SD* = 2.90) of the experimental group is greater than the performance of students in pre-test on Mathematical Beliefs (*M* = 22.29, *SD* = 15.15).

17. Comparison of mean scores of pre-test and post-test on Achievement in Mathematics for the control group of secondary school students indicated no significant difference (t = 1.11, p > .05). Therefore, the control group of secondary school students is not different in terms of pre-test and post-test status on Achievement in Mathematics.

18. Comparison of mean scores of pre-test and post-test on Logical Reasoning for the control group indicated no significant difference (t = 0.38, p >.05). Therefore, the control group of secondary school students is not different in terms of pre-test and post-test status on Logical Reasoning.

19. Comparison of mean scores of pre-test and post-test on Mathematics Anxiety for the control group indicated significant difference (t = 4.83, p < .01). The mean scores of pre-test (*M* = 54.97, *SD* = 10.04) on Mathematics Anxiety of control group is greater than the mean scores of post - test (*M* = 50.68, *SD* = 8.75). Therefore, the control group of secondary school students is different in terms of pre-test and post-test status on Mathematics Anxiety.

20. Comparison of mean scores of pre-test and post-test on Achievement Motivation in Mathematics for the control group indicated no significant difference (t = 0.93, p > .05). Hence, the control group of secondary school

students is not different in terms of pre-test and post-test status on Achievement Motivation in Mathematics.

21. Comparison of mean scores of pre-test and post-test on Mathematical Beliefs for the control group indicated significant difference (t = 4.37, p < .01). The mean scores of post-test (M = 22.03, SD = 3.98) on Mathematical Beliefs of the control group is greater than the mean scores of pre - test (M = 19.65, SD = 4.12). Therefore, the control group of secondary school students is different in terms of pre-test and post-test status on Mathematical Beliefs.

22. Comparison of mean scores of gain scores on Achievement in Mathematics for experimental and control groups revealed a significant difference (t = 3.19, p < .01). Thus, the two groups - experimental and control groups are different in terms of gain scores on Achievement in Mathematics. The mean gain scores on Achievement in Mathematics for the experimental group (M = 4.42, SD = 3.40) is greater than the mean gain scores on Achievement in Mathematics for the control group (M = 0.42, SD = 6.09).

23. Comparison of mean scores of gain scores on Logical Reasoning for experimental and control groups revealed significant difference (t = 2.40, p < .05). Hence, the two groups - experimental and control groups are different in terms of gain scores on Logical Reasoning. The mean gain scores on Logical Reasoning for the experimental group (M = 2.12, SD = 3.91) is greater than the mean gain scores on Logical Reasoning for the control group (M = 0.16, SD = 2.35).

24. Comparison of mean scores of gain scores on Mathematics Anxiety for experimental and control groups revealed significant difference (t = -11.93, p < .01). Thus, the two groups - experimental and control groups are different in terms of gain scores on Mathematics Anxiety. The mean gain scores on Mathematics Anxiety for the experimental group (M = -29.06, SD = 10.45) is lower than the mean gain scores on Mathematics Anxiety for the control group (M = -4.29, SD = 4.95).

25. Comparison of mean scores of gain scores on Achievement Motivation in Mathematics for experimental and control groups revealed significant difference (t = 2.78, p < .01). Thus, the two groups - experimental and control groups are different in terms of gain scores on Achievement Motivation in Mathematics. The mean gain scores on Achievement Motivation in Mathematics for the experimental group (M = 21.68, SD = 20.67) is greater than the mean gain scores on Achievement Motivation in Mathematics for the control group (M = 4.65, SD = 27.94).

26. Comparison of mean scores of gain scores on Mathematical Beliefs for experimental and control groups revealed no significant difference (t = 0.80, p > .05). Thus, the two groups - experimental and control groups are not different in terms of gain scores on Mathematical Beliefs. Comparison of mean post-test scores of Mathematical Beliefs for experimental and control groups after controlling pre-test scores of Mathematical Beliefs revealed there was significant difference (F (1,59) = 8.35, p < .001, η_2 = 0.12) between the experimental and control groups in post-test scores on Mathematical Beliefs

by considering pre-test scores of Mathematical Beliefs controlling variable for the covariate.

27. The comparison of mean scores of post-test on Achievement in Mathematics for experimental and control groups revealed that the experimental group is having higher Achievement in Mathematics than the control group. The comparison of mean scores of pre-test and post-test on Achievement in Mathematics for the experimental group indicated that the post-test scores of Achievement in Mathematics is higher than that of the pre-test scores of Achievement in Mathematics for the experimental group. The comparison of mean scores of gain scores on Achievement in Mathematics for experimental and control groups indicated that the experimental group is having higher Achievement in Mathematics than the control group. Hence, the Process Stage Model is effective in enhancing Achievement in Mathematics of secondary school students.

28. The comparison of mean scores of post-test on Logical Reasoning for experimental and control groups revealed that the experimental group is having higher Logical Reasoning than the control group. The comparison of mean scores of pre-test and post-test on Logical Reasoning for the experimental group indicated that the post-test scores of Logical Reasoning is higher than that of the pre-test scores of Logical Reasoning for the experimental group. The comparison of mean scores of gain scores on Logical Reasoning for experimental and control groups indicated that the experimental group is having higher Logical Reasoning than the control group. Hence, the

Process Stage Model is effective in enhancing Logical Reasoning of secondary school students.

29. The comparison of mean scores of post-test on Mathematics Anxiety for experimental and control groups revealed no significant difference in the mean scores of Mathematics Anxiety between the both groups. But the comparison of mean scores of pre-test on Mathematics Anxiety showed that the experimental group is having higher Mathematics Anxiety than the control group. The comparison of mean scores of pre-test and post-test on Mathematics Anxiety for the experimental group indicated that the post-test scores of Mathematics Anxiety is lower than that of the pre-test scores of Mathematics Anxiety for the experimental group. The comparison of mean scores of gain scores on Mathematics Anxiety for experimental and control groups indicates that the experimental group is having lower Mathematics Anxiety than the control group. Hence, the Process Stage Model is effective in reducing the Mathematics Anxiety of secondary school students.

30. The comparison of mean scores of post-test on Achievement Motivation in Mathematics for experimental and control groups revealed that the experimental group is having higher Achievement Motivation in Mathematics than the control group. The comparison of mean scores of pre-test and post-test on Achievement Motivation in Mathematics for the experimental group indicated that the post-test scores of Achievement Motivation in Mathematics is higher than that of the pre-test scores of Achievement Motivation in Mathematics for the experimental group. The comparison of mean scores of

gain scores on Achievement Motivation in Mathematics for experimental and control groups indicated that the experimental group is having higher Achievement Motivation in Mathematics than the control group. Hence, the Process Stage Model is effective in enhancing Achievement Motivation in Mathematics of secondary school students.

31. The comparison of mean scores of post-test on Mathematical Beliefs for experimental and control groups revealed that the experimental group is having higher Mathematical Beliefs than the control group. The comparison of mean scores of pre-test and post-test on Mathematical Beliefs for the experimental group indicated that the post-test scores of Mathematical Beliefs is higher than that of the pre-test scores of Mathematical Beliefs for the experimental group. The comparison of mean scores of gain scores on Mathematical Beliefs for experimental and control groups indicated no significant difference in mean scores of gain scores on Mathematical Beliefs. But, the mean scores of gain scores on Mathematical Beliefs of the experimental group are higher than the control group. The ANCOVA with covariate (pre-test scores on Mathematical Beliefs) and the dependent variable (post-test scores on Mathematical Beliefs) for the pre-test scores on Mathematical Beliefs showed a significant difference while considering the effect of covariate. The comparison of estimated marginal means of experimental and control group showed that the experimental group showed better Mathematical beliefs than the control group considering pre-test scores

of Mathematical Beliefs as covariate. Therefore, the Process Stage Model is effective in enhancing Mathematical Beliefs of secondary school students.

Tenability of Hypotheses

The hypotheses framed for the study are tested on the basis of findings of the study and the tenability of hypotheses are described in this section.

Hypothesis 1

The first hypothesis states that *secondary school students are having moderate level of Mathematical Beliefs*. Findings of the study showed that the secondary school students are having moderate level of Mathematical Beliefs. Hence, the *hypothesis is substantiated.*

Hypothesis 2

The second hypothesis states that *there exists no significant difference in the mean scores of pre-test on Achievement in Mathematics for experimental and control groups of secondary school students*. Findings revealed that there is no significant difference in the mean scores of pre-test on Achievement in Mathematics for experimental and control groups of secondary school students. Hence, *the hypothesis is substantiated.*

Hypothesis 3

The third hypothesis states that *there exists no significant difference in the mean scores of pre-test on Logical Reasoning for experimental and control groups of* *secondary school students*. Findings revealed that there is no significant difference in the mean scores of pre-test on Logical Reasoning for experimental and control groups of secondary school students. Hence, *the hypothesis is substantiated*.

Hypothesis 4

The fourth hypothesis states that *there exists no significant difference in the mean scores of pre-test on Mathematics Anxiety for experimental and control groups of secondary school students*. Findings indicated that there is significant difference in the mean scores of pre-test on Mathematics Anxiety for experimental and control groups. Hence, the *hypothesis is rejected.*

Hypothesis 5

The fifth hypothesis states that *there exists no significant difference in the mean scores of pre-test on Achievement Motivation in Mathematics for experimental and control groups of secondary school students*. Findings revealed that there is no significant difference in the mean scores of pre-test on Achievement Motivation in Mathematics for experimental and control groups. Hence, *the hypothesis is substantiated*.

Hypothesis 6

The sixth hypothesis states that *there exists no significant difference in the mean scores of pre-test on Mathematical Beliefs for experimental and control groups of secondary school students.* Findings indicated that there is significant difference in the mean scores of pre-test on Mathematical Beliefs for experimental and control groups. Hence, *the hypothesis is rejected.*

Hypothesis 7

The seventh hypothesis states that *there exists significant difference in the mean scores of post-test on Achievement in Mathematics for experimental and control groups of secondary school students.* Findings indicated that there is significant difference in the mean scores of post-test on Achievement in Mathematics for experimental and control groups. Hence, *the hypothesis is substantiated.*

Hypothesis 8

The eighth hypothesis states that *there exists significant difference in the mean scores of post-test on Logical Reasoning for experimental and control groups of secondary school students.* Findings revealed that there is significant difference in the mean scores of post-test on Achievement in Mathematics for experimental and control groups. Hence, *the hypothesis is substantiated.*

Hypothesis 9

The ninth hypothesis states that *there exists significant difference in the mean scores of post-test on Mathematics Anxiety for experimental and control groups of secondary school student*s. Findings revealed that there is no significant difference in the mean scores of post-test on Mathematics Anxiety for experimental and control groups. Hence, *the hypothesis is rejected.*

Hypothesis 10

The tenth hypothesis states that *there exists significant difference in the mean scores of post-test on Achievement Motivation in Mathematics for experimental and control groups of secondary school students,* Findings revealed that there is significant difference in the mean scores of post-test on Achievement Motivation in Mathematics for experimental and control groups. Hence, *the hypothesis is substantiated.*

Hypothesis 11

The eleventh hypothesis states that *there exists significant difference in the mean scores of post-test on Mathematical Beliefs for experimental and control groups of secondary school students.* Findings revealed that there is significant difference in the mean scores of post-test on Mathematical Beliefs for experimental and control groups. Hence, *the hypothesis is substantiated.*

Hypothesis 12

The twelfth hypothesis states that *there exists significant difference in the mean scores of pre-test and post-test on Achievement in Mathematics for experimental group of secondary school students.* Findings revealed that there is significant difference in the mean scores of pre-test and post-test on Achievement in Mathematics for experimental group. Hence, *the hypothesis is substantiated.*

Hypothesis 13

The thirteenth hypothesis states *that there exists significant difference in the mean scores of pre-test and post-test on Logical Reasoning for experimental group of secondary school students*. Findings indicated that there is significant difference in the mean scores of pre-test and post-test on Logical Reasoning for experimental group. Hence, *the hypothesis is substantiated.*

Hypothesis 14

The fourteenth hypothesis states that *there exists significant difference in the mean scores of Pre-test and Post-test on Mathematics Anxiety for experimental group of secondary school students*. Findings revealed that there is significant difference in the mean pre-test and post-test scores on Mathematics Anxiety of the experimental group. Hence, *the hypothesis is substantiated.*

Hypothesis 15

The fifteenth hypothesis states that *there exists significant difference in the mean scores of pre-test and post-test on Achievement Motivation in Mathematics for experimental group of secondary school students.* Findings revealed that there exists significant difference in the mean pre-test and post-test scores on Achievement Motivation in Mathematics for the experimental group. Hence, *the hypothesis is substantiated.*

Hypothesis 16

The sixteenth hypothesis states that *there exists significant difference in the mean scores of pre-test and post-test on Mathematical Beliefs for experimental group of secondary school students.* Findings revealed that there exists significant difference in the mean pre-test and post-test scores on Mathematical Beliefs for the experimental group. Hence, *the hypothesis is substantiated*.

Hypothesis 17

The seventeenth hypothesis states that *there exists significant difference in the mean scores of pre-test and post-test on Achievement in Mathematics for control group of secondary school students*. Findings revealed that there exists no significant difference in the mean scores of pre-test and post-test on Achievement in Mathematics for control group. Hence, *the hypothesis is rejected.*

Hypothesis 18

The eighteenth hypothesis states that *there exists significant difference in the mean scores of pre-test and post-test on Logical Reasoning for control group of secondary school students.* Findings revealed that there exists no significant difference in the mean scores of pre-test and post-test on Logical Reasoning for control group. Hence, *the hypothesis is rejected*.

Hypothesis 19

The nineteenth hypothesis states that t*here exists significant difference in the mean scores of pre-test and post-test on Mathematics Anxiety for control group of* *secondary school students.* Findings indicated that there is significant difference in the mean scores of pre-test and post-test on Mathematics Anxiety for control group. Hence, *the hypothesis is substantiated*.

Hypothesis 20

The twentieth hypothesis states that t*here exists significant difference in the mean scores of pre-test and post-test on Achievement Motivation in Mathematics for control group of secondary school students*. Findings revealed that there is no significant difference in the mean scores of pre-test and post-test on Achievement Motivation in Mathematics for control group. Hence, *the hypothesis is rejected*.

Hypothesis 21

The twenty first hypothesis states that *there exists significant difference in the mean scores of pre-test and post-test on Mathematical Beliefs for control group of secondary school students*. Findings indicated that there is significant difference in the mean scores of pre-test and post-test on Mathematical Beliefs for control Group. Hence, *the hypothesis is substantiated*.

Hypothesis 22

The twenty second hypothesis states that *there exists significant difference in the mean scores of gain scores on Achievement in Mathematics for experimental and control groups of secondary school students*. Findings revealed that there is significant difference in the mean scores of gain scores on Achievement in Mathematics for experimental and control groups. Hence, *the hypothesis is substantiated.*

Hypothesis 23

The twenty third hypothesis states that *there exists significant difference in the mean scores of gain scores on Logical Reasoning for experimental and control groups of secondary school students*. Findings indicated that there is significant difference in the mean scores of gain scores on Logical Reasoning for experimental and control groups. Hence, *the hypothesis is substantiated.*

Hypothesis 24

The twenty fourth hypothesis states that there exists significant difference in the mean scores of gain scores on Mathematics Anxiety for experimental and control groups of secondary school students. Findings indicated there is significant difference in the mean scores of gain scores on Mathematics Anxiety for experimental and control groups. Hence, *the hypothesis is substantiated.*

Hypothesis 25

The twenty fifth hypothesis states that *there exists significant difference in the mean scores of gain scores on Achievement Motivation in Mathematics for experimental and control groups of secondary school students*. Findings indicated that there is significant difference in the mean scores of gain scores on Achievement Motivation in Mathematics for experimental and control groups. Hence, *the hypothesis is substantiated*.

Hypothesis 26

The twenty sixth hypothesis states that *there exists significant difference in the mean scores of gain scores on Mathematical Beliefs for experimental and control groups of secondary school students*. Findings revealed that there is no significant difference in the mean scores of gain scores on Mathematical Beliefs for experimental and control groups. Hence, *the hypothesis is rejected*.

Hypothesis 27

The twenty seventh hypothesis states that *the Process Stage Model is effective for enhancing Achievement in Mathematics of secondary school students.* Findings revealed that the Process stage model is effective for enhancing Achievement in Mathematics. Hence, *the hypothesis is substantiated.*

Hypothesis 28

The twenty eighth hypothesis states that *the Process Stage Model is effective for enhancing Logical Reasoning of secondary school students***.** Findings indicated that the Process Stage Model is effective for enhancing Logical Reasoning. Hence, *the hypothesis is substantiated.*

Hypothesis 29

The twenty ninth hypothesis states that *the Process Stage Model is effective for reducing Mathematics Anxiety of secondary school students.* Findings revealed that the Process Stage Model is effective for reducing Mathematics Anxiety. Hence, *the hypothesis is substantiated*

Hypothesis 30

The thirtieth hypothesis states that *the Process Stage Model is effective for enhancing Achievement Motivation in Mathematics of secondary school students*. Findings showed that the Process Stage Model is effective for enhancing Achievement Motivation in Mathematics. Hence, *the hypothesis is substantiated.*

Hypothesis 31

The thirty first hypothesis states that *the Process Stage Model is effective for enhancing Mathematical Beliefs of secondary school students.* Findings indicated that the Process Stage Model is effective for enhancing Mathematical Beliefs. Hence, the *hypothesis is substantiated*.

Conclusions

Findings of the study revealed that the level of Mathematical Beliefs of secondary school students is moderate. The analysis of the mean post-test scores of dependent variables for experimental and control groups, the analysis of mean pre-test and post-test scores of dependent variables for experimental groups, and the analysis of mean gain scores of dependent variables for experimental and control groups indicated that the Process Stage Model is effective in enhancing the learning outcomes such as Achievement in Mathematics, Logical Reasoning, Achievement Motivation in Mathematics and Mathematical Beliefs of secondary schools students. In addition to that, the comparison of mean scores of post-test on Mathematics Anxiety for experimental and control groups, the comparison of mean scores of pre-test and post-test on Mathematics Anxiety for experimental groups, and the comparison of mean scores of gain scores on Mathematics Anxiety for experimental and control groups indicated that the Process Stage Model is effective for reducing Mathematics Anxiety of secondary school students.

The result indicated that the Process Stage Model is significantly better than the constructivist model of teaching for enhancing Achievement in Mathematics among secondary school students. After the intervention students of the experimental group scored higher Achievement in Mathematics than those of the control group. The comparison of mean scores of gain scores on Achievement in Mathematics for the experimental and control groups also exhibited significant difference with high effect size. The analysis of pre-test and post-test scores of Achievement in Mathematics for experimental groups also showed significant difference. This statistical evidences indicated that the Process Stage Model is effective for the enhancement of Achievement in Mathematics among secondary school students. The result of the study supported the previous studies that instructional strategies are effective for enhancing Achievement in various subjects as reported by Pandy (2011), Yeh et al., (2019), Bhatt (2020), and Indrapangastyti et al., (2021).

The experimental group students exhibited higher Logical Reasoning ability after the intervention than the control group students. The analysis of mean post-test scores of Logical Reasoning for experimental and control groups, the analysis of mean pre-test and post-test scores of Logical Reasoning for the experimental group, and the mean gain scores of Logical Reasoning for the experimental and control group showed a significant difference with moderate effect size. This statistical analysis revealed that the Process Stage Model is effective for enhancing the Logical Reasoning of secondary school students than the constructivist model of teaching. Similarly, the implementation of innovative learning models had a notable impact on enhancing students' logical thinking skills (Riyantil et al., 2018; Anwar et al., 2019; Fathima et al., 2021; Khan & Rana, 2021).

The statistical analysis of mean scores of post-test on Mathematics Anxiety of the experimental and control groups indicated no significance difference even though the mean score of the two groups indicated observable differences after treatment. It is notable that, the experimental group had higher Mathematics Anxiety than control group in pre-test scores. The statistical analysis of mean scores of pre-test and post-test scores of Mathematics Anxiety of experimental and control group, and analysis of mean scores of gain scores on Mathematics Anxiety for experimental and control groups indicated significant difference with high effect size. This statistical evidences showed that the Process Stage Model is effective for reducing Mathematics Anxiety of secondary school students. Similarly, various researches found that the use of strategies and models of teaching helps in reducing Mathematics Anxiety (Niaei et al., 2021; Tsegaw et al., 2021; Yaftin & Barghamads, 2022).

The statistical analysis of mean scores of post-test on Achievement Motivation in Mathematics for experimental and control groups, and analysis of mean scores of pre-test and post-test on Achievement Motivation in Mathematics for experimental and control groups indicated significant difference with high effect size. The statistical analysis of mean scores of gain scores on Achievement Motivation in Mathematics for experimental and control groups indicated significant differences with moderate effect size. This statistical evidences showed that the Process Stage Model is effective for enhancing Achievement Motivation in Mathematics of secondary school students. Similarly, various research studies reported that teaching methods, techniques and models of teaching are effective in enhancing Achievement Motivation (You et al., 2016; Mohanty, 2016; Kuar & Sankhiab, 2017; Veesar & Khaskheli, 2019; Amir et al., 2020; Zaiden et al., 2022).

The statistical analysis of mean scores of post-test on Mathematical Beliefs for experimental and control groups, and the analysis of mean scores of pre-test and post-test on Mathematical Beliefs for experimental groups, indicated significant differences on Mathematical Beliefs with high effect size. But the analysis of mean scores of gain scores on Mathematical Beliefs for experimental and control groups showed no significant differences. Additionally, the statistical analysis of covariance showed significant difference in the mean scores of Mathematical Beliefs between experimental and control groups while considering the effect of covariate. Hence, the Process Stage Model is effective for enhancing Mathematical Beliefs of secondary school students. The result of previous studies indicated that inquiry based model, innovative methods of teaching and context based approaches enhanced students' beliefs about the subject (Rahayu & Kurniash, 2014; Mues et al., 2022; Abebe et al., 2023; Pedersen & Haavold, 2023). Based on the findings, it has been concluded that the Process Stage Model is effective for enhancing Achievement in Mathematics, Logical Reasoning, Achievement Motivation in Mathematics, and Mathematical

Beliefs. Also, the Process Stage Model is effective for reducing Mathematics Anxiety. Therefore, it can be concluded that those students who experienced the Process Stage Model, enhanced Achievement in Mathematics, Logical Reasoning, Achievement Motivation in Mathematics, and Mathematical Beliefs and also reduced Mathematics Anxiety.

Chapter 6

IMPLICATIONS, RECOMMENDATIONS, AND SUGGESTIONS

- Educational Implications of the Study
- Recommendations of the Study
- Suggestions for Further Research

IMPLICATIONS, RECOMMENDATIONS, AND SUGGESTIONS

The present study focuses on the effectiveness of the Process Stage model on select learning outcomes such as achievement in mathematics, logical reasoning, mathematics anxiety, and achievement motivation in mathematics and mathematical belief of secondary school students. This chapter discusses the educational implications, recommendations of the study, and suggestions for further research.

Educational Implications of the Study

The quality of the subject and the quality of the teaching and learning process are evaluated by the assessment of the cognitive and affective learning outcomes of students. Our educational system provides several teaching and learning strategies and methods to enhance the student's learning outcomes. The effectiveness of teaching and learning strategies and methods is evaluated by measuring the student's learning outcomes. Here, the present study investigated the effectiveness of the Process Stage Model on select learning outcomes in mathematics such as achievement in mathematics, logical reasoning, mathematics anxiety, achievement motivation in mathematics, and mathematical beliefs among secondary school students.

The foundation of any educational system is teachers and are the best source of change as well as the success of any curriculum depends upon the teachers. Effective teaching is necessary and educators must be willing to put in extra effort to implement innovative teaching modalities and pedagogical approaches for making the learning of mathematics life- oriented. The result of experimentation implied that educators need to implement the Process Stage Model since it enhances achievement in mathematics, logical reasoning, achievement motivation in mathematics, and mathematical beliefs among secondary school students. The results of the study also indicated that the Process Stage Model helps to reduce mathematics anxiety among secondary school students.

In the first phase of the study, the survey phase, it has revealed that secondary school students are having a moderate level of mathematical beliefs. As beliefs play and important role in teaching-learning process and are closely related to the learning outcomes in mathematics, the investigator identified the requirement of and intervention to develop a model of teaching by integrating beliefs and values in a systematics way for enhancing achievement in mathematics, logical reasoning, achievement motivation in mathematics, mathematical beliefs and reducing mathematics anxiety of secondary school students. The survey helped to understand the existing level of mathematical beliefs of secondary school students studying in eighth standard. It also enabled the investigator to identify the mathematical values and beliefs that are to be incorporated while implementing the Process Stage Model.

The Process Stage Model enables the learner to engage in learning through reflection which plays an important role in the development of cognitive and affective outcomes of mathematics. Process Stage Model outlines the stage of learning through interaction with the environment, reflection, value formation, and application, each can be effectively used as a strategy to enhance achievement in mathematics, logical reasoning, achievement motivation in mathematics, mathematical beliefs and to integrate mathematical values and beliefs that helps in reducing mathematics anxiety. Results indicated that along with cognitive outcomes in mathematics, the Process Stage Model is effective in enhancing the desirable affective outcomes and removing undesirable affective outcomes. The educational implications of applying the Process Stage Model in various contexts are discussed in the section.

Enhancing Achievement in Mathematics

The results of the study implicated that the Process Stage Model is effective in enhancing the achievement in mathematics of secondary school students. Through reflective thinking the learner develops the better understanding of mathematical concepts and its importance in day to day life by analysing their experiences, thoughts, beliefs and actions. In addition to reflective thinking the Process Stage Model helps the teachers to engage the students in critical thinking thus enabling them in developing higher order thinking skills. Development of higher order thinking skills is essential as the future generation desperately needs which allows them to construct and explore knowledge in meaningful ways. Thus, by using the Process Stage Model the teachers are able to make the learning of mathematics more meaningful by applying reflective thinking and activity oriented approach. Deeper understanding and mastery of mathematical concepts is possible as the Process Stage Model engages students in a series of stages.

The first phase of the Process Stage Model emphasises interaction with the environment, which can be translated into hands-on and experiential learning in mathematics by engaging students in activities such as problem-solving, simulation, and real-world applications; they become active participants in their learning process.

This approach not only deepens their understanding of mathematical concepts but also improves their overall achievements in mathematics by making learning more meaningful and relevant.

After interacting with mathematical problems, students are encouraged to engage in reflective thinking. This phase involves analysing and making sense of their experiences with mathematical tasks, leading to deeper comprehension of the subject matter. Reflective practices, such as journaling or group discussions, can help students to consolidate their understanding and recognize their learning progress and ultimately boost their performance in mathematics.

Enhancing Logical Reasoning

The results of the study indicated that the Process Stage Model is effective in enhancing logical reasoning of secondary school students. As the Process Stage Model follows a structured approach through a series of stages, it enables the learners to analyse the concepts in mathematics which include inductive and deductive reasoning. The teachers by using the process stage model can focus on analysing the problem and systematic way to find solution to the problems by reflecting upon their experiences in their daily life.

In the third phase of Process Stage Model students formulate values of their beliefs based on reflective thinking, which is crucial in developing logical reasoning skills. By reflecting on their interactions with mathematical problems, students can identify the pattern, inter relationships, and formulate logical rules. This process helps in building a strong foundation in logical reasoning as students learn to construct and evaluate arguments, draw conclusions, and apply logical principles in solving mathematical problems.

In the final phase, students apply the logical principles they have developed to the new mathematical situation. This step reinforces their logical reasoning skills, as they transfer and adapt their reasoning strategies to diverse problems, enhancing their ability to think critically and logically in various contexts.

Reducing Mathematical Anxiety

The findings of the study indicated that the Process Stage Model is effective in reducing the mathematics anxiety of secondary school students. Engaging in the activities, progressively approaching the problems, analysing their own beliefs which are the root cause of mathematics anxiety, the learner will be able to uncover their misconceptions related to the mathematics subject. Students by addressing aspects of fear of mathematics the students can build self-confidence and self-esteem.

Creating an interactive and supportive learning environment where students can explore mathematical concepts without fear of judgement is essential in reducing mathematics anxiety. The emphasis on the interaction allows students to engage with mathematics in a low-stress, exploratory manner, which helps to reduce the anxiety associated with learning the subject.

Reflective thinking allows the students to reframe their experience with mathematics. Instead of seeing challenges as failures, they learn to view them as opportunities for growth. This reflective process can help students to manage their emotions and reduce the anxiety they feel towards mathematics. By formulating positive beliefs and values about their abilities and the subject, students can gradually overcome their fear of mathematics. Applying what they have learned in new situations gives students the confidence to tackle unfamiliar mathematical problems. As they experience success in applying their knowledge, their anxiety decreases, and they begin to see mathematics as a subject they can master rather than something to fear.

Enhancing Achievement Motivation in Mathematics

The finding of the study indicated that the Process Stage Model is effective in enhancing the achievement motivation in mathematics of secondary school students. By following a structured and systematic approach of the process in stages, the model enables the learner to accomplish the mathematical endeavours by setting goals and building self confidence. By enhancing achievement motivation in mathematics. A positive mind set can be fostered towards the learning of mathematics.

Motivation in mathematics can be significantly enhanced when students perceive their learning as meaningful. The first phase of the Process Stage Model focuses on engaging students in meaningful interactions with mathematical content. When students see the relevance of mathematics to real-life situations and their personal interest, their intrinsic motivation to achieve in mathematics can be strengthened.

Reflection on their learning experiences allows students to set personal goals and values related to mathematics. As students reflect on their success and challenges, they can develop a growth mindset, which is essential for sustained achievement motivation. This reflective process helps students to internalise the value of perseverance and effort in mathematics, fostering a strong desire to achieve.

Developing Sophisticated Mathematical Beliefs

Results of the study also indicated that the Process Stage Model is effective in enhancing mathematical beliefs of secondary school students. The use of Process Stage Model helps the learners to be aware of their own beliefs about teaching and learning of mathematics as well as the values of mathematics. By reflectively thinking about their beliefs and values in mathematics, the learner will be able to develop more sophisticated beliefs in learning mathematics.

The third phase of the Process Stage Model is critical in shaping students' mathematical beliefs. As students engage in reflective thinking about their own experiences, they begin to formulate beliefs about their own abilities, the nature of mathematics, and the value of mathematical knowledge. Educators can guide this process by encouraging sophisticated beliefs, such as the beliefs that mathematical ability can be developed through effort and practice, and that mathematics is a valuable tool for problem-solving in everyday life.

The final phase of the Process Stage Model involves applying these formulated beliefs in new situations. When students successfully apply their mathematical beliefs to solve problems, it reinforces their confidence and positive beliefs that have formed about mathematics. This ongoing reinforcement helps students to maintain a constructive outlook on their mathematical abilities and the subject as a whole.

Teachers can employ Process Stage Model at secondary stage which helps the learner to develop sophisticated beliefs about teaching and learning mathematics.

Integrating Mathematical Values

Process Stage Model enables the teachers to incorporate mathematical beliefs and values in the teaching learning process by understanding the level of students. Through reflective thinking, students can also develop and internalise mathematical values such as precision logic and persistence etc. By reflecting on the importance of these values in solving mathematical problems, students learn to appreciate the intrinsic value of mathematics, beyond just getting the right answer. This value based approach can help to reduce anxiety, as students focus more on the learning process and less on the fear of making mistakes.

Applying mathematical values and beliefs to new situations helps students' to reduce anxiety. Reflection helps learners to connect their experiences with prior knowledge and future application. The Process Stage Model enables students to learn Mathematics at their own pace and provide enough freedom to the students. As they successfully navigate mathematical challenges using the values and beliefs they have internalised, their fear of mathematics diminishes, and their anxiety is replaced with a sense of accomplishment and self-efficacy.

In short, by integrating the Process Stage Model in mathematics education, teachers can create a learning environment that not only enhances students' achievement in mathematics and logical reasoning but also fosters a positive attitude towards mathematics, strengthens achievement motivation, integrates mathematical values and reduces mathematics anxiety. Process Stage Model is helpful in creating a learning environment that meets meaningful connections between concepts learned in class and real-life situations. It also develops a positive classroom climate by focusing on affective outcomes along with cognitive outcomes. The classroom is active with discussions connecting to real-life context and enables the students to imbibe the values with the help of the teachers. Students become active thinkers and teachers only give guidance, additional instructions, and help to incorporate mathematical values or beliefs in their learning. Hence, it is evident that the Process Stage Model has a positive impact on the cognitive and affective learning outcomes which in turn helps to make mathematics learning enjoyable and value oriented as per vision national Curriculum Framework for School Education (NCFSE, 2003). It also enables the teachers to achieve the goals of mathematics education by creating a passion towards mathematics.

Recommendations of the Study

The present study has proved the effectiveness of the Process Stage Model on enhancing learning outcomes in mathematics such as achievement in mathematics, logical reasoning, achievement motivation in mathematics, mathematical beliefs and reducing mathematics anxiety of secondary school students. On the basis of the findings of the study the investigator has framed certain recommendations that will be beneficial to stakeholders of secondary education to bring necessary changes.

1. While developing the mathematics curriculum of secondary stage, a balance between cognitive outcomes and affective outcomes can be maintained by

emphasising on logical reasoning, problem solving along with mathematical values and reflective thinking.

2. Modify the curriculum of secondary education that promotes active learning by incorporating a value integrated approach. The values and sophisticated mathematical beliefs can be integrated into the curriculum of secondary education.

3. Direct methods of teaching values and beliefs are helpful in developing mathematical values and beliefs among secondary school students. Along with these cognitive outcomes, affective outcomes can be emphasised through the direct method of teaching values.

4. Curriculum can be designed in a way to provide opportunity for students to use reflective strategies in the learning process. Encourage students to reflect on their daily lessons by using journalising, self-assessment activities and group discussions.

5. Training can be given to teachers to help students to use reflective strategies in the teaching-learning process. Teachers can introduce more complex lessons through the stages systematically, integrate values and more sophisticated beliefs in the lesson. Workshops on hands-on training for using Process Stage Model and development of lesson transcripts can be given to the teachers.

6. Cognitive behaviour techniques can be used by the teachers which help them to replace naive beliefs or undesirable values with that of sophisticated beliefs and desirable values related to mathematics.

7. Teachers can encourage curiosity in uncovering the problems of mathematics by relating with real life situations and help them to challenge their naive beliefs about mathematics.

8. Create a supporting learning environment in the mathematics classrooms by encouraging self reflection and peer reflection to develop appropriate values and beliefs about mathematics subjects.

9. Mathematical beliefs and stage specific values of mathematics can be mentioned in the curriculum itself which in turn helps the teachers to frame lesson transcripts on the basis of the identified values and beliefs.

10. The chapters in textbooks can be organized on the basis of the values related to mathematics according to the level of the students. Some units in the textbook can be arranged according to the syntax of Process Stage Model.

11. ICT resources can be prepared for demonstrating how to teach with Process Stage Model.

12. Provide opportunities for independent exploration and self-directed inquiry. Present complex, open-ended problems that require both theoretical knowledge and practical application. For example, allow students to investigate mathematical concepts in physics, economics, or biology, and in other subjects and how these are applied in real-word scenario.

13. Encourage deep reflection and critical evaluation of their problem-solving processes, and facilitate discussions about alternative solutions or perspectives. Guide and provide help for developing higher-order thinking

among students. For example, engage students in meta-cognitive activities where they analyse their mathematical reasoning when tackling calculus or complex algebraic proofs.

14. Foster the beliefs that mathematics is not just a set of rules but a tool for understanding complex systems and structures in various domains. Encourage the development of values such as intellectual curiosity, and a drive for precision.

15. Challenge students to apply their learning novel, interdisciplinary, or real-world problems, such as solving complex societal issues through quantitative reasoning. Encourage the transfer of skills across disciplines.

16. Focus on real-life applications and case studies that resonate with their personal interests. Make the learning context highly relevant to their goals. Add practical problem solving sessions related to finance, data analysis, or industry to apply mathematics in real life situations.

17. Use of structured reflection prompts to help learners to assess how their previous experiences inform their current understanding of new mathematical concepts.

18. Encourage learners to develop growth mindset by focussing on the long-term benefits of mastering mathematical concepts for personal growth. Foster beliefs in lifelong learning and the importance of adapting skills to evolving professional demands.

19. Encourage the application of mathematical principles in novel, real-word settings that align with their career or life goals.

20. Promote ongoing self-assessment and reflection.

Suggestions for Further Research

The suggestions for extending this research are as follows.

1. Effectiveness of Process Stage Model in primary classes, Upper primary classes, and higher education could be studied.

2. The same study can be extended to a larger sample with a longer duration and a coverage of more units can be attempted.

3. Effectiveness of Process Stage Model can be extended to other curricular areas and to other subjects.

4. A comparative study of the effectiveness of Process Stage Model for gifted and slow learners can be carried out.

5. Effectiveness of integration of Process Stage Model with other models of teaching can be carried out with concepts in mathematics.

6. Comparative analysis of Process Stage Model in different disciplines can be carried out.

7. Effectiveness of Process Stage Model in hybrid and online mode can be carried out.

8. A study to identify the factors that affect successful implementation as well as difficulties for applying Process Stage Model in various subjects can be analyzed.

9. Investigate the long-term impact of Process Stage Model on students' mathematical thinking and problem solving abilities

10. Explore how the model affects different cognitive processes, other than achievement and logical reasoning.

11. Investigate how students with different learning styles, abilities, or prior knowledge respond to the model.

12. Test the model in other STEM fields could provide insights into its broader applicability and effectiveness in fostering problem-solving and critical thinking.

13. Effectiveness of anxiety reducing techniques on mathematics achievement and mathematics beliefs can be carried out.

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APPENDICES

Appendix I

FAROOK TRAINING COLLEGE
Research Centre in Education

LESSON TRANSCRIPT ON PROCESS STAGE MODEL (Malayalam)

Name of the teacher	:	Class	: ....
Name of the school	:	Division	: ....
Subject	:	Strength	: ....
Unit	: **സർവ്വസമവാക്യങ്ങൾ**	Date	: ....
Topic	: **തുകകളുടെ ഗുണനം**	Duration	: ....

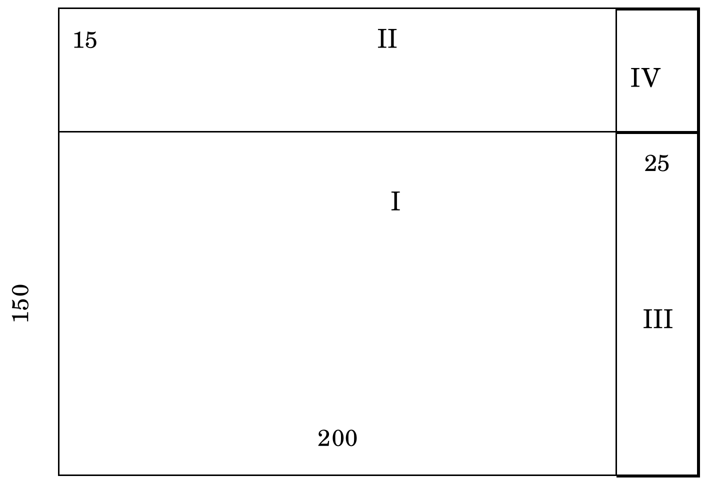
Focus	1. നിത്യജീവിതത്തിലെ വിവിധ സന്ദർഭങ്ങളെ ഗണിതവൽക്കരിച്ച് രണ്ടു സംഖ്യകൾ തമ്മിൽ ഗുണിക്കുമ്പോൾ ആവശ്യമെങ്കിൽ (x + Y)(U+V) = XU + XV + YU + YV ഉപയോഗിച്ച് ഗുണനഫലം കണ്ടെത്തുന്നതിന് . 2. നിത്യജീവിതത്തിൽ സംഖ്യകൾക്കുള്ള പ്രാധാന്യം കണ്ടെത്തുന്നതിന് . 3. നിത്യജീവിതവുമായി ഗണിതശാസ്ത്രം എങ്ങിനെ ബന്ധപ്പെട്ടിരിക്കുന്നു എന്ന് കണ്ടെത്തുന്നതിന്. 4. ഗണിതശാസ്ത്രത്തിലെ വിവിധ ശാഖകൾ തമ്മിലുള്ള ബന്ധം വിശദീകരണത്തിലൂടെ കണ്ടെത്തുന്നതിന് .
Social System	Phase 1 : ക്ലാസിന്റെ ആദ്യഭാഗങ്ങളിൽ അധ്യാപിക കൂടുതൽ ഇടപെടലുകൾ നടത്തുന്നു. Phase 2 : ആദ്യം കുട്ടികൾക്ക് പ്രാധാന്യം നൽകുന്നു. അവസാന ഭാഗങ്ങളിൽ അധ്യാപികയ്ക്കും കുട്ടികൾക്കും ഒരുപോലെ പ്രാധാന്യം വരുന്നു. Phase 3 : അധ്യാപികയുടെ ഇടപെടലുകളിലൂടെ കുട്ടികളുടെ പ്രാധാന്യം വർദ്ധിക്കുന്നു. Phase 4 : ക്ലാസിന്റെ അവസാനഭാഗത്ത് കുട്ടികളുടെ ഇടപെടലുകൾ വർദ്ധിക്കുന്നു.
Support System	ആശയാവതരണത്തിനു വേണ്ടിയുള്ള ചിത്രങ്ങൾ
Principles of Reaction	അധ്യാപിക ഓരോ ഘട്ടത്തിലും ഉചിതമായ നിർദ്ദേശങ്ങൾ നൽകുകയും കുട്ടികളുടെ പ്രതികരണങ്ങൾക്കും ചർച്ചകൾക്കും

	ആവശ്യമായ തിരുത്തലുകളും പിന്തുണകയും നൽകുകയും ചെയ്യുന്നു.
Instructional Effects	• (X+Y) (U+V) = XU + XV + YU + YV എന്ന ആശയത്തെക്കുറിച്ച് വ്യക്തമായ ധാരണയിൽ എത്തിച്ചേരുന്നു. • ഗണിതം മറ്റു വിഷയങ്ങളുടെ പഠനത്തിന് സഹായിക്കുന്നു എന്ന അനുമാനത്തിൽ എത്തുന്നു. • വിവിധ ജീവിത സന്ദർഭങ്ങൾ ഗണിതവുമായി ബന്ധപ്പെട്ടിരിക്കുന്നു എന്ന വിശ്വാസം വളർത്തിയെടുക്കുന്നു. • ഗണിതം എല്ലാവർക്കും ഒരുപോലെ കൈകാര്യം ചെയ്യാവുന്ന വിഷയമാണ് എന്ന വിശ്വാസം വളർത്തിയെടുക്കുന്നു.
Nurturant Effects	• യുക്തിചിന്ത വർദ്ധിക്കുന്നു • ആശയാവതരണശേഷി വർദ്ധിക്കുന്നു. • പ്രശ്നപരിഹാരശേഷി വർദ്ധിക്കുന്നു. • നിത്യജീവിതത്തിൽ സംഖ്യകളുടെ പ്രാധാന്യം കണ്ടെത്തുന്നു.
Syntax	
Phase 1	**Interact with Environment.** അധ്യാപിക വിദ്യാർത്ഥികളോട് ദൈനംദിന ജീവിതവുമായി ബന്ധപ്പെട്ട ചോദ്യങ്ങൾ ചോദിക്കുന്നു. നിങ്ങൾ കടയിൽ പോയി സാധനങ്ങൾ വാങ്ങാറുണ്ടോ? സാധനങ്ങൾ വാങ്ങിയാൽ ചെലവായ മൊത്തം തുക കണക്കാക്കാറില്ലേ ? ഉദാഹരണത്തിന്, ഒരു പുസ്തകത്തിന് 20 രൂപയായാൽ 10 പുസ്തകത്തിന് എത്ര രൂപയായിരിക്കും ? $20 \times 10 = 200$ ഒരു പുസ്തകത്തിന് 28 രൂപയായാൽ 10 പുസ്തകത്തിനോ ? $28 \times 10 = 280$ 17 പുസ്തകവും 28 രൂപയും ആയാലോ ? 17×28

10 × 20 = 200, 10 × 28 = 280 എന്നിവ ചെയ്ത അത്ര എളുപ്പത്തിൽ 17 × 28 ചെയ്യാമോ?

ഇത്തരത്തിൽ സംഖ്യകളുടെ ഗുണനഫലം കാണേണ്ടി വരുമ്പോൾ മനക്കണക്കായ ഗുണനഫലം കാണാൻ സഹായിക്കുന്ന ചില എളുപ്പവഴികൾ ഉണ്ട്. അതിൽ ഒന്ന് നമുക്ക് ഇന്ന് കണ്ടെത്താം.

ഒരു പൂന്തോട്ടത്തിന് 200 മീറ്റർ നീളവും 150 മീറ്റർ വീതിയും ഉണ്ട് . പിന്നീട് പൂന്തോട്ടം വലുതാക്കുന്നതിനായി നീളം 25 മീറ്ററും വീതി 15 മീറ്ററും കൂട്ടി ഈ പൂന്തോട്ടത്തിനോടൊപ്പം കൂട്ടിച്ചേർത്തു. അപ്പോൾ പൂന്തോട്ടം വലുതായില്ലേ? ഈ പൂന്തോട്ടത്തിന്റെ ആകെ വലിപ്പം എത്രയായിരിക്കും? ചിത്രത്തിന്റെ സഹായത്തോടെ അധ്യാപിക പൂന്തോട്ടത്തിന്റെ പ്രത്യേകതകൾ ക്ലാസിൽ അവതരിപ്പിക്കുന്നു .



I, II, III, IV എന്നിങ്ങനെ ഓരോ ചതുരത്തിനും പേരുകൾ നൽകി ഈ നാല് ചതുരത്തിന്റെയും പരപ്പളവ് ചർച്ച ചെയ്യുന്നു .

ഒന്നാമത്തെ ചതുരത്തിന്റെ പരപ്പളവ് = 200 × 150 ച. മി

രണ്ടാമത്തെ ചതുരത്തിന്റെ പരപ്പളവ് = = 200 × 15 ച. മി

മൂന്നാമത്തെ ചതുരത്തിന്റെ പരപ്പളവ് = 150 × 25 ച. മി

നാലാമത്തെ ചതുരത്തിന്റെ പരപ്പളവ് = 25 × 15 ച. മി

	ആകെ പരപ്പളവ് = (200 × 150) + (200 × 15)+ (150 × 25)+ (25 × 15)ച. മി ഈ പൂന്തോട്ടത്തിന്റെ വശങ്ങളുടെ നീളങ്ങൾ എത്രയായിരിക്കും? (200+25) മീറ്ററും (150+ 15) മീറ്ററും. വശങ്ങളുടെ നീളങ്ങൾ 225 = (200 + 25), 165 = (150 + 15) ഇത്രയായാൽ പൂന്തോട്ടത്തിന്റെ പരപ്പളവ് എത്രയായിരിക്കും ? (200 + 25) × (150 + 15). ഈ രണ്ട് രീതിയിലും പരപ്പളവ് കണ്ടത് ഒരേ ചതുരത്തിന്റെ ആയതിനാൽ ഈ രണ്ടു സംഖ്യകളും തമ്മിലുള്ള ബന്ധം എന്തായിരിക്കും? എന്തുകൊണ്ട് ? ഇവ തുല്യമായിരിക്കും അല്ലേ? അതിനാൽ (200+ 25)(150+15)= (200 × 150)+ (200x 15)+ (25 × 150)+ (25 × 15) ആയിരിക്കും . ഇനി (112 × 107) ആയാലോ? 112 = 100+12, 107 = 100+7 എന്നാക്കി എഴുതാം അല്ലേ? കാരണമെന്ത് ?
Phase 2	**Reflective Thinking on the Meaning of Interaction.** കുട്ടികളെ ഗ്രൂപ്പുകളാക്കി തിരിച്ച് ഓരോ ഗ്രൂപ്പിനും രണ്ട് സംഖ്യകൾ നൽകുന്നു. 1) ഈ സംഖ്യകളുടെ ഗുണനഫലം എളുപ്പത്തിൽ കണ്ടെത്തുന്നതിനായി സംഖ്യകളെ രണ്ടു സംഖ്യകളുടെ തുകയാക്കി എങ്ങനെ എഴുതാം? ഇങ്ങനെ ഗുണനഫലം കാണേണ്ടി വരുന്ന സന്ദർഭം വിശദീകരിച്ച് അവയുടെ പരിഹാരം കണ്ടെത്തുക. ഗ്രൂപ്പ് 1 : 34 × 16 ഗ്രൂപ്പ് 2: 23 × 104 ഗ്രൂപ്പ് 3: 115 × 44 ഗ്രൂപ്പ് 4: 37 × 26

	ഓരോ ഗ്രൂപ്പുകാരും അവരവർക്ക് കിട്ടിയ സംഖ്യകളുടെ ഗുണനഫലം എളുപ്പത്തിൽ കണ്ടെത്താനുള്ള വഴി ഉപയോഗിച്ച് സംഖ്യകളെ രണ്ടു സംഖ്യകളുടെ തുകയായി എഴുതുന്നു. ഇങ്ങനെയുള്ള ഗുണനഫലം കണ്ടെത്തേണ്ട സന്ദർഭങ്ങൾ വിശദീകരിക്കുന്നു. ഓരോ ഗ്രൂപ്പുകാരും കണ്ടെത്തിയ സന്ദർഭങ്ങളും ഉത്തരത്തിൽ എത്തിച്ചേർന്ന വഴികളും ക്ലാസ്സിൽ അവതരിപ്പിക്കുന്നു. അധ്യാപിക താഴെ പറയുന്ന ചോദ്യങ്ങൾ കുട്ടികളുടെ അവതരണ സമയത്ത് ഓരോ ഗ്രൂപ്പുകാരോടും ചോദിക്കുന്നു. 1) ഈ സന്ദർഭം ഇങ്ങനെ വിശദീകരിക്കുവാനുള്ള കാരണമെന്ത് ? 2) ഈ സംഖ്യകൾക്ക് പകരം മറ്റു സംഖ്യകളായാൽ നിങ്ങളുടെ ഉത്തരങ്ങൾ എങ്ങനെയായിരിക്കും? കാരണമെന്ത് ? ഓരോ ഗ്രൂപ്പുകാരുടെയും അവതരണത്തിനുശേഷം കുട്ടികൾ കണ്ടെത്തിയതിൽ നിന്നും (X+Y)(U+V) എന്തായിരിക്കും എന്ന് അധ്യാപിക ചോദിക്കുന്നു. $(X + Y)(U+V) = XU + XV + YU + YV$ ഇവിടെ വലതുവശത്തെ സംഖ്യകൾ എന്താണ് ? ഈ സംഖ്യകൾക്ക് ഇടതുവശത്തെ സംഖ്യകളുമായുള്ള ബന്ധം എന്ത് ? ഇടതുവശത്തെ സംഖ്യകളുടെ പ്രത്യേകത എന്ത് ? രണ്ട് സംഖ്യകളെ തുകകളാക്കി ഗുണിക്കുമ്പോൾ എത്ര സംഖ്യകൾ വലതുവശത്ത് ഉണ്ട് ? അവ എങ്ങിനെ കിട്ടി ? ഇവിടെ ഇടതുവശത്തെ സംഖ്യകൾ തമ്മിൽ ഗുണിക്കുന്നതിന് ആദ്യത്തെ തുകയിലെ ഓരോന്നിനെയും രണ്ടാമത്തെ തുകയിലെ ഓരോന്നു കൊണ്ടും ഗുണിച്ചു കൂട്ടുകയാണ് വേണ്ടത്. ഓരോ ഗ്രൂപ്പും തയ്യാറാക്കിയ സന്ദർഭങ്ങളിൽ നിന്നും കണ്ടെത്തിയ ഈ സമവാക്യം ഏത് സംഖ്യകൾക്കും ശരിയാണ്

	അതിനാൽ ഇതിനെ ഒരു സർവ്വസമവാക്യമായി കണക്കാക്കുന്നു എന്ന് അധ്യാപിക വിശദീകരിക്കുന്നു. ഈ സമവാക്യം ഉപയോഗിക്കുന്ന സന്ദർഭങ്ങൾ പലതാണ്. എന്നാൽ എല്ലായിപ്പോഴും ഇത് ഉപയോഗപ്പെടണം എന്നും ഇല്ല.
Phase 3	**Based on the Reflective Thought, Formulate Values/Beliefs.** അധ്യാപിക താഴെ തന്നിരിക്കുന്ന ചോദ്യങ്ങൾക്ക് ഉത്തരങ്ങൾ നൽകാൻ ആവശ്യപ്പെടുന്നു. 1) ഈ പാഠഭാഗം നിത്യജീവിതവുമായി ബന്ധപ്പെട്ടിട്ടുണ്ടോ? ഉണ്ടെങ്കിൽ എന്തുകൊണ്ട്? ഇല്ലെങ്കിൽ എന്തുകൊണ്ട്? 2) യുക്തിചിന്താശേഷി വർദ്ധിപ്പിക്കാൻ ഗണിതപഠനം സഹായിക്കുന്നുണ്ടോ? ഉണ്ടെങ്കിൽ എങ്ങനെ? 3) നിത്യജീവിതത്തിലെ വിവിധ പ്രശ്നങ്ങൾ ഗണിതവൽക്കരിച്ച് പ്രശ്നപരിഹാരം കണ്ടെത്താൻ സഹായിക്കുന്നുണ്ടോ? 4) ഗണിതപഠനം മറ്റു വിഷയങ്ങളുടെ പഠനത്തിന് സഹായിക്കുന്നുണ്ടോ?
Phase 4	**Based on Reflective Thinking Apply Formulated Values to New Situations.** ഗുണനഫലം എളുപ്പവഴിയിൽ (നേരിട്ട് ഗുണിക്കാതെ) കണ്ടെത്തുക. 1) 23×14 2) 1005×310 നിത്യജീവിതത്തിൽ മുകളിൽ പറഞ്ഞ ഗുണനഫലങ്ങൾക്ക് സമാനമായ സാഹചര്യങ്ങൾ വിശദീകരിക്കുക.

Appendix II

FAROOK TRAINING COLLEGE
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LESSON TRANSCRIPT ON PROCESS STAGE MODEL
(English)

Name of the teacher	:	Class	:	....
Name of the school	:	Division	:	....
Subject	:	Strength	:	....
Unit	: Identities	Date	:	....
Topic	: Sum of squares	Duration	:	....

Focus	1. By various situations of every day life, when multiplying two numbers, if needed to find the product using (X+Y)(U+V) = XU+ XV+YU+YV 2. To identify the importance of numbers in daily life 3. To analyse how Mathematics is related to everyday life 4. To analyse the relationship between various branches of Mathematics through explanation
Social System	Phase 1: Teacher makes more interventions during the initial part. Phase 2: During the initial stage children are given importance. But during the latter stages equal importance for both the teacher and the students. Phase 3: The involvement of students increases through the intervention of teacher. Phase 4: Students' participation is more in last phase of the class
Support System	Pictures for presenting concepts.

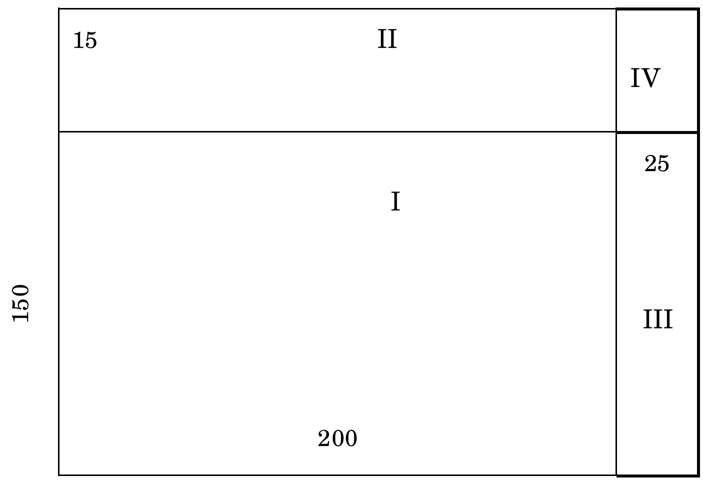
Principles of Reaction	Appropriate instructions for each phase was given to the students by the teacher and supports the students during their responses and discussions.
Instructional Effects	• Arrives at the concept of (X+Y)(U+V) = XU+ XV+YU+YV. • Mathematics helps in the study of other subjects. • Real-life situations are closely connected with Mathematics. • Mathematics can be handled easily by everyone.
Nurturant Effects	• Enhances logical reasoning. • Enhances presentation skills. • Improves problem-solving skills. • Understand the importance of numbers in daily life.
Syntax	
Phase 1	**Interact with Environment.** **Teacher asks questions related to daily life to the students.** Do you go shopping? Don't you calculate the total cost of goods purchased? For example, If a book costs 20 rupees, how much will 10 book cost? $10 \times 20 = 200$ If one book costs 28, how much will 10 books costs? $10 \times 28 = 280$ If it is 17 books and 28 rupees? Then we have to find out 17×28 Can you do 17×28 as easily as you did 10×20 and 10×28?

There are some easy ways for mental calculation while multiplying these type of numbers. Let's look at one of them today.

A garden is 200 meters long and 150 meters wide. Later 25 meter in length and 15 meters in width are added to it. Now the garden is extended. Right?

What will be the total size of this garden?

With the help of the picture, the teacher introduces the characteristics of the garden to the class.



By naming each squares I, II, III and IV, teacher discusses the area of these four rectangles.

The area of the first rectangle = 200×150 square meters

The area of the second rectangle =25×150 square meters

The area of the third rectangle = 200×15 square meters

The area of the fourth rectangle = 25×15 square meters

Total area = $(200 \times 150) + (25 \times 150) + (200 \times 15) + (25 \times 15)$

If the length of the sides are (200+ 25), (150+ 15) What will be the area of this garden?

	Is there any relationship between these two numbers since the area we get through both these methods is at same rectangle? Why? So, $(200+25) \times (150+15) = (200 \times 150) + (25 \times 150) + (200 \times 15) + (25 \times 15)$ Now (112×107)? Can we write 112 = 100+12? What is the reason? $107 = 100 + 7$ So, $(100+12) \times (100+7) =$ ______________________.
Phase 2	**Reflective Thinking on the Meaning of Interaction.** The teacher divides the children into four groups and assigns two numbers to each group. 1) 34, 16 2) 23, 104 3) 115, 44 4) 37, 26 Each Group writes the numbers as the sum of two numbers, to find out the product of multiplication easily, and explains such situations in which they have to find out the answer (result of multiplication). Students find out the product and members from each group present the situations and the method by which they got the answer. The teacher asks the following questions to each group members during their presentation. 1) Why do you explain this situation like this? 2) What will be your answer if these numbers are replaced by other numbers? Why? After their presentation, the teacher asks what (X+Y)(U+V) will be? $(X+Y)(U+V) = XU + XV + YU + YV$ What do the numbers on the right side represent?

	What is the relationship between the numbers of the right and left? What is the specialty of the numbers on the left side? How many numbers are there on the right side when two numbers are multiplied after writing them as the sum of two numbers? Here, in order to multiply the numbers on the left side, you need to multiply each of the first sum by each of the second sum and add them. The teacher explains that this equation which they got as the result of the situations presented by them is applicable for all numbers and therefore it is considered as identities. But it need not be helpful for all situations. The situations in which this equation is used may vary.
Phase 3	**Based on the Reflective Thought, Formulate Values/Beliefs.** The teacher asks them to explain the following questions. 1) Is this topic related to daily life situations? If yes, Why? If no, Why? 2) Does the study of Mathematics helps to develop logical reasoning? If yes, how? 3) Does it help to find solution to various problems in daily life by Mathematizing them? 4) Does study of mathematics helps in study of other subjects?
Phase 4	**Based on Reflective Thinking Apply Formulated Values to New Situations**. Find out the product with out direct multiplication 1) 23×14 2) 1005×310 Teacher asks the students to identify and explain situations in everyday life similar to the above multiplication

Appendix III

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LESSON TRANSCRIPT ON CONSTRUCTIVIST MODEL
(Malayalam)

Name of the teacher	:	Class	:	....
Name of the school	:	Division	:	....
Subject	:	Strength	:	....
Unit	: **സർവ്വസമവാക്യങ്ങൾ**	Date	:	....
Topic	: **തുകകളുടെ ഗുണനം**	Duration	:	....

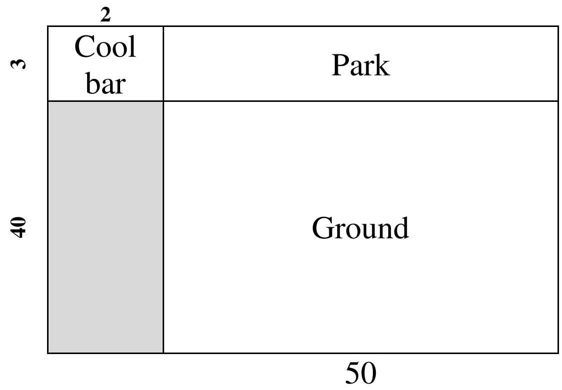
Learning Outcome	പഠിതാവ് • ഒരു തുകയെ മറ്റൊരു തുകകൊണ്ട് ഗുണിക്കാൻ, ആദ്യത്തെ തുകയിലെ ഓരോ സംഖ്യയേയും രണ്ടാമത്തെ തുകയിലെ ഓരോ സംഖ്യകൊണ്ടും ഗുണിച്ച് കിട്ടിയ ഗുണനഫലമെല്ലാം കൂട്ടണമെന്ന് ബീജഗണിതരൂപം ഉപയോഗിച്ച് കണ്ടെത്തുന്നു. • (x + y) (u + v) = xu + xv + yu + yv എന്ന സർവ്വസമവാക്യം ഉപയോഗിച്ച് സംഖ്യാപ്രശ്നങ്ങൾ പരിഹരിക്കുന്നു.
Content Analysis	
Term	സർവ്വസമവാക്യങ്ങൾ
Concept	ഒരു തുകയെ മറ്റൊരു തുകകൊണ്ട് ഗുണിക്കാൻ, ആദ്യത്തെ തുകയിലെ ഓരോ സംഖ്യയേയും രണ്ടാമത്തെ തുകയിലെ ഓരോ സംഖ്യകൊണ്ടും ഗുണിച്ച് കിട്ടിയ ഗുണനഫലങ്ങളുടെയെല്ലാം തുക കണ്ടെത്തിയാൽ ഒരു സർവ്വസമവാക്യം ലഭിക്കും.
Principle	(x + y) (u + v) = xu + xv + yu + yv

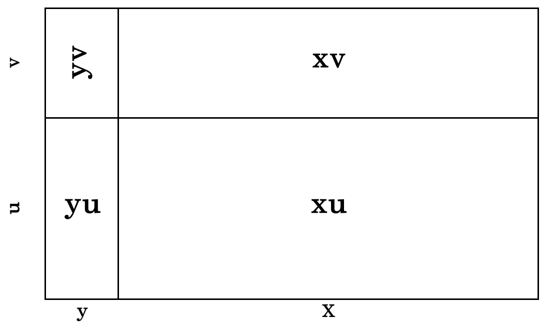
Prerequisites	വിവിധ രൂപങ്ങളുടെ പരപ്പളവ് കണ്ടെത്താനുള്ള സമവാക്യങ്ങൾ അറിയണം.
Learning Resources	

Learning Material	Purpose
Model	നിത്യജീവതപ്രശ്നം അവതരിപ്പിക്കാൻ
പി.പി.ടി.	ഗ്രൂപ്പ് പ്രവർത്തന നിർദ്ദേശങ്ങൾ നൽകുന്നതിന്.
പ്രവർത്തന കാർഡ്	പ്രശ്നപരിഹരണത്തിന്
ചാർട്ട്	പൊതുതത്ത്വം പ്രദർശിപ്പിക്കുന്നതിന്
വീഡിയോ	പൊതുതത്ത്വം വിശദീകരിക്കുന്നതിന്
പോക്കറ്റ് ചാർട്ട്	പ്രശ്നപരിഹരണത്തിന്

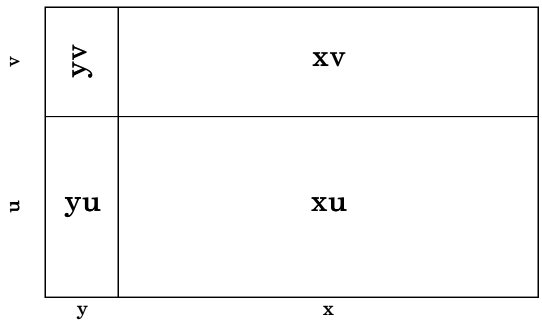
Attitude and Values	സഹകരണ മനോഭാവം, പ്രശ്ന പരിഹാരശേഷി, പ്രായോഗിക പ്രശ്നങ്ങൾ ഗണിതപരമായ രീതിയിൽ നിർദ്ധാരണം ചെയ്യാനുള്ള കഴിവ്, വിമർശനാത്മക ചിന്ത.

പഠനപ്രക്രിയ	പ്രതികരണങ്ങൾ
കുട്ടികളുമായി സൗഹൃദ സംഭാഷണത്തിലേർപ്പെട്ടുകൊണ്ട് അധ്യാപിക/അധ്യാപകൻ ക്ലാസ്സ് ആരംഭിക്കുന്നു. സ്കൂൾ വിട്ട് വീട്ടിലേക്ക് പോയാൽ കളിക്കാറുണ്ടോ എന്നും അതിനോടൊപ്പം കളിക്കുന്ന കളികളുടെ പേരും കളിക്കാൻ പോകാറുള്ള സ്ഥലവും ചോദിക്കുന്നു. കുട്ടികളുടെ വീടിന്റെ അടുത്ത് കുട്ടികൾക്ക് കൂട്ടമായി കളിക്കാനുള്ള സ്ഥലങ്ങളെക്കുറിച്ച് ചോദിക്കുന്നു. അതിനുശേഷം അധ്യാപിക/അധ്യാപകൻ അവരുടെ വീടിന്റെ അടുത്ത് ഫുട്ബോൾ കളിക്കാൻ കുട്ടികൾക്ക് വേണ്ടി ക്ലബ് ചതുരാകൃതിയുള്ള ഒരു സ്ഥലം വാങ്ങി എന്നുപറയുന്നു. ഈ സ്ഥലത്തിന്റെ ഒരു മൂലയിൽ 50 മീറ്റർ നീളവും 40 മീറ്റർ വീതിയുമുള്ള ഒരു ഗ്രൗണ്ട് ഉണ്ടാക്കി. കൂടാതെ അടുത്ത മൂലയിൽ 50 മീറ്റർ നീളവും 3 മീറ്റർ വീതിയുമുള്ള സ്ഥലം പാർക്കാക്കി മാറ്റി. മറ്റൊരു മൂലയിൽ 3 മീറ്റർ നീളവും 2 മീറ്റർ വീതിയുമുള്ള സ്ഥലം കൂൾബാറാക്കി മാറ്റി. 40 മീറ്റർ നീളവും 2 മീറ്റർ വീതിയുമുള്ള സ്ഥലം വിശ്രമസ്ഥലമായും മാറ്റി, ക്ലബ് ഏറ്റെടുത്ത സ്ഥലം	

മുഴുവനായും ഉപയോഗിച്ചാൽ സ്ഥലത്തിന്റെ ആകെ പരപ്പളവ് എത്രയായിരിക്കും. എന്ന് അധ്യാപിക/അധ്യാപകൻ ചോദിക്കുന്നു. Improvised Still Model ഉപയോഗിച്ച് പ്രശ്നം വ്യക്തമാക്കുന്നു.  കുട്ടികളുടെ പ്രതികരണത്തിനുശേഷം അധ്യാപിക/ അധ്യാപകൻ, മാതൃകയുടെ സഹായത്തോടെ ആശയം ആവർത്തിക്കുന്നു.	
Developmental Activity	
കുട്ടികളെ ഗ്രൂപ്പുകളാക്കി തിരിച്ച് ചർച്ചയിലൂടെ ക്ലബ് ഏറ്റെടുത്ത സ്ഥലത്തിന്റെ പരപ്പളവ് കണക്കാക്കാൻ ആവശ്യപ്പെടുന്നു. അധ്യാപിക/ അധ്യാപകൻ കുട്ടികളെ 4 പേരടങ്ങുന്ന 5 ഗ്രൂപ്പുകളായി തിരിക്കുന്നു. പ്രവർത്തനത്തിനാവശ്യ മായ നിർദ്ദേശങ്ങൾ PPT പ്രദർശിപ്പിച്ച് വിശദീകരിക്കുന്നു. 1. സമയം 5 മിനുട്ട് 2. എല്ലാവരും ചർച്ചയിൽ പങ്കെടുക്കുക. 3. ക്ലബ് ഏറ്റെടുത്ത സ്ഥലത്തിന്റെ പരപ്പളവ് ചർച്ചയിലൂടെ കണ്ടെത്തി പ്രവർത്തന കാർഡ് പൂരിപ്പിക്കുക. 4. ആദ്യം പ്രവർത്തനം ശരിയായി പൂർത്തീകരിക്കുന്ന ഗ്രൂപ്പായിരിക്കും വിജയി. കുട്ടികൾ ചർച്ചചെയ്ത് പൂരിപ്പിച്ച പ്രവർത്തന കാർഡ് ക്ലാസിൽ അവതരിപ്പിക്കാനാവശ്യപ്പെടുന്നു. ആദ്യം പ്രവർത്തനം പൂർത്തീകരിക്കുന്ന ഗ്രൂപ്പ് ബോർഡിൽ എഴുതി വിശദീകരിക്കുന്നു.	

കുട്ടികളുടെ വിശദീകരണത്തിനുശേഷം അധ്യാപിക /അധ്യാപകൻ പരപ്പളവ് കാണുന്നത് വിശദീകരിക്കുന്നു.  ആകെ പരപ്പളവ് = (1) ന്റെ പരപ്പളവ് + (2) ന്റെ പരപ്പളവ് + (3) ന്റെ പരപ്പളവ് + (4) ന്റെ പരപ്പളവ് = (50 X 40) + (50 X 3) + (40 X 2) + (3 X 2) = 2236 ച.മീ. ആദ്യം പ്രവർത്തനം പൂർത്തീകരിച്ച ഗ്രൂപ്പിനെ അധ്യാപിക/അധ്യാപകൻ അഭിനന്ദിക്കുന്നു.	
Consolidation Activity	
സ്ഥലത്തിന്റെ വശങ്ങൾ 52, 43 എന്നിവക്ക് പകരം വേറെ അളവുകളാണെങ്കിലും നമുക്ക് ആകെ പരപ്പളവ് കണക്കാക്കുവാൻ സാധിക്കില്ലേ എന്ന് അധ്യാപിക/അധ്യാപകൻ ചോദിക്കുന്നു. പ്രവർത്തനമാതൃകയുടെ സഹായത്തോടെ പൊതുതത്ത്വം രൂപീകരിക്കാൻ അധ്യാപിക/ അധ്യാപകൻ കുട്ടികളെ സഹായിക്കുന്നു. (x + y) (u + v) = xu + xv + yu + yv  അധ്യാപിക ചാർട്ട് പ്രദർശിപ്പിച്ച് വീഡിയോയിലൂടെ ആശയം വ്യക്തമാക്കുന്നു.	

തുകകളുടെ ഗുണനം



ആകെ നീളം = x + y

ആകെ വീതി = u + v

∴ ആകെ വീതി = (x + y) (u + v)

(x + y) (u + v) = xu + xv + yu + yv

PPT പ്രദർശിപ്പിച്ച് ആശയം വ്യക്തമാക്കുന്നു.

തുകകളുടെ ഗുണനം

രണ്ട് സംഖ്യകളുടെ തുകയെ മറ്റൊരു തുകകൊണ്ട് ഗുണിക്കാൻ, ആദ്യത്തെ തുകയിലെ ഓരോ സംഖ്യയേയും രണ്ടാമത്തെ തുകയിലെ ഓരോ സംഖ്യകൊണ്ടും ഗുണിച്ച് അവയുടെ തുക കണ്ടാൽ മതി.

സമാനമായ സംഖ്യാപ്രശ്നം അവതരിപ്പിക്കുന്നു.

x + y = 20 + 2 ഉം

u + v = 10 + 1 ഉം ആയാൽ

(20 + 2) (10 + 1) = (x + y) (u + v)

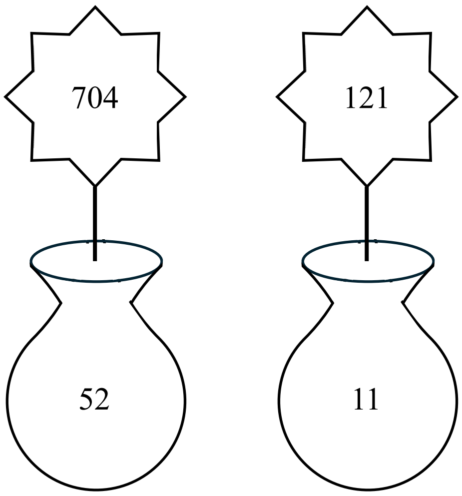
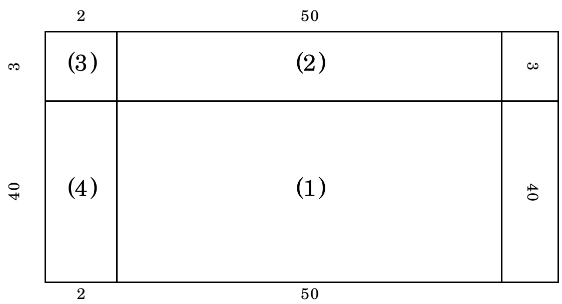
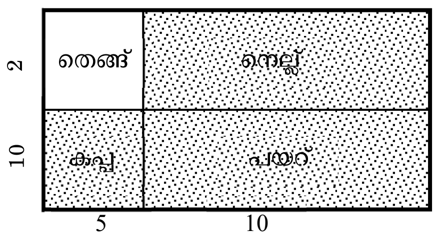
(20+2) (10+1) = (20x10)+(20x1)+(2x10)+(2x1)

= 200 + 20 + 20 + 2

= 242

കുട്ടികളോട് താഴെ കൊടുത്തിട്ടുള്ള സംഖ്യകളെ സർവസമവാക്യം ഉപയോഗിച്ച് എഴുതാനാവശ്യപ്പെടുന്നു. ഇവയുടെ ഗുണനഫലം കണ്ടെത്തി അവ pocket chartൽ പൂരിപ്പിക്കാനാവശ്യപ്പെടുന്നു.

(1) 704 x 52 (2) 121 x 11

	
Black Board Summary	
ഗണിതം  ആകെ പരപ്പളവ് = 1 + 2 + 3 + 4 = (50X40) + (50X30) + (40X2) + (3X2) = 2236	
തുകകളുടെ ഗുണനം $(x+y)(u+v) = xu + xv + yu + yv$	
Follow up Activity	
	

Improvised Still Model പ്രദർശിപ്പിച്ച് കൃഷിസ്ഥലത്തിന്റെ ആകെ പരപ്പളവ് കണക്കാക്കാൻ ആവശ്യപ്പെടുന്നു. കൃഷിസ്ഥല ത്തിൽ 15 മീറ്റർ നീളവും 12 മീറ്റർ വീതിയും ആയാൽ ആകെ പരപ്പളവ് കാണുക.	

Appendix IV

LESSON TRANSCRIPT ON CONSTRUCTIVIST MODEL (English)

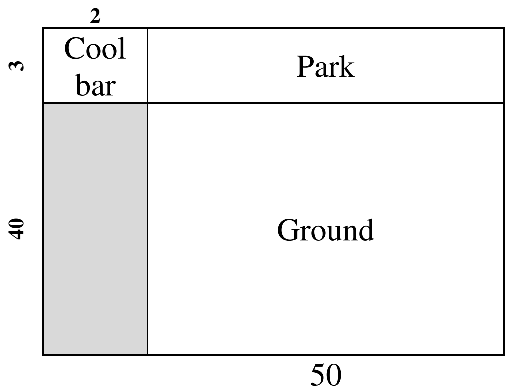
Name of the teacher	:	Class	: ....
Name of the school	:	Division	: ....
Subject	: Mathematics...........................	Strength	: ....
Unit	: Identities	Date	: ....
Topic	: തുകകളുടെ ഗുണനം	Duration	: ....

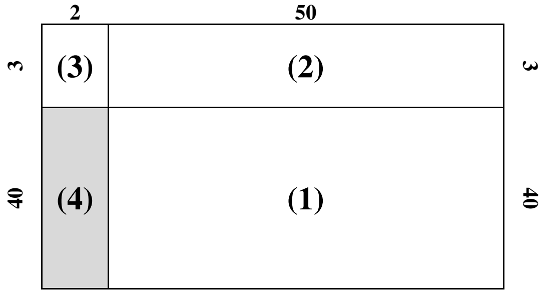
Learning Outcomes	**Learner** • Explains how to multiply a sum of positive numbers by a sum of positive numbers, multiply each number in the second. Sum by each number in the first sum and add. • Solves problems using (x + y) (u + v) = xu + xv + yu + yv identity.
Content Analysis	
Term	Identities
Concept	An identity is formed by multiplying a sum of positive numbers by sum of another positive numbers, multiply each number in the second sum by each number to the first sum and add.
Principle	$(x + y)(u + v) = xu + xv + yu + yv$
Prerequisites	Formulae to find out the area of different geometrical figures.
Attitude and Values	Co-operation, problem solving ability, solve problems in different situations, critical thinking.

Appendix

Learning Resources	Learning Material	Purpose
	Model	To present daily life situations
	PPT	For provide group work instructions
	Activity Card	To solve problems
	Chart	To present identity
	Video	To explain the identity
	Pocket chart	To solve problems.

Learning process	**Assessment**
Introductory activity The teacher engages in friendly conversation with the students. The teacher asks whether they play games when they return home, the names of the different games, and the place where they play. The teacher also asks about places where they can play in groups. The teacher shares the following. In teacher's home town, the club purchased a ground shaped like a rectangle for children in that region. A ground 50 meters long and 40 meters wide was made in one corner of this plot. And in another corner a 50 meter long and 2 meter wide area has been converted into a park. In another corner of the purchased land, a 3 meter long and 2 meter wide area was build in to a cool bar and 40 meter long and 2 meter wide area was used as rest area. Then there is no vacant place in that purchased plot. If so, what is the total area of the land purchased by the club and how to find it?	

Then we have to find the total area and how to find total area? The teacher explains the situation using improvised still model. 	
Developmental Activity	
Students are split in to groups and are asked to find out the area of the land bought through discussion. The teacher provides activity cards to the students. Also, the students are given instruction along with the PPT 1. Time 5 minutes 2. All students should participate in discussion 3. Through discussion find the total area of land bought by the club and fill the activity card. 4. The 1st group who complete the task will win the activity The students present the answer in the class after discussion and filling the activity card. The first group who complete the activity solves it on the blackboard .	

<table>
<tr><td>


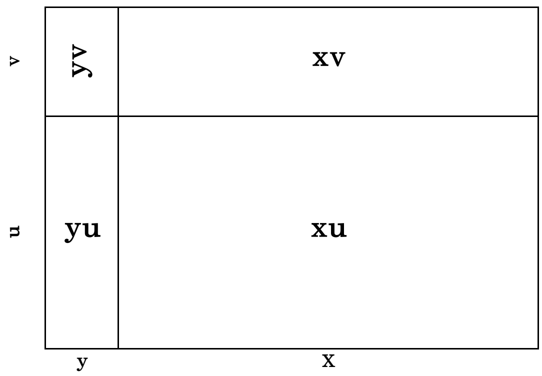
Total area = Area of (1) + Area of (2) + Area of (3) + Area of (4)

= (50 x 40) + (50 x 3) + (40 x 2) + (3 x 2)

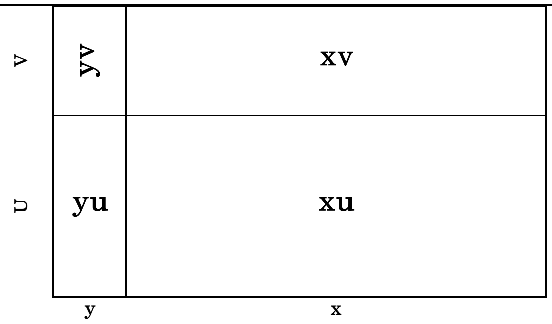
= 2236 m^2

The teacher appreciate the team which completed the activity first.
</td><td></td></tr>
<tr><td>Consolidation Activity</td><td></td></tr>
<tr><td>
Teacher asks whether we can find the area of the land if the measurements 52m and 43m, are changed? If the measurement as x, y and u, v, then what will be its area? The teacher helps the students to form the equation and explains the algebraic equation using the working model.

(x + y) (u + v) = xu + xv + yu + yv.



The concept is made clean by presenting chart, and showing videos.
</td><td></td></tr>
</table>



Product of Sums

Total length = x + y

Total breadth = u + v

Total area = (x + y) (u + v)

= xu + xv + yu + yv.

The concept is made clear through PPT

Product of sums

To multiply a sum of positive number by a sim of another positive numbers, multiply each number in the second sum by each number in the first sum and add.

Understanding the concept through solving similar number problems .

If, (x + y) = 20 + 2 and (u + v) = 10 + 1,

(20 + 2) (10 + 1) = (x + y) (u + v)

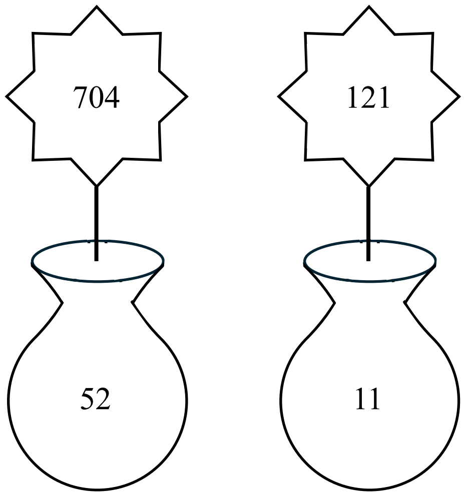
(20 + 2) (10 + 1) = (20 x 10) + (20 x 1) + (2x 10) + (2 x 1)

= 242

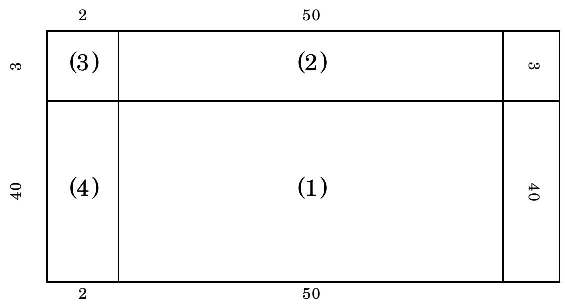
The students write the sum of the given numbers, They find out the product of these numbers using the above identify and fill out the pocket chart.

Appendix

Find out



Black Board Summary

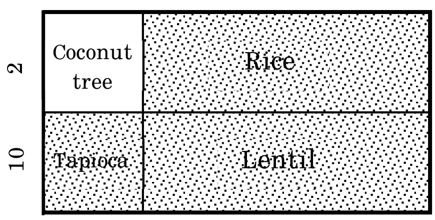


Total area = 1 + 2 + 3 + 4

= 50 x 40 + 50 x 3 + 40 x 2 + 3 x 2

2000 + 150 + 80 + 6 = 2236m^2

Follow up activity



The teacher asks students to find out the area of the farm field with total length 15 meter and width 12 meter.

Appendix V

FAROOK TRAINING COLLEGE
Research Centre in Education

ACHIEVEMENT TEST IN MATHEMATICS

(Malayalam – Draft)

Standard VIII

Radhika T.
Research Scholar

Dr. Niranjana K.P.
Assistant Professor

PERSONAL DETAILS

Name:..

School: ....

Class:..Roll No.: ....

നിർദ്ദേശങ്ങൾ

- സർവ്വസമവാക്യങ്ങൾ എന്ന പാഠഭാഗം സംബന്ധിച്ച പരീക്ഷയാണിത്.
- 40 ചോദ്യങ്ങളാണ് ഇതിലുള്ളത്.
- ഓരോ ചോദ്യത്തിനും a, b, c, d എന്നീ പ്രതികരണങ്ങൾ നൽകിയിട്ടുണ്ട്.
- നിങ്ങൾക്ക് തന്നിരിക്കുന്ന പ്രതികരണ പേജിൽ ചോദ്യനമ്പറുകൾ ക്രമമായി എഴുതിയിരിക്കുന്നു. ശരിയായ ഉത്തരം കണ്ടെത്തി ചോദ്യനമ്പറിനുനേരെയുള്ള കോളത്തിൽ '✓' അടയാളം രേഖപ്പെടുത്തുക.
- എല്ലാ ചോദ്യത്തിനും ഉത്തരം എഴുതുക.
- ഓരോ ചോദ്യത്തിനും ഓരോ മാർക്ക് വീതമാണ്.
- പരമാവധി 40 മാർക്ക്.
- പരമാവധി സമയം 40 മിനിറ്റ്.

ചോദ്യങ്ങൾ

1. X x (XY + 1) = ...

   a) $X^2Y + X$ c) $2XY + X$

   b) $XY + 1$ d) $X^2Y + 1$

2. 3 x 14 = __________ ?

   a) 3(10 + 4) c) 3(10 + 1)

   b) 4(10 + 4) d) 4(3 + 10)

3. $X \times (X + 1) + X$ = ...

   a) $X^2 + X$ c) $X^2 + 2X$

   b) $3X + 1$ d) $X^2 + X + 1$

4. (X + Y) (U + V) = …………………

a) XU + XV + YU + YV c) XY + UV

b) XU - XV + YU - YV d) XUYV

5. 51^2 നെ തുകയുടെ വർഗമായി എഴുതുന്നതിന് താഴെ പറയുന്നവയിൽ ഏതു രീതി ഉപയോഗിക്കുന്നതാണ് ഏറ്റവും ഉചിതം?

a) $51^2 = (48+2)^2$ c) $51^2 = (50+1)^2$

b) $51^2 = (55-4)^2$ d) $51^2 = 51 \times 51$

6. $65^2 = 60^2 + 25 +$ --------

a) 2 x 60 c) 2x 60 x 5

b) 2 x 5 d) 2x 65 x 25

7. രണ്ടു അധി സംഖ്യകളുടെ തുകയുടെ വർഗം =

a) അധി സംഖ്യകളുടെയും വർഗങ്ങളുടെ തുക

b) ആദ്യത്തെ അധി സംഖ്യയുടെ വർഗം

c) സംഖ്യകൾ തമ്മിലുള്ള ഗുണനഫലം

d) സംഖ്യകളുടെ വർഗങ്ങളുടെയും ഗുണനഫലത്തിന്റെ രണ്ടു മടങ്ങിന്റെയും തുക.

8. $(X + Y)^2 = X^2 +$ ------------

a) $X^2 + Y^2$ c) $Y^2 + 2XY$

b) $X^2 + 2XY$ d) $X^2Y^2 + 2X^2Y^2$

9. $(6\frac{1}{2})^2 =$ -----------------

a) $6^2 \times \frac{1}{2}^2$ c) $(6 + \frac{1}{2})^2$

b) $6^2 + \frac{1}{2}^2$ d) $6^2 + \frac{1}{8}$

10. $(2X - 1)^2 =$ ___________ ?

a) 4x(x-1) + 1 c) 2x(x-1)

b) 4x(1-x) + 1 d) $2(x-1)^2$

11. X > Y ,U > V ആയ ഏതു അധിസംഖ്യകളായാലും (X – Y) (U-V) =

a) XU + XV + YU – YV c) XY - XV +YU -YV

b) XU - XV - YU +YV d) XU + XV + YU + YV

12. 397 X 98 നെ വ്യത്യാസഗുണനമായി എഴുതുന്ന രീതി

a) (400 -3) (100 - 2) c) (395 + 2) (95 +3)

b) (400 – 3) X 98 d) (400-3) (95 +3)

13. (X + Y) (U-V) =

a) XU - XV + YU – YV c) XY - XV - YU -YV

b) XU + XV - YU - YV d) XU + XV + YU + YV

14. 303 X 198 നെ തുകയുടെയും വ്യത്യാസത്തിന്റെയും ഗുണനഫലമായി എഴുതുന്നതിൽ എറ്റവും ഉചിതമായത് ഏത് ?

a) 303(190 + 8)
b) (300+3) (195 +3)
c) (300+3) (200 – 2)
d) (305-2) (200 - 2)

15. (10+2) (15 +3) = (10x15) + _______ + (2 x 15) + (2x6)

a) 10 x 3
b) 15 x 10
c) 10x 6
d) 15x 3

16. 6½ x 8 ½ = -----------

a) 48¼
b) 45¼
c) 55 ¼
d) 49

17. 2x 195 = 2x ------- = 400 – 10

a) (90 + 5)
b) (180+15)
c) (200 - 5)
d) (180 +10)

18. $(40 - 2)^2 = 40^2 + 2^2 +$ ------------

a) - 2x40 x 2
b) - 40 x 2
c) 2 x 40x 2
d) 40x 2

19. $(X + Y)^2 - (X - Y)^2 =$ ------------

a) 2XY
b) 4XY
c) XY
d) 2 (X + Y)

20. 52 x 48 =

a) $50^2 - 2^2$
b) $52^2 - 48^2$
c) $(50 - 2)^2$
d) $50^2 + 2^2$

21. 45 നെ രണ്ടു പൂർണവർഗങ്ങളുടെ വ്യത്യാസമായി എഴുതുന്നതെങ്ങനെ?

a) $(9 - 6)^2$
b) $9^2 - 5^2$
c) 9 x 5
d) $9^2 - 6^2$

22. 101 x 99 = --------

a) 999
b) 99000
c) 9999
d) 9900

23. ഒരു പൂന്തോട്ടത്തിന്റെ നീളം 5 മീറ്ററും, വീതി 3 മീറ്ററുമായിരുന്നു. എന്നാൽ ആ പൂന്തോട്ടത്തിന്റെ നീളം 2 മീറ്ററും വീതി 1 മീറ്ററും കൂട്ടിയാൽ ആ പൂന്തോട്ടത്തിൽ ചെടികൾ വച്ചുപിടിപ്പിക്കാവുന്ന ആകെ സ്ഥലത്തിന്റെ അളവ് എത്ര ?

a) $44m^2$
b) $11m^2$
c) $34m^2$
d) $28m^2$

24. സീത 13 പുസ്തകങ്ങൾ 22 രൂപക്കും 12 പേനകൾ 8 രൂപക്കും വാങ്ങിയാൽ സീതയ്ക്ക് ചിലവായ ആകെ തുക എത്ര ?

a) 272 c) 282

b) 382 d) 172

25. വശത്തിന്റെ നീളം 20½സെ.മി ആയ ഒരു ചതുരക്കടലാസിന്റെ പരപ്പളവ് ?

a) 400cm^2 c) 420 ¼ $c\ m^2$

b) 400/4cm^2 d) 240 cm^2

26. (Y + 2) (X+2) = XY + 2Y +2X + 4 എന്ന തത്ത്വത്തിൽ 2 ന പകരം 1 എടുത്താൽ വരുന്ന ഉത്തരം (Y+ 1) (X+1) =

a) YX +X + Y + 1 c) XY + 2Y+ X +1

b) 2XY + 1 d) XY + Y + 2X + 2

27. ഏത് ഒറ്റ സംഖ്യയുടെ വർഗത്തിനെയും 4 കൊണ്ട് ഹരിച്ചാൽ കിട്ടുന്ന ശിഷ്ടം എത്രയായിരിക്കും ?

a) 0 c) 2

b) 1 d) 3

28. 53 X 49 എന്ന ഗുണനഫലം കണ്ടെത്താനുപയോഗിക്കാവുന്ന ഏറ്റവും ഉചിതമായ സർവ്വസമവാക്യം

a) (X+Y) (U+V) = XU + XV +YU + YV

b) (X+Y) (U-V) = XU - XV +YU - YV

c) (X-Y) (U-V) = XU - XV -YU + YV

d) $(X-Y)^2 = X^2 + Y^2 - 2XY$

29. രാജുവിന്റെ കടയിലെ 10 കുടകളിൽ 6 കുടകൾ 148 രൂപയ്ക്കും 4 കുടകൾ 152 രൂപയ്ക്കുമാണ് വിറ്റത്. എന്നാൽ സോനു തന്റെ കടയിലെ 10 കുടകളിൽ 6 കുടകൾ 147 രൂപയ്ക്കും 4 കുടകൾ 153 രൂപയ്ക്കും വിറ്റു എങ്കിൽ ഏറ്റവും കൂടുതൽ തുക ലഭിച്ചത് ആർക്ക്?

a) രാജുവിന് സോനുവിനേക്കാൾ കൂടുതൽ തുക ലഭിച്ചു.

b) സോനുവിന് രാജുവിനേക്കാൾ കൂടുതൽ തുക ലഭിച്ചു.

c) രാജുവിനും സോനുവിനും ലഭിച്ച തുക തുല്യമാണ്.

d) രാജുവിനും സോനുവിനും ലഭിച്ച തുക കണ്ടെത്താൻ സാധ്യമല്ല

30. $X(X+2) = (X+1)^2 - 1$ എന്ന ബീജഗണിതരൂപം സംബന്ധിച്ച് ഉചിതമായ പ്രസ്താവന ഏത്?

a) ഏത് രണ്ട് ഇരട്ടസംഖ്യകളുടെയും ഗുണനഫലത്തെ സൂചിപ്പിക്കുന്ന ബീജഗണിതരൂപം.

b) ഏതു രണ്ട് ഒറ്റ സംഖ്യകളുടെയും ഗുണനഫലത്തെ സൂചിപ്പിക്കുന്ന ബീജഗണിതരൂപം

c) ഏതു രണ്ട് ഒന്നിടവിട്ട എണ്ണൽ സംഖ്യകളുടേയും ഗുണനഫലത്തെ സൂചിപ്പിക്കുന്ന ബീജഗണിതരൂപം

d) ഏതു രണ്ട് അഭാജ്യസംഖ്യകളുടേയും ഗുണനഫലത്തെ സൂചിപ്പിക്കുന്ന ബിജഗണിതരൂപം

31. $(10\frac{1}{2})^2$ = -------------

a) 100¼ c) 100

b) 110¼ d) 101

32. $50^2 = 2500$ ആയാൽ 51^2 = ---------------------

a) 2500 + 50 + 51 c) 2500 + 2x 51

b) 2500 + 2x 50 d) 2500 +2(50 + 51)

33. 62 x 58 എന്നതിന് തുല്യമായത്

a) 3600 – 4 c) 3600 + 2

b) 3600 + 4 d) 3600 – 2

34. 42x 17 = 800 – 40x3 +……. + (-6)

a) 40 c) 20

b) 120 d) 3

35. 102x 98 എന്ന ഗുണനഫലം കണ്ടെത്താനുപയോഗിക്കാവുന്ന ഏറ്റവും ഉചിതമായ സർവ്വസമവാക്യം

a) (X+Y) (U+V) = XU + XV +YU + YV

b) (X+Y) (U-V) = XU - XV +YU - YV

c) (X-Y) (U-V) = XU - XV -YU + YV

d) (X+Y) (X-Y) = $X^2 - Y^2$

36. ഒരു കലണ്ടറിന്റെ ഭാഗമാണ് താഴെ തന്നിരിക്കുന്നത്

2	3
9	10

ഈരൂപത്തിൽ എഴുതാൻ കഴിയുന്ന സംഖ്യകളുടെ ബീജഗണിതരൂപം

a)

x	X-1
X+1	X+8

b)

x	X+1
X+5	X+4

c)

x	X+2
X+1	X+4

d)

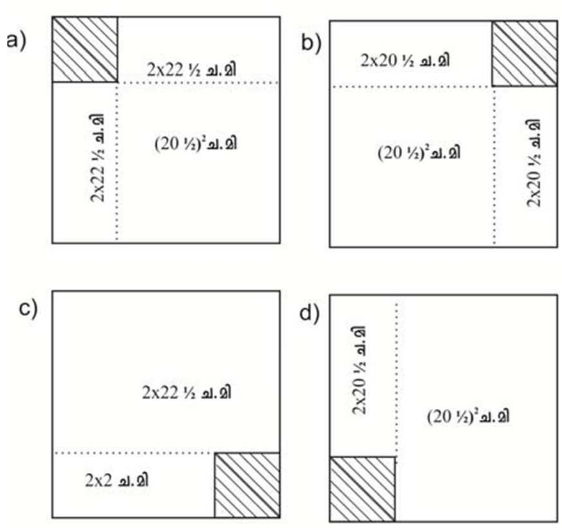
x	X+1
X+7	X+8

37. 28 x 17 = 600 - ……….+6

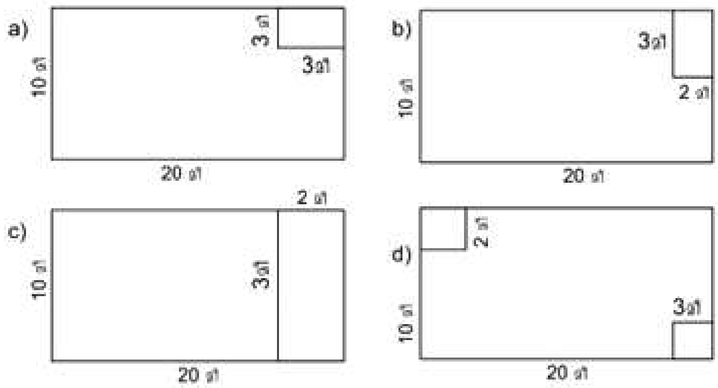
a) 130 c) 40

b) 90 d) 110

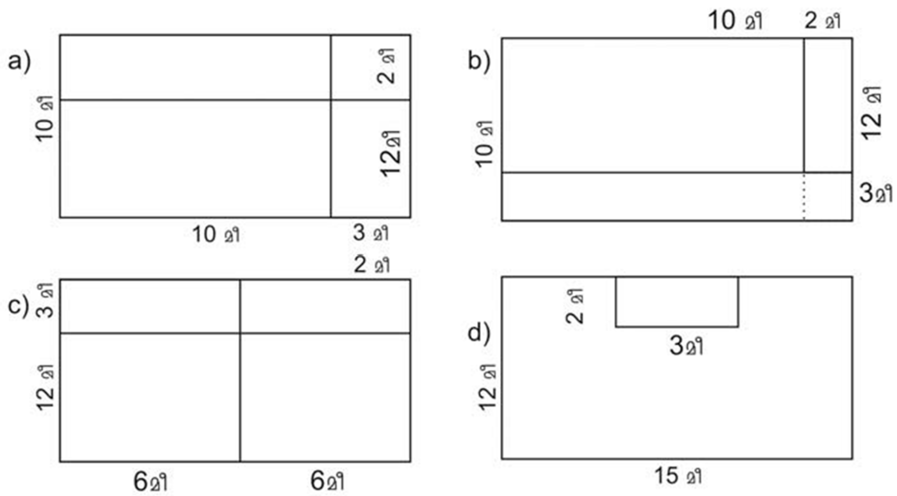
38. 22½ മീറ്റർ വശങ്ങളുള്ള സമചതുരാകൃതിയിലുള്ള ഒരു കളി സ്ഥലത്തിന്റെ ഒരു മൂലയിൽ നിന്നും 2 മീറ്റർ വശങ്ങളുള്ള സമചതുരാകൃതിയിലുള്ള സ്ഥലം ഒഴിവാക്കിയാൽ കിട്ടുന്ന കളിസ്ഥലത്തിന്റെ പരപ്പളവിനെ സൂചിപ്പിക്കുന്ന ചിത്രങ്ങളിൽ ഉചിതമായത് താഴെ തന്നിരിക്കുന്നവയിൽ ഏത്?



39. കുട്ടന്റെ വീടിന്റെ ഒരു മുറിക്ക് 20 മീറ്റർ നീളവും 10 മീറ്റർ വീതിയും ഉണ്ട്. നീളം 3 മീറ്ററും വീതി 2 മീറ്ററുമുള്ള ഒരു കബോർഡ് ആ റൂമിന്റെ ഒരു മൂലയിലെ തറയിൽ നിർമിച്ചു. ഇതിന്റെ ജ്യാമിതീയ രൂപം ഏത്?



40. (10+2)(12+3) എന്നതിന്റെ ജ്യാമിതീയ രൂപം ഏത്?



Appendix VI

FAROOK TRAINING COLLEGE
Research Centre in Education

ACHIEVEMENT TEST IN MATHEMATICS

(Malayalam – Final)

Standard VIII

Radhika T. **Dr. Niranjana K.P.**
Research Scholar Assistant Professor

PERSONAL DETAILS

Name:..

School: ....

Class:...Div.: ....

നിർദ്ദേശങ്ങൾ

- സർവ്വസമവാക്യങ്ങൾ എന്ന പാഠഭാഗം സംബന്ധിച്ച പരീക്ഷയാണിത്.
- 30 ചോദ്യങ്ങളാണ് ഇതിലുള്ളത്.
- ഓരോ ചോദ്യത്തിനും a, b, c, d എന്നീ പ്രതികരണങ്ങൾ നൽകിയിട്ടുണ്ട്.
- നിങ്ങൾക്ക് തന്നിരിക്കുന്ന പ്രതികരണ പേജിൽ ചോദ്യനമ്പറുകൾ ക്രമമായി എഴുതിയിരിക്കുന്നു. ശരിയായ ഉത്തരം കണ്ടെത്തി ചോദ്യനമ്പറിനുനേരെയുള്ള കോളത്തിൽ '✓' അടയാളം രേഖപ്പെടുത്തുക.
- എല്ലാ ചോദ്യത്തിനും ഉത്തരം എഴുതുക.
- ഓരോ ചോദ്യത്തിനും ഓരോ മാർക്ക് വീതമാണ്.
- പരമാവധി 40 മാർക്ക്.
- പരമാവധി സമയം 40 മിനിറ്റ്.

ചോദ്യങ്ങൾ

1. $65^2 = 60^2 + 25 +$ --------

   a) 2 x 60 c) 2x 60 x 5

   b) 2 x 5 d) 2x 65 x 25

2. രണ്ടു അധി സംഖ്യകളുടെ തുകയുടെ വർഗം =

   a) അധി സംഖ്യകളുടെയും വർഗങ്ങളുടെ തുക

   b) ആദ്യത്തെ അധി സംഖ്യയുടെ വർഗം

   c) സംഖ്യകൾ തമ്മിലുള്ള ഗുണനഫലം

   d) സംഖ്യകളുടെ വർഗങ്ങളുടെയും ഗുണനഫലത്തിന്റെ രണ്ടു മടങ്ങിന്റെയും തുക.

3. $(X + Y)^2 = X^2 +$ ------------

a) $X^2 + Y^2$

b) $X^2 + 2XY$

c) $Y^2 + 2XY$

d) $X^2Y^2 + 2X^2Y^2$

4. $(2X - 1)^2 =$ ___________ ?

a) 4x(x-1) + 1

b) 4x(1-x) + 1

c) 2x(x-1)

d) $2(x-1)^2$

5. X > Y ,U > V ആയ ഏതു അധിസംഖ്യകളായാലും (X – Y) (U-V) =

a) XU + XV + YU – YV

b) XU - XV - YU +YV

c) XY - XV +YU -YV

d) XU + XV + YU + YV

6. 397 X 98 നെ വ്യത്യാസഗുണനമായി എഴുതുന്ന രീതി

a) (400 -3) (100 - 2)

b) (400 – 3) X 98

c) (395 + 2) (95 +3)

d) (400-3) (95 +3)

7. (X + Y) (U-V) =

a) XU - XV + YU – YV

b) XU + XV - YU - YV

c) XY - XV - YU -YV

d) XU + XV + YU + YV

8. 303 X 198 നെ തുകയുടെയും വ്യത്യാസത്തിന്റെയും ഗുണനഫലമായി എഴുതുന്നതിൽ എറ്റവും ഉചിതമായത് ഏത് ?

a) 303(190 + 8)

b) (300+3) (195 +3)

c) (300+3) (200 – 2)

d) (305-2) (200 - 2)

9. (10+2) (15 +3) = (10x15) + _______ + (2 x 15) + (2x6)

a) 10 x 3

b) 15 x 10

c) 10x 6

d) 15x 3

10. 2x 195 = 2x ------- = 400 – 10

a) (90 + 5)

b) (180+15)

c) (200 - 5)

d) (180 +10)

11. $(40 - 2)^2 = 40^2 + 2^2 +$ ------------

a) - 2x40 x 2

b) - 40 x 2

c) 2 x 40x 2

d) 40x 2

12. $(X + Y)^2 - (X - Y)^2 =$ ------------

a) 2XY

b) 4XY

c) XY

d) 2 (X + Y)

13. 52 x 48 =

a) $50^2 - 2^2$ c) $(50 - 2)^2$

b) $52^2 - 48^2$ d) $50^2 + 2^2$

14. 45 നെ രണ്ടു പൂർണവർഗങ്ങളുടെ വ്യത്യാസമായി എഴുതുന്നതെങ്ങനെ?

a) $(9 - 6)^2$ c) 9 x 5

b) $9^2 - 5^2$ d) $9^2 - 6^2$

15. 101 x 99 = --------

a) 999 c) 9999

b) 99000 d) 9900

16. ഒരു പൂന്തോട്ടത്തിന്റെ നീളം 5 മീറ്ററും, വീതി 3 മീറ്ററുമായിരുന്നു. എന്നാൽ ആ പൂന്തോട്ടത്തിന്റെ നീളം 2 മീറ്ററും വീതി 1 മീറ്ററും കൂട്ടിയാൽ ആ പൂന്തോട്ടത്തിൽ ചെടികൾ വച്ചുപിടിപ്പിക്കാവുന്ന ആകെ സ്ഥലത്തിന്റെ അളവ് എത്ര ?

a) $44m^2$ c) $34m^2$

b) $11m^2$ d) $28m^2$

17. സീത 13 പുസ്തകങ്ങൾ 22 രൂപക്കും 12 പേനകൾ 8 രൂപക്കും വാങ്ങിയാൽ സീതയ്ക്ക് ചിലവായ ആകെ തുക എത്ര ?

a) 272 c) 282

b) 382 d) 172

18. വശത്തിന്റെ നീളം 20½സെ.മി ആയ ഒരു ചതുരക്കടലാസിന്റെ പരപ്പളവ് ?

a) $400cm^2$ c) $420\ ¼\ c\ m^2$

b) $400/4cm^2$ d) $240\ cm^2$

19. (Y + 2) (X+2) = XY + 2Y +2X + 4 എന്ന തത്ത്വത്തിൽ 2 ന പകരം 1 എടുത്താൽ വരുന്ന ഉത്തരം (Y+ 1) (X+1) =

a) YX +X + Y + 1 c) XY + 2Y+ X +1

b) 2XY + 1 d) XY + Y + 2X + 2

20. ഏത് ഒറ്റ സംഖ്യയുടെ വർഗത്തിനെയും 4 കൊണ്ട് ഹരിച്ചാൽ കിട്ടുന്ന ശിഷ്ടം എത്രയായിരിക്കും ?

a) 0 c) 2

b) 1 d) 3

21. 53 X 49 എന്ന ഗുണനഫലം കണ്ടെത്താനുപയോഗിക്കാവുന്ന ഏറ്റവും ഉചിതമായ സർവ്വസമവാക്യം

a) (X+Y) (U+V) = XU + XV +YU + YV

b) (X+Y) (U-V) = XU - XV +YU - YV

c) (X-Y) (U-V) = XU - XV -YU + YV

d) $(X-Y)^2 = X^2 + Y^2 - 2XY$

22. രാജുവിന്റെ കടയിലെ 10 കുടകളിൽ 6 കുടകൾ 148 രൂപയ്ക്കും 4 കുടകൾ 152 രൂപയ്ക്കുമാണ് വിറ്റത്. എന്നാൽ സോനു തന്റെ കടയിലെ 10 കുടകളിൽ 6 കുടകൾ 147 രൂപയ്ക്കും 4 കുടകൾ 153 രൂപയ്ക്കും വിറ്റ എങ്കിൽ ഏറ്റവും കൂടുതൽ തുക ലഭിച്ചത് ആർക്ക്?

a) രാജുവിന് സോനുവിനേക്കാൾ കൂടുതൽ തുക ലഭിച്ചു.

b) സോനുവിന് രാജുവിനേക്കാൾ കൂടുതൽ തുക ലഭിച്ചു.

c) രാജുവിനും സോനുവിനും ലഭിച്ച തുക തുല്യമാണ്.

d) രാജുവിനും സോനുവിനും ലഭിച്ച തുക കണ്ടെത്താൻ സാധ്യമല്ല

23. $X(X+2) = (X+1)^2 - 1$ എന്ന ബീജഗണിതരൂപം സംബന്ധിച്ച് ഉചിതമായ പ്രസ്താവന ഏത്?

a) ഏത് രണ്ട് ഇരട്ടസംഖ്യകളുടെയും ഗുണനഫലത്തെ സൂചിപ്പിക്കുന്ന ബീജഗണിതരൂപം.

b) ഏതു രണ്ട് ഒറ്റ സംഖ്യകളുടെയും ഗുണനഫലത്തെ സൂചിപ്പിക്കുന്ന ബീജഗണിതരൂപം

c) ഏതു രണ്ട് ഒന്നിടവിട്ട എണ്ണൽ സംഖ്യകളുടേയും ഗുണനഫലത്തെ സൂചിപ്പിക്കുന്ന ബീജഗണിതരൂപം

d) ഏതു രണ്ട് അഭാജ്യസംഖ്യകളുടേയും ഗുണനഫലത്തെ സൂചിപ്പിക്കുന്ന ബിജഗണിതരൂപം

24. $(10\frac{1}{2})^2$ = -------------

a) 100¼ c) 100

b) 110¼ d) 101

25. $50^2 = 2500$ ആയാൽ 51^2 = ----------------------

a) 2500 + 50 + 51 c) 2500 + 2x 51

b) 2500 + 2x 50 d) 2500 +2(50 + 51)

26. 42x 17 = 800 − 40x3 +……. + (-6)

a) 40 c) 20

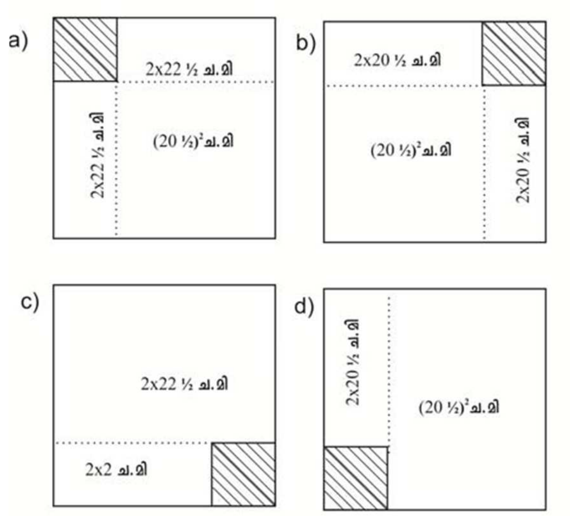
b) 120 d) 3

27. 28 x 17 = 600 - ……….+6

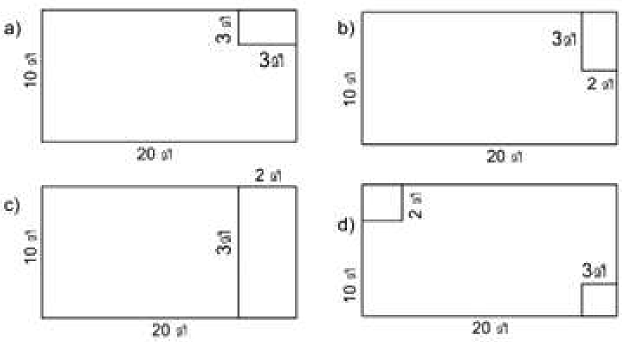
a) 130 c) 40

b) 90 d) 110

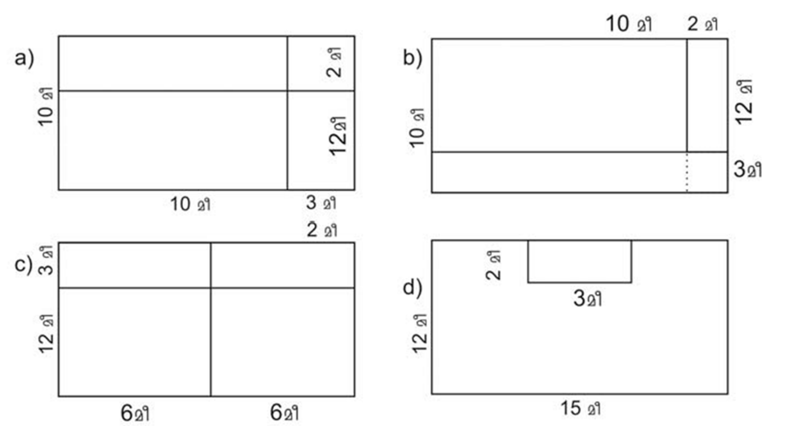
28. 22½ മീറ്റർ വശങ്ങളുള്ള സമചതുരാകൃതിയിലുള്ള ഒരു കളി സ്ഥലത്തിന്റെ ഒരു മൂലയിൽ നിന്നും 2 മീറ്റർ വശങ്ങളുള്ള സമചതുരാകൃതിയിലുള്ള സ്ഥലം ഒഴിവാക്കിയാൽ കിട്ടുന്ന കളിസ്ഥലത്തിന്റെ പരപ്പളവിനെ സൂചിപ്പിക്കുന്ന ചിത്രങ്ങളിൽ ഉചിതമായത് താഴെ തന്നിരിക്കുന്നവയിൽ ഏത്?



29. കുട്ടന്റെ വീടിന്റെ ഒരു മുറിക്ക് 20 മീറ്റർ നീളവും 10 മീറ്റർ വീതിയും ഉണ്ട്. നീളം 3 മീറ്ററും വീതി 2 മീറ്ററുമുള്ള ഒരു കബോർഡ് ആ റൂമിന്റെ ഒരു മൂലയിലെ തറയിൽ നിർമിച്ചു. ഇതിന്റെ ജ്യാമിതീയ രൂപം ഏത്?



30. (10+2)(12+3) എന്നതിന്റെ ജ്യാമിതീയ രൂപം ഏത്?



Appendix VII

FAROOK TRAINING COLLEGE
Research Centre in Education

ACHIEVEMENT TEST IN MATHEMATICS

(English – Final)

Standard VIII

Radhika T.
Research Scholar

Dr. Niranjana K.P.
Assistant Professor

PERSONAL DETAILS

Name:..

School: ....

Class:...Div.: ....

Instruction

- This is a test in **Identities**.
- There are 30 questions.
- Each question has 4 responses as a, b, c, d.
- In the response sheet given to you, the question numbers are written in order. Find out the correct answer and put a '✓' mark on appropriate column for each question.
- Answer all questions
- Each question carries 1 mark.
- Maximum Score is 30.
- Maximum Time is 30 minutes.

Questions

1. $65^2 = 60^2 + 25 +$ --------

   a) 2 x 60 c) 2x 60 x 5

   b) 2 x 5 d) 2x 65 x 25

2. Square of sum of two positive numbers = _________

   a) Square of sum of two positive numbers

   b) Square of first positive number

   c) Multiplication of two numbers

   d) Sum of squares of the two numbers and the twice of their product.

3. $(X + Y)^2 = X^2 +$ ------------

a) $X^2 + Y^2$

b) $X^2 + 2XY$

c) $Y^2 + 2XY$

d) $X^2Y^2 + 2X^2Y^2$

4. $(2X - 1)^2 =$ ___________ ?

a) 4x(x-1) + 1

b) 4x(1-x) + 1

c) 2x(x-1)

d) $2(x-1)^2$

5. If X > Y, U > V are two positive numbers, then (X – Y) (U-V) = ______

a) XU + XV + YU – YV

b) XU - XV - YU +YV

c) XY - XV +YU -YV

d) XU + XV + YU + YV

6. The method of writing product of difference of 397 X 98 _______

a) (400 -3) (100 - 2)

b) (400 – 3) X 98

c) (395 + 2) (95 +3)

d) (400-3) (95 +3)

7. (X + Y) (U-V) =

a) XU - XV + YU – YV

b) XU + XV - YU - YV

c) XY - XV - YU -YV

d) XU + XV + YU + YV

8. Which is appropriate way to write 303 X 198 as the product of sum and difference?

a) 303(190 + 8)

b) (300+3) (195 +3)

c) (300+3) (200 – 2)

d) (305-2) (200 - 2)

9. (10+2) (15 +3) = (10x15) + _______ + (2 x 15) + (2x6)

a) 10 x 3

b) 15 x 10

c) 10x 6

d) 15x 3

10. 2x 195 = 2x ------- = 400 – 10

a) (90 + 5)

b) (180+15)

c) (200 - 5)

d) (180 +10)

11. $(40 - 2)^2 = 40^2 + 2^2 +$ ------------

a) - 2x40 x 2

b) - 40 x 2

c) 2 x 40x 2

d) 40x 2

12. $(X + Y)^2 - (X - Y)^2 =$ ------------

a) 2XY

b) 4XY

c) XY

d) 2 (X + Y)

13. 52 x 48 =

a) $50^2 - 2^2$

b) $52^2 - 48^2$

c) $(50 - 2)^2$

d) $50^2 + 2^2$

14. How to write 45 as the difference of two square numbers?

a) $(9 - 6)^2$ c) 9 x 5

b) $9^2 - 5^2$ d) $9^2 - 6^2$

15. 101 x 99 = --------

a) 999 c) 9999

b) 99000 d) 9900

16. A garden was 5 meters long and 3 meters wide. The length of the garden is increased by 2 meters and the width by 1 meter, what is the total area that can be planted in that garden?

a) $44m^2$ c) $34m^2$

b) $11m^2$ d) $28m^2$

17. If Sita buys 13 books for 22 rupees and 12 pens for 8 rupees, what is the total cost?

a) 272 c) 282

b) 382 d) 172

18. What is the area of a square paper if the side length is 20½cm?

a) $400cm^2$ c) 420 ¼ cm^2

b) $400/4cm^2$ d) 240 cm^2

19. (Y + 2) (X+2) = XY + 2Y +2X + 4. Substituting 1 for 2 gives the answer (Y+ 1) (X+1) =

a) YX +X + Y + 1 c) XY + 2Y+ X +1

b) 2XY + 1 d) XY + Y + 2X + 2

20. If the square of any odd number is divided by 4, what will be the remainder?

a) 0 c) 2

b) 1 d) 3

21. Which is the appropriate identity used to find the product of 53 X 49 ?

a) (X+Y) (U+V) = XU + XV +YU + YV

b) (X+Y) (U-V) = XU - XV +YU - YV

c) (X-Y) (U-V) = XU - XV -YU + YV

d) $(X-Y)^2 = X^2 + Y^2 - 2XY$

22. Out of 10 umbrellas in Raju's shop, 6 umbrellas were sold for Rs.148 and 4 umbrellas for Rs.152. At the same time, Sonu sold 6 umbrellas for Rs 147 and 4 umbrellas for Rs 153 out of 10 umbrellas in his shop, who got the more amount?

a) Raju received more amount than Sonu.

b) Sonu received more amount than Raju.

c) The amount received by Raju and Sonu is equal.

d) It is not possible to trace the amount received by Raju and Sonu

23. Which statement is correct about the algebraic expression $X(X+2) = (X+1)^2 - 1$?

    a) Algebraic form representing the product of any two even numbers.

    b) Algebraic form representing the product of any two odd numbers

    c) Algebraic form representing the product of any two alternative counting numbers

    d) Algebraic form representing the product of any two prime numbers

24. $(10\frac{1}{2})^2$ = -------------

    a) 100¼ c) 100

    b) 110¼ d) 101

25. If $50^2 = 2500$ then 51^2 = --------------------

    a) 2500 + 50 + 51 c) 2500 + 2x 51

    b) 2500 + 2x 50 d) 2500 +2(50 + 51)

26. 42x 17 = 800 – 40x3 +....... + (-6)

    a) 40 c) 20

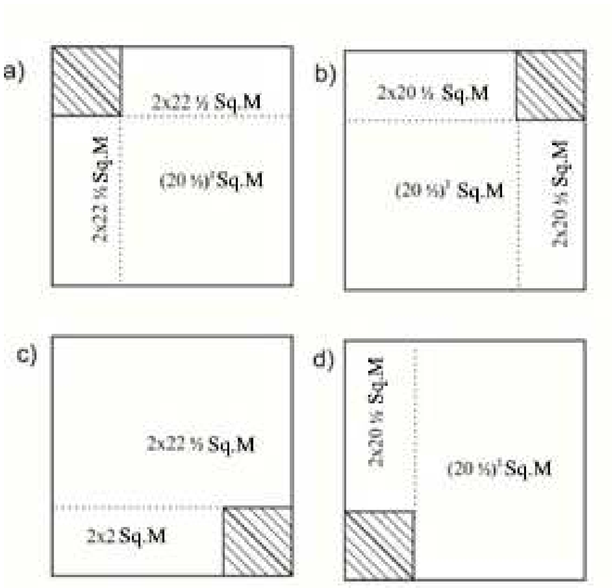
    b) 120 d) 3

27. 28 x 17 = 600 - ....+6

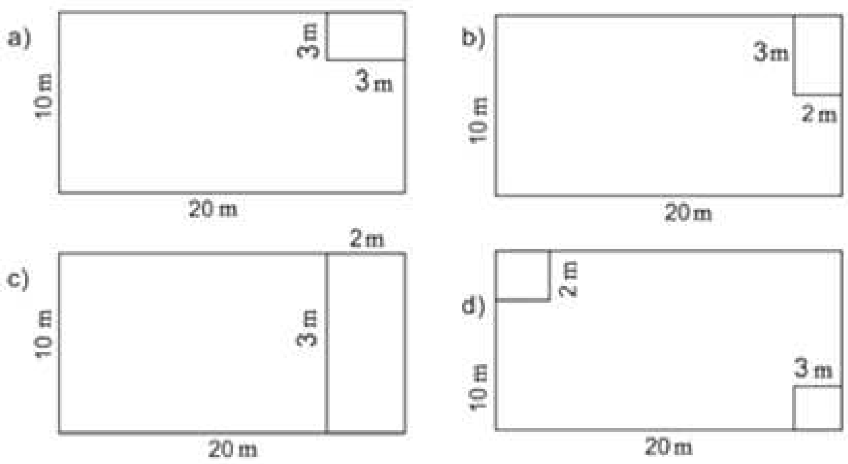
    a) 130 c) 40

    b) 90 d) 110

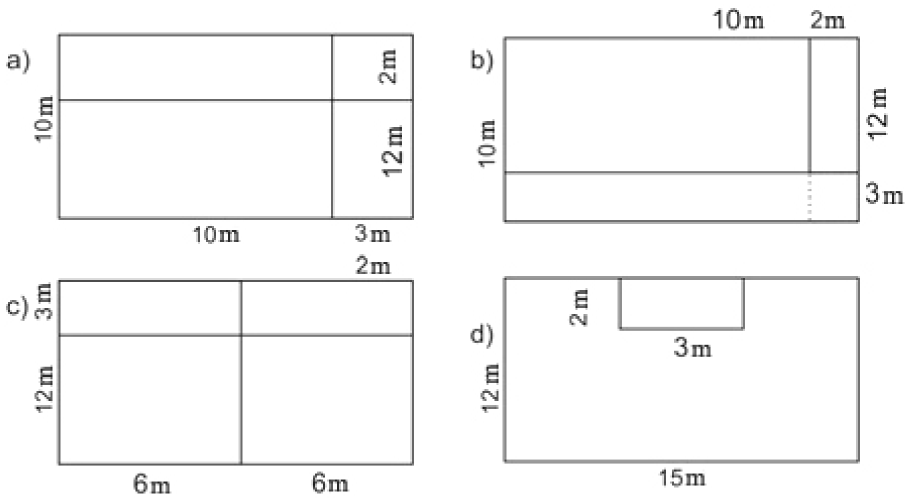
28. Which of the following figures represents the area of the playground obtained by subtracting a rectangular area of side 2 m from one corner of a rectangular playground of sides 22½ m?



29. A room in Kuttan's house is 20 meters long and 10 meters wide. A cupboard 3 meters long and 2 meters wide was built on the floor of a corner of that room. What is its geometric form?



30. What is the geometric form of (10+2)(12+3)?



Appendix VIII

FAROOK TRAINING COLLEGE
Research Centre in Education

ACHIEVEMENT TEST IN MATHEMATICS

Standard VIII

RESPONSE SHEET

Radhika T.
Research Scholar

Dr. Niranjana K.P.
Assistant Professor

PERSONAL DETAILS

Name:...

School: ....

Class:..Div.: ....

Sl. No.	a	b	c	d
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

Sl. No.	a	b	c	d
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

Appendix IX

FAROOK TRAINING COLLEGE
Research Centre in Education

ACHIEVEMENT TEST IN MATHEMATICS

Standard VIII

SCORING KEY

Radhika T.
Research Scholar

Dr. Niranjana K.P.
Assistant Professor

PERSONAL DETAILS

Name:..

School: ....

Class:...Div.: ....

Sl. No.	a	b	c	d
1			c	
2				d
3			c	
4	a			
5		b		
6	a			
7	a			
8			c	
9	a			
10			c	
11	a			
12		b		
13	a			
14				d
15			c	

Sl. No.	a	b	c	d
16				d
17		b		
18			c	
19	a			
20		b		
21		b		
22	a			
23			c	
24		b		
25	a			
26	a			
27	a			
28		b		
29		b		
30		b		

Appendix X

FAROOK TRAINING COLLEGE
Research Centre in Education

LOGICAL REASONING TEST

(Malayalam – Draft)

Standard VIII

Radhika T.	**Dr. Niranjana K.P.**
Research Scholar	Assistant Professor

PERSONAL DETAILS

Name:..

School: ....

Class:..Roll No.: ....

നിർദ്ദേശങ്ങൾ

- യുക്തിചിന്ത സംബന്ധിച്ച ചോദ്യങ്ങളാണ് താഴെ തന്നിരിക്കുന്നത്.
- 40 ചോദ്യങ്ങളാണ് ഇതിലുള്ളത്.
- ഓരോ ചോദ്യത്തിനും A, B, C, D എന്നീ പ്രതികരണങ്ങൾ നൽകിയിട്ടുണ്ട്.
- നിങ്ങൾക്ക് തന്നിരിക്കുന്ന പ്രതികരണ പേജിൽ ചോദ്യനമ്പറുകൾ ക്രമമായി എഴുതിയിരിക്കുന്നു. ശരിയായ ഉത്തരം കണ്ടെത്തി ചോദ്യനമ്പറിനുനേരെയുള്ള കോളത്തിൽ '✓' അടയാളം രേഖപ്പെടുത്തുക.
- എല്ലാ ചോദ്യത്തിനും ഉത്തരം എഴുതുക.
- ഓരോ ചോദ്യത്തിനും ഓരോ മാർക്ക് വീതമാണ്.
- പരമാവധി 40 മാർക്ക്.
- പരമാവധി സമയം 40 മിനിറ്റ്.

ചോദ്യങ്ങൾ

I. വിട്ടുപോയ ഭാഗം പൂരിപ്പിക്കുക.

1. 0, 3, 8, 15, _____

A) 35 B) 24 C) 48 D) 49

2. 2, 3, 5, 8, 12, _____

A) 19 B)24 C) 14 D) 17

3. 30, 29, 30, 30, 30, 31, 30, 32, ____, ____

A) 25, 32 B) 31, 32 C) 30, 33 D) 29, 32

4. 6, 11, 16, 21, -----

A) 26 B) 36 C) 25 D) 24

5. 4, 16, 36, 64, -----

A) 100 B) 91 C) 64 D) 81

6. 16, 36, 54, 74, 92, ____

A) 110 B) 112 C) 108 D) 114

7. 20, 25, 30, 50, 40, 65, 50, ____

A) 65 B) 60 C) 80 D) 85

8. 9, 25, ---, 81, 121

A) 49 B) 36 C) 12 D) 17

9. 52, 50, 48, 45, 42, 40, 38, 35, 32, ----, -----

A) 30, 32 B) 26, 23 C) 26, 24 D) 30, 28

10. 20, 100, 200, 320, 460, ----

A) 430 B) 400 C) 620 D) 530

II. വിട്ടുപോയ ഭാഗം പൂരിപ്പിക്കുക.

1. 6 : 24 :: 9 : ----

A) 15 B) 26 C) 36 D) 18

2. 124: 31 :: ---- : 100

A) 150 B) 400 C) 300 D) 160

3. 32: 64:: 33 : -----

A) 99 B) 81 C) 65 D) 66

4. ക്യൂബ് സമചതുരവുമായി ബന്ധപ്പെട്ടിരിക്കുന്നുവെങ്കിൽ സമചതുരം എന്തിമായി ബന്ധപ്പെട്ടിരിക്കുന്നു?

A) ത്രികോണം B) ബിന്ദു C) രേഖ D) ദീർഘചതുരം

5. നീളം: മീറ്റർ::----: ഡിഗ്രി

A) കോൺ B) വൃത്തം C) ബിന്ദു D) ദൂരം

6. ഗണിതം: സംഖ്യകൾ:: സംഭവങ്ങൾ:

A) ജനങ്ങൾ B) ഹിസ്റ്ററി C) ദിവസങ്ങൾ D) യുദ്ധങ്ങൾ

7. EGI : CAY :: LNP :-----

A) ABC B) ZWG C) JLW D)JHF

8. AD : EH:: MP; ------

A) QT B) TX C)UV D)FJ

9. 9 : 27 എന്ന സംഖ്യ ജോഡിയോടു ബന്ധപ്പെട്ട ജോഡി തെരഞ്ഞെടുത്തെഴുതുക

A) 8 : 64 B) 5:125 C) 15 : 135 D) 81 : 729

10. 4 : 6 എന്ന സംഖ്യ ജോഡിയോടു ബന്ധപ്പെട്ട ജോഡി തെരഞ്ഞെടുത്തെഴുതുക

A) 8 : 12 B) 9:10 C) 20 : 40 D) 29 : 81

III. താഴെ തന്നിരിക്കുന്ന ഓരോ ചോദ്യത്തിലും പ്രസ്താവനകളും അവയെ തുടർന്ന് രണ്ടു നിഗമനങ്ങളും നൽകിയിരിക്കുന്നു. പ്രസ്താവനകളെ അടിസ്ഥാനപ്പെടുത്തി ഏതെല്ലാം നിഗമനങ്ങളാണ് പിന്തുടരാവുന്നതെന്നു കണ്ടെത്തി ഉചിതമായ ഉത്തരം അടയാളപ്പെടുത്തുക.

1. പ്രസ്താവനകൾ : കുറച്ചുചെടികൾ മരങ്ങളാണ്

: എല്ലാ ചെടികളും വനങ്ങളാണ്

നിഗമനങ്ങൾ 1. എല്ലാ മരങ്ങളും ചെടികളാണ്

2. കുറച്ചു മരങ്ങളെങ്കിലും വനങ്ങളാണ്

A) നിഗമനം (1) പിന്തുടരുന്നു.

B) നിഗമനം (2) പിന്തുടരുന്നു

C) നിഗമനം (1)അല്ലെങ്കിൽ നിഗമനം (2) പിന്തുടരുന്നു

D) നിഗമനം (1) ഉം നിഗമനം (2) ഉം പിന്തുടരുന്നു.

2. പ്രസ്താവനകൾ : എല്ലാ നക്ഷത്രങ്ങളും ലൈറ്റുകളാണ്

: എല്ലാ സൂര്യനും ഗ്രഹങ്ങളാണ്

ഒരു നക്ഷത്രവും ഭ്രമണപഥം അല്ല

നിഗമനങ്ങൾ 1. ചില ഭ്രമണപഥങ്ങൾ ഗ്രഹങ്ങളാണ്

2. ചില ഗ്രഹങ്ങൾ ലൈറ്റുകളാണ്

A) നിഗമനം (1) പിന്തുടരുന്നു.

B) നിഗമനം (2) പിന്തുടരുന്നു

C) നിഗമനം (1)അല്ലെങ്കിൽ നിഗമനം (2) പിന്തുടരുന്നു

D) നിഗമനം (1) ഉം നിഗമനം (2) ഉം പിന്തുടരുന്നു.

3. പ്രസ്താവനകൾ : ഒരു വർഷവും മാസമല്ല

: ചില മാസങ്ങൾ ആഴ്ചകളാണ്

നിഗമനങ്ങൾ 1. ഒരു ആഴ്ചയും മാസമല്ല

2. ചില ആഴ്ചകൾ മാസങ്ങളാണ്

A) നിഗമനം (1) പിന്തുടരുന്നു.

B) നിഗമനം (2) പിന്തുടരുന്നു

C) നിഗമനം (1)അല്ലെങ്കിൽ നിഗമനം (2) പിന്തുടരുന്നു

D) നിഗമനം (1) ഉം നിഗമനം (2) ഉം പിന്തുടരുന്നു.

4. പ്രസ്താവനകൾ : എല്ലാ മൃഗങ്ങളും കടുവകളാണ്

: ചില കടുവകൾ കുതിരകളാണ്

നിഗമനങ്ങൾ 1. ചില കടുവകൾ മൃഗങ്ങളാണ്

2. എല്ലാ കുതിരകളും മൃഗങ്ങളാണ്

A) നിഗമനം (1) പിന്തുടരുന്നു.

B) നിഗമനം (2) പിന്തുടരുന്നു

C) നിഗമനം (1)അല്ലെങ്കിൽ നിഗമനം (2) പിന്തുടരുന്നു

D) നിഗമനം (1) ഉം നിഗമനം (2) ഉം പിന്തുടരുന്നു.

5. പ്രസ്താവനകൾ : ചില ജീവികൾ പശുക്കളാണ്

: എല്ലാ പശുക്കളും കുതിരകളാണ്

നിഗമനങ്ങൾ 1. ചില കുതിരകൾ ജീവികളാണ്

2. ചില ജീവികൾ കുതിരകളാണ്

A) നിഗമനം (1) പിന്തുടരുന്നു.

B) നിഗമനം (2) പിന്തുടരുന്നു

C) നിഗമനം (1)അല്ലെങ്കിൽ നിഗമനം (2) പിന്തുടരുന്നു

D) നിഗമനം (1) ഉം നിഗമനം (2) ഉം പിന്തുടരുന്നു.

6. പ്രസ്താവനകൾ : എല്ലാ പേനകളും പെൻസിലുകളാണ്

: ഒരു പെൻസിലും പുസ്തകമല്ല

നിഗമനങ്ങൾ 1. ഒരു പുസ്തകവും പേനയല്ല

2. ഒരു പേനയും പുസ്തകമല്ല

A) നിഗമനം (1) പിന്തുടരുന്നു.

B) നിഗമനം 2 പിന്തുടരുന്നു

C) നിഗമനം (1)അല്ലെങ്കിൽ നിഗമനം (2) പിന്തുടരുന്നു

D) നിഗമനം (1) ഉം നിഗമനം (2) ഉം പിന്തുടരുന്നു.

7. പ്രസ്താവനകൾ : ചില ആളുകൾ സുന്ദരന്മാരാണ്

: ചില ആളുകൾ ബുദ്ധിമാന്മാരാണ്

നിഗമനങ്ങൾ 1. ചില ബുദ്ധിമാന്മാർ സുന്ദരന്മാരാണ്

2. ചില സുന്ദരന്മാർ ബുദ്ധിമാന്മാരാണ്.

A) നിഗമനം (1) പിന്തുടരുന്നു.

B) നിഗമനം (2) പിന്തുടരുന്നു

C) നിഗമനം (1) അല്ലെങ്കിൽ നിഗമനം (2) പിന്തുടരുന്നു

D) നിഗമനം (1) ഉം നിഗമനം (2) ഉം പിന്തുടരുന്നു.

8. പ്രസ്താവനകൾ : രാജു എപ്പോഴും വിജയിക്കുന്നു

: ഒരു വിഡ്ഢിയും എപ്പോഴും വിജയിക്കില്ല

നിഗമനങ്ങൾ 1. രാജു ഒരു വിഡ്ഢിയാണ്

2. രാജു ഒരു മണ്ടനല്ല

A) നിഗമനം (1) പിന്തുടരുന്നു.

B) നിഗമനം (2) പിന്തുടരുന്നു

C) നിഗമനം (1) അല്ലെങ്കിൽ നിഗമനം (2) പിന്തുടരുന്നു

D) നിഗമനം (1) ഉം നിഗമനം (2) ഉം പിന്തുടരുന്നു.

9. പ്രസ്താവനകൾ : എല്ലാ ക്ലോക്കുകളും വാച്ചുകളാണ്

: ചില വാച്ചുകൾ നീലയാണ്

നിഗമനങ്ങൾ 1. എല്ലാ വാച്ചുകളും ക്ലോക്കുകളാണ്

2. ചില ക്ലോക്കുകൾ നീലയാണ്

A) നിഗമനം (1) പിന്തുടരുന്നു.

B) നിഗമനം (2) പിന്തുടരുന്നു

C) നിഗമനം (1) അല്ലെങ്കിൽ നിഗമനം (2) പിന്തുടരുന്നു

D) നിഗമനം (1) ഉം നിഗമനം (2) ഉം പിന്തുടരുന്നു.

10. പ്രസ്താവനകൾ : ഒരു ഫോണും കപ്പലല്ല

: എല്ലാ ബസ്സും കപ്പലാണ്

നിഗമനങ്ങൾ 1. ഒരു ബസ്സും ഫോണല്ല

2. ചില കപ്പലെങ്കിലും ഫോണാണ്

A) നിഗമനം (1) പിന്തുടരുന്നു.

B) നിഗമനം (2) പിന്തുടരുന്നു

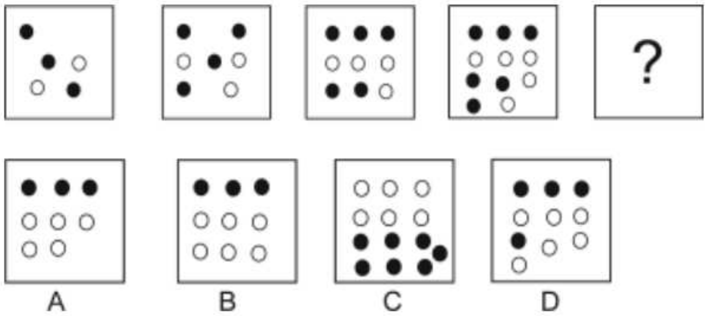
C) നിഗമനം (1) അല്ലെങ്കിൽ നിഗമനം (2) പിന്തുടരുന്നു

D) നിഗമനം (1) ഉം നിഗമനം (2) ഉം പിന്തുടരുന്നു.

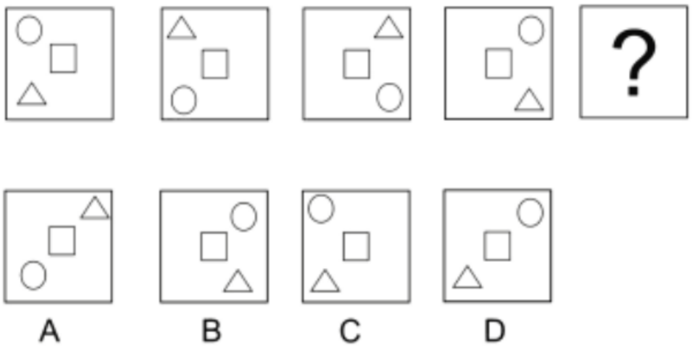
Appendix

IV. താഴെ തന്നിരിക്കുന്ന ഓരോ ചോദ്യത്തിലും വിട്ടുപോയ ഭാഗം ഉചിതമായ ചിത്രം ഉപയോഗിച്ച് പൂരിപ്പിക്കുക.

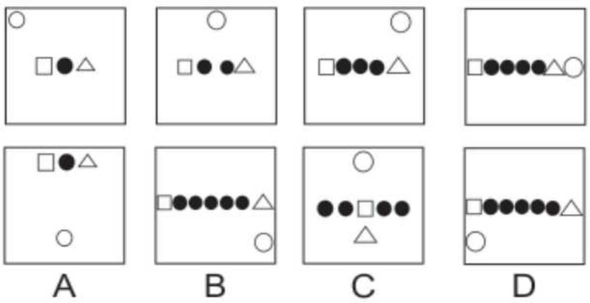
1.



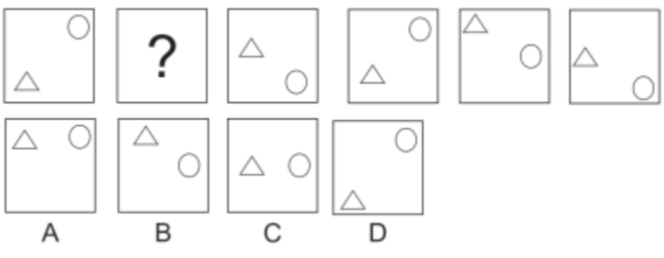
2.



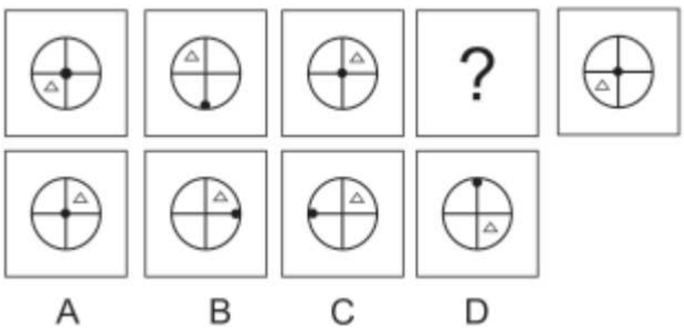
3.



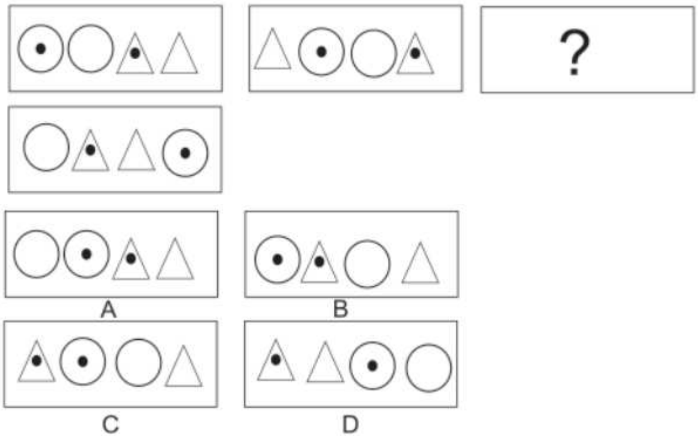
4.



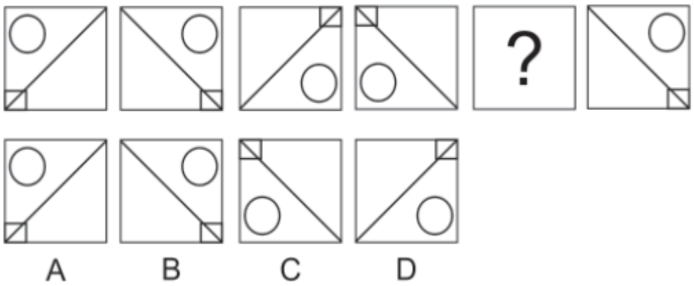
5.



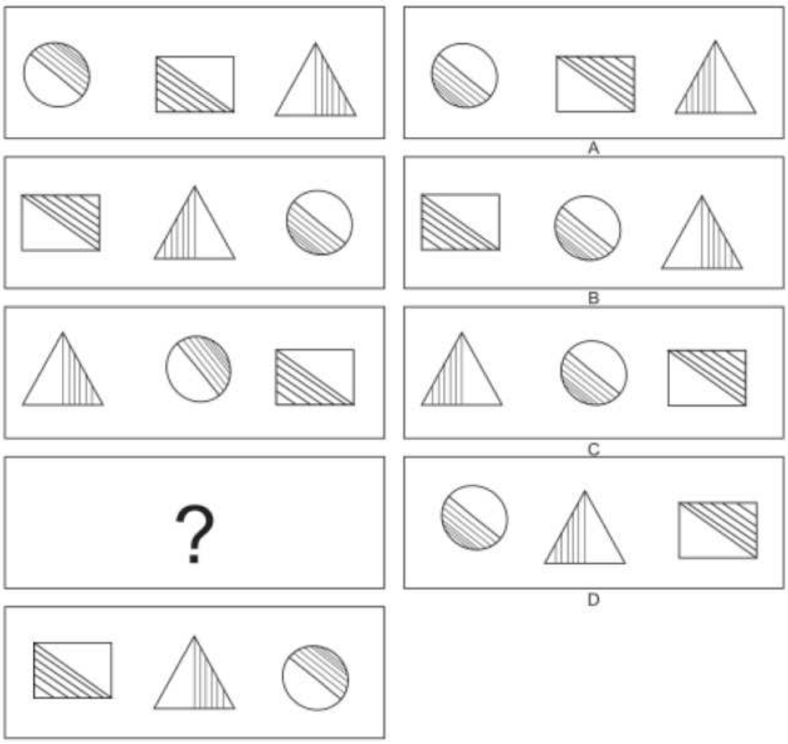
6.



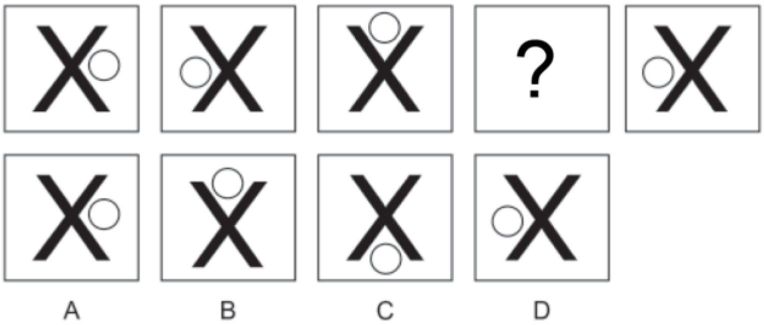
7.



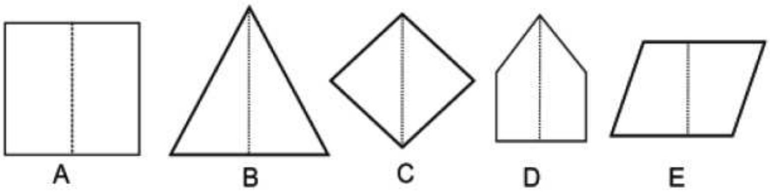
8.



9.



10.



കൂട്ടത്തിൽ പെടാത്തത് ഏത്?

A(B) B(C) C(D) D(E)

Appendix XI

FAROOK TRAINING COLLEGE
Research Centre in Education

LOGICAL REASONING TEST

(Malayalam – Final)

Standard VIII

Radhika T. — Research Scholar

Dr. Niranjana K.P. — Assistant Professor

PERSONAL DETAILS

Name:..

School: ....

Class:...Roll No.: ....

നിർദ്ദേശങ്ങൾ

- യുക്തിചിന്ത സംബന്ധിച്ച ചോദ്യങ്ങളാണ് താഴെ തന്നിരിക്കുന്നത്.
- 31 ചോദ്യങ്ങളാണ് ഇതിലുള്ളത്.
- ഓരോ ചോദ്യത്തിനും A, B, C, D എന്നീ പ്രതികരണങ്ങൾ നൽകിയിട്ടുണ്ട്.
- നിങ്ങൾക്ക് തന്നിരിക്കുന്ന പ്രതികരണ പേജിൽ ചോദ്യനമ്പറുകൾ ക്രമമായി എഴുതിയിരിക്കുന്നു. ശരിയായ ഉത്തരം കണ്ടെത്തി ചോദ്യനമ്പറിനുനേരെയുള്ള കോളത്തിൽ '✓' അടയാളം രേഖപ്പെടുത്തുക.
- എല്ലാ ചോദ്യത്തിനും ഉത്തരം എഴുതുക.
- ഓരോ ചോദ്യത്തിനും ഓരോ മാർക്ക് വീതമാണ്.
- പരമാവധി 31 മാർക്ക്.
- പരമാവധി സമയം 31 മിനിറ്റ്.

ചോദ്യങ്ങൾ

I. വിട്ടുപോയ ഭാഗം പൂരിപ്പിക്കുക.

1. 6, 11, 16, 21, -----

A) 26 B) 36 C) 25 D) 24

2. 16, 36, 54, 74, 92, ____

A) 110 B) 112 C) 108 D) 114

3. 20, 25, 30, 50, 40, 65, 50, ____

A) 65 B) 60 C) 80 D) 85

4. 52, 50, 48, 45, 42, 40, 38, 35, 32, ----, -----

A) 30, 32 B) 26, 23 C) 26, 24 D) 30, 28

5. 20, 100, 200, 320, 460, ----

A) 430 B) 400 C) 620 D) 530

II. വിട്ടുപോയ ഭാഗം പൂരിപ്പിക്കുക.

1. 6 : 24 :: 9 : ----

A) 15 B) 26 C) 36 D) 18

2. 124: 31 :: ---- : 100

A) 150 B) 400 C) 300 D) 160

3. 32: 64:: 33 : -----

A) 99 B) 81 C) 65 D) 66

4. നീളം: മീറ്റർ::----: ഡിഗ്രി

A) കോൺ B) വൃത്തം C) ബിന്ദു D) ദൂരം

5. ഗണിതം: സംഖ്യകൾ:: സംഭവങ്ങൾ:

A) ജനങ്ങൾ B) ഹിസ്റ്ററി C) ദിവസങ്ങൾ D) യുദ്ധങ്ങൾ

6. AD : EH:: MP; ------

A) QT B) TX C)UV D)FJ

7. 9 : 27 എന്ന സംഖ്യ ജോഡിയോടു ബന്ധപ്പെട്ട ജോഡി തെരഞ്ഞെടുത്തെഴുതുക

A) 8 : 64 B) 5:125 C) 15 : 135 D) 81 : 729

8. 4 : 6 എന്ന സംഖ്യ ജോഡിയോടു ബന്ധപ്പെട്ട ജോഡി തെരഞ്ഞെടുത്തെഴുതുക

A) 8 : 12 B) 9:10 C) 20 : 40 D) 29 : 81

III. താഴെ തന്നിരിക്കുന്ന ഓരോ ചോദ്യത്തിലും പ്രസ്താവനകളും അവയെ തുടർന്ന് രണ്ടു നിഗമനങ്ങളും നൽകിയിരിക്കുന്നു. പ്രസ്താവനകളെ അടിസ്ഥാനപ്പെടുത്തി ഏതെല്ലാം നിഗമനങ്ങളാണ് പിന്തുടരാവുന്നതെന്നു കണ്ടെത്തി ഉചിതമായ ഉത്തരം അടയാളപ്പെടുത്തുക.

1. പ്രസ്താവനകൾ : കുറച്ചുചെടികൾ മരങ്ങളാണ്

: എല്ലാ ചെടികളും വനങ്ങളാണ്

നിഗമനങ്ങൾ 1. എല്ലാ മരങ്ങളും ചെടികളാണ്

2. കുറച്ചു മരങ്ങളെങ്കിലും വനങ്ങളാണ്

A) നിഗമനം (1) പിന്തുടരുന്നു.

B) നിഗമനം (2) പിന്തുടരുന്നു

C) നിഗമനം (1)അല്ലെങ്കിൽ നിഗമനം (2) പിന്തുടരുന്നു

D) നിഗമനം (1) ഉം നിഗമനം (2) ഉം പിന്തുടരുന്നു.

2. പ്രസ്താവനകൾ : എല്ലാ നക്ഷത്രങ്ങളും ലൈറ്റുകളാണ്

: എല്ലാ സൂര്യനും ഗ്രഹങ്ങളാണ്

ഒരു നക്ഷത്രവും ഭ്രമണപഥം അല്ല

നിഗമനങ്ങൾ 1. ചില ഭ്രമണപഥങ്ങൾ ഗ്രഹങ്ങളാണ്

2. ചില ഗ്രഹങ്ങൾ ലൈറ്റുകളാണ്

A) നിഗമനം (1) പിന്തുടരുന്നു.

B) നിഗമനം (2) പിന്തുടരുന്നു

C) നിഗമനം (1)അല്ലെങ്കിൽ നിഗമനം (2) പിന്തുടരുന്നു

D) നിഗമനം (1) ഉം നിഗമനം (2) ഉം പിന്തുടരുന്നു.

3. പ്രസ്താവനകൾ : ഒരു വർഷവും മാസമല്ല

: ചില മാസങ്ങൾ ആഴ്ചകളാണ്

നിഗമനങ്ങൾ 1. ഒരു ആഴ്ചയും മാസമല്ല

2. ചില ആഴ്ചകൾ മാസങ്ങളാണ്

A) നിഗമനം (1) പിന്തുടരുന്നു.

B) നിഗമനം (2) പിന്തുടരുന്നു

C) നിഗമനം (1)അല്ലെങ്കിൽ നിഗമനം (2) പിന്തുടരുന്നു

D) നിഗമനം (1) ഉം നിഗമനം (2) ഉം പിന്തുടരുന്നു.

4. പ്രസ്താവനകൾ : എല്ലാ മൃഗങ്ങളും കടുവകളാണ്

: ചില കടുവകൾ കുതിരകളാണ്

നിഗമനങ്ങൾ 1. ചില കടുവകൾ മൃഗങ്ങളാണ്

2. എല്ലാ കുതിരകളും മൃഗങ്ങളാണ്

A) നിഗമനം (1) പിന്തുടരുന്നു.

B) നിഗമനം (2) പിന്തുടരുന്നു

C) നിഗമനം (1)അല്ലെങ്കിൽ നിഗമനം (2) പിന്തുടരുന്നു

D) നിഗമനം (1) ഉം നിഗമനം (2) ഉം പിന്തുടരുന്നു.

5. പ്രസ്താവനകൾ : ചില ജീവികൾ പശുക്കളാണ്

: എല്ലാ പശുക്കളും കുതിരകളാണ്

നിഗമനങ്ങൾ 1. ചില കുതിരകൾ ജീവികളാണ്

2. ചില ജീവികൾ കുതിരകളാണ്

A) നിഗമനം (1) പിന്തുടരുന്നു.

B) നിഗമനം (2) പിന്തുടരുന്നു

C) നിഗമനം (1)അല്ലെങ്കിൽ നിഗമനം (2) പിന്തുടരുന്നു

D) നിഗമനം (1) ഉം നിഗമനം (2) ഉം പിന്തുടരുന്നു.

6. പ്രസ്താവനകൾ : എല്ലാ പേനകളും പെൻസിലുകളാണ്

: ഒരു പെൻസിലും പുസ്തകമല്ല

നിഗമനങ്ങൾ 1. ഒരു പുസ്തകവും പേനയല്ല

2. ഒരു പേനയും പുസ്തകമല്ല

A) നിഗമനം (1) പിന്തുടരുന്നു.

B) നിഗമനം 2 പിന്തുടരുന്നു

C) നിഗമനം (1)അല്ലെങ്കിൽ നിഗമനം (2) പിന്തുടരുന്നു

D) നിഗമനം (1) ഉം നിഗമനം (2) ഉം പിന്തുടരുന്നു.

7. പ്രസ്താവനകൾ : ചില ആളുകൾ സുന്ദരന്മാരാണ്

: ചില ആളുകൾ ബുദ്ധിമാന്മാരാണ്

നിഗമനങ്ങൾ 1. ചില ബുദ്ധിമാന്മാർ സുന്ദരന്മാരാണ്

2. ചില സുന്ദരന്മാർ ബുദ്ധിമാന്മാരാണ്.

A) നിഗമനം (1) പിന്തുടരുന്നു.

B) നിഗമനം (2) പിന്തുടരുന്നു

C) നിഗമനം (1)അല്ലെങ്കിൽ നിഗമനം (2) പിന്തുടരുന്നു

D) നിഗമനം (1) ഉം നിഗമനം (2) ഉം പിന്തുടരുന്നു.

8. പ്രസ്താവനകൾ : എല്ലാ ക്ലോക്കുകളും വാച്ചുകളാണ്

: ചില വാച്ചുകൾ നീലയാണ്

നിഗമനങ്ങൾ 1. എല്ലാ വാച്ചുകളും ക്ലോക്കുകളാണ്

2. ചില ക്ലോക്കുകൾ നീലയാണ്

A) നിഗമനം (1) പിന്തുടരുന്നു.

B) നിഗമനം (2) പിന്തുടരുന്നു

C) നിഗമനം (1)അല്ലെങ്കിൽ നിഗമനം (2) പിന്തുടരുന്നു

D) നിഗമനം (1) ഉം നിഗമനം (2) ഉം പിന്തുടരുന്നു.

9. പ്രസ്താവനകൾ : ഒരു ഫോണും കപ്പലല്ല

: എല്ലാ ബസ്സും കപ്പലാണ്

നിഗമനങ്ങൾ 1. ഒരു ബസ്സും ഫോണല്ല

2. ചില കപ്പലെങ്കിലും ഫോണാണ്

A) നിഗമനം (1) പിന്തുടരുന്നു.

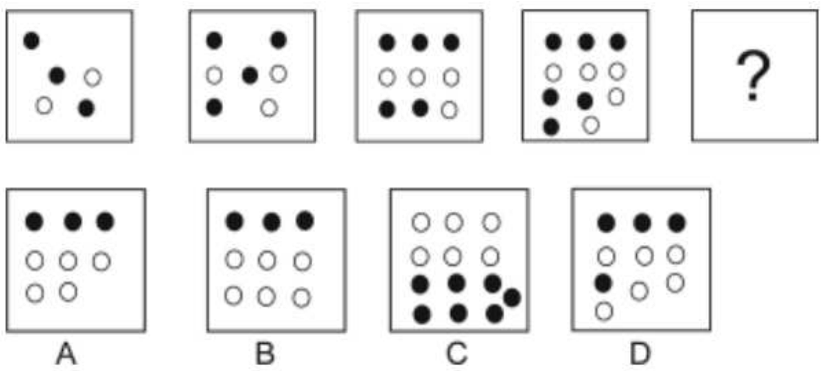
B) നിഗമനം (2) പിന്തുടരുന്നു

C) നിഗമനം (1) അല്ലെങ്കിൽ (2) പിന്തുടരുന്നു

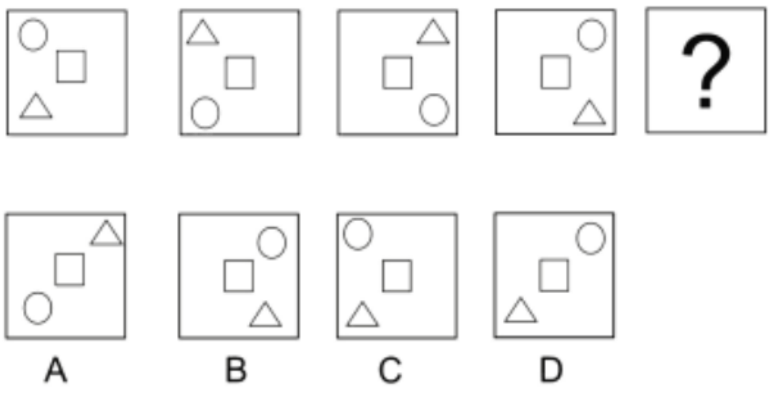
D) നിഗമനം (1) ഉം നിഗമനം (2) ഉം പിന്തുടരുന്നു.

IV. താഴെ തന്നിരിക്കുന്ന ഓരോ ചോദ്യത്തിലും വിട്ടുപോയ ഭാഗം ഉചിതമായ ചിത്രം ഉപയോഗിച്ച് പൂരിപ്പിക്കുക.

1.



2.



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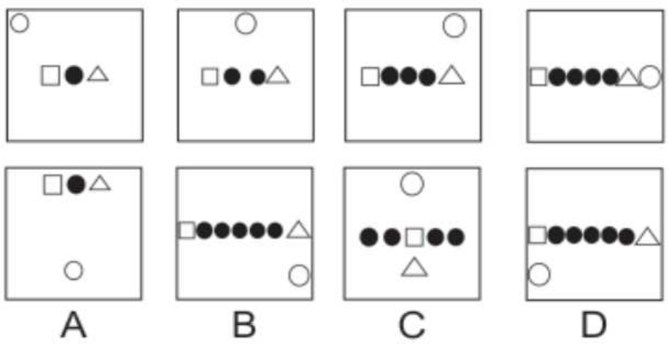
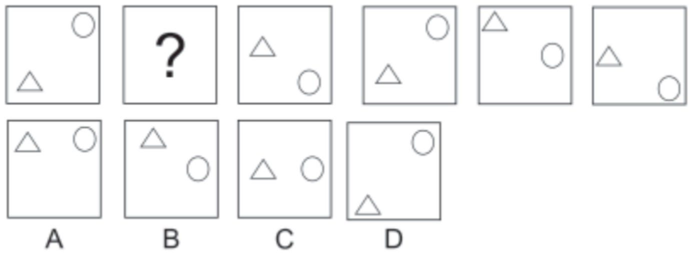
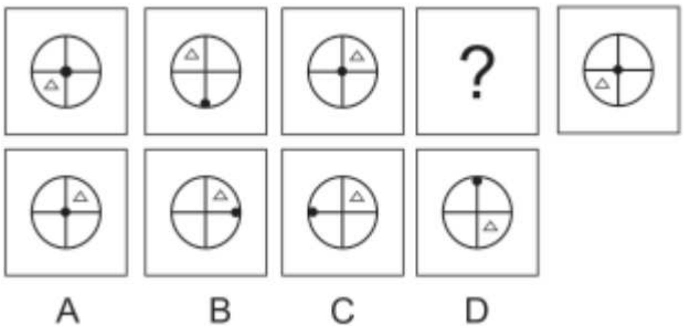


Appendix

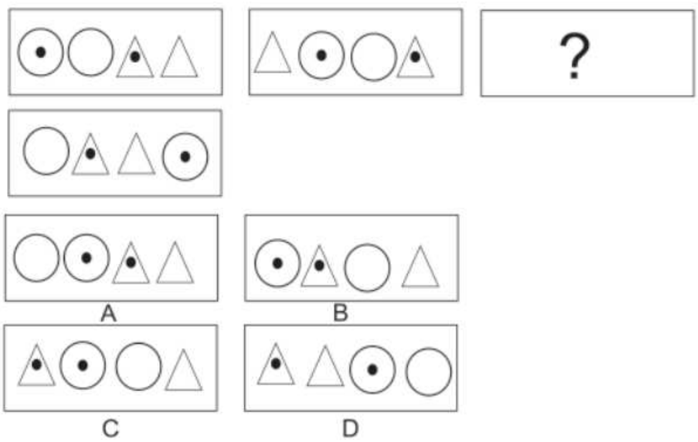
4.



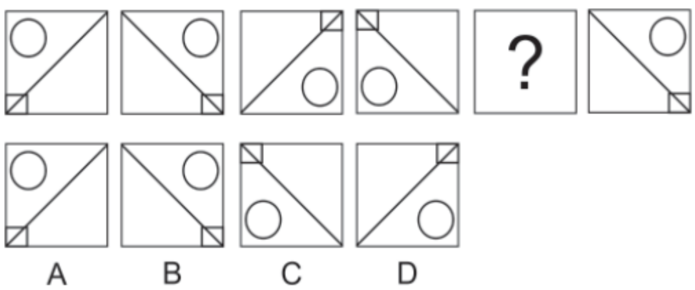
5.



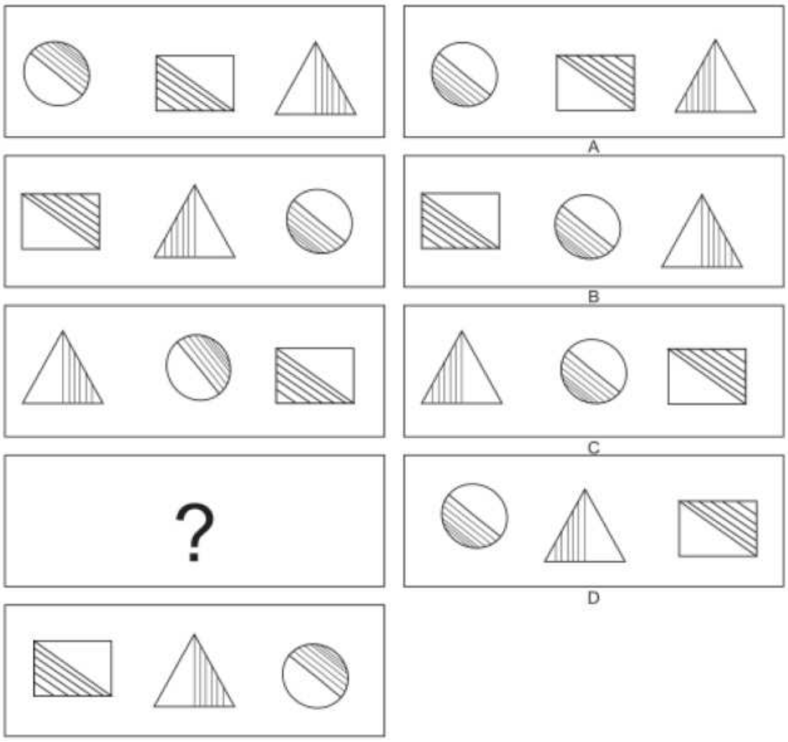
6.



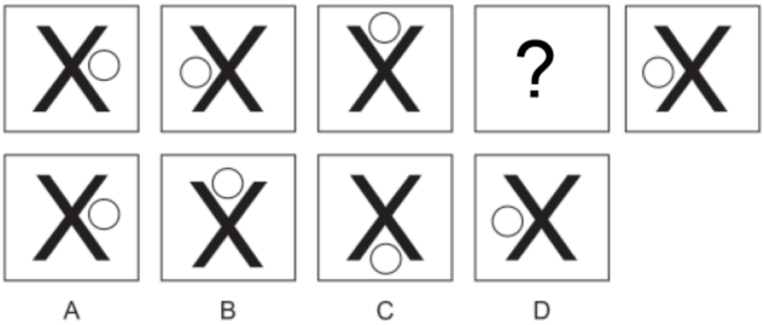
7.



8.



9.



Appendix XII

FAROOK TRAINING COLLEGE
Research Centre in Education

LOGICAL REASONING TEST

(English – Final)

Standard VIII

Radhika T.
Research Scholar

Dr. Niranjana K.P.
Assistant Professor

PERSONAL DETAILS

Name:..

School: ....

Class:...Div.: ....

Instruction

- The following questions are related to Logical Reasoning.
- There are 31 questions.
- Each question has 4 responses as A, B, C, D.
- In the response sheet given to you, the question numbers are written in order. Find out the correct answer and put a '✓' mark on appropriate column for each question.
- Answer all questions
- Each question carries 1 mark.
- Maximum Score is 31.
- Maximum Time is 31 minutes.

Questions

I. Fill in the blanks.

1. 6, 11, 16, 21, ___

   A) 26 B) 36 C) 25 D) 24

2. 16, 36, 54, 74, 92, ___

   A) 110 B) 112 C) 100 D) 114

3. 20, 35, 30, 50, 40, 65, 50, ___

   A) 65 B) 60 C) 80 D) 85

4. 52, 50, 48, 45, 42, 40, 38, 35, 32, ___, ___

   A) 30, 32 B) 26, 23 C) 26, 24 D) 30, 38

5. 20, 100, 200, 320, 460, ____

   A) 430 B) 400 C) 620 D) 530

II. Fill in the blanks

1. 6 : 24 :: 9 : ----

   A) 15 B) 26 C) 36 D) 18

2. 124: 31 :: ---- : 100

   A) 150 B) 400 C) 300 D) 160

3. 32: 64:: 33 : -----

   A) 99 B) 81 C) 65 D) 66

4. Length : Meter :: _____, Degree

   A) angle B) Circle C) Point D) Distance

5. Maths : Number :: incidents : _____

   A) People B) History C) Days D) War

6. AD : EH:: MP; ------

   A) QT B) TX C)UV D)FJ

7. 52, 50, 48, 45, 42, 40, 38, 35, 32, ----, -----

   A) 30, 32 B) 26, 23 C) 26, 24 D) 30, 28

8. 20, 100, 200, 320, 460, ----

   A) 430 B) 400 C) 620 D) 530

III. A few statements followed by certain conclusions are given below based on the statement choose the correct conclusion that can be followed.

1. Statements : A few plants are trees
   : All plants are forests

   Conclusions 1. All trees are plants
   2. At least a few trees are forests

   A) Conclusion 1 can be followed
   B) Conclusion 2 can be followed
   C) conclusions 1 or 2 can be followed
   D) Conclusions 1 and 2 can be followed

2. Statements : All stars are lights
   : All lights are planets
   No star is an orbit

Conclusions 1. A few orbits are planets

2. A few planets are lights

A) Conclusion 1 can be followed

B) Conclusion 2 can be followed

C) Conclusions 1 or 2 can be followed

D) Conclusions 1 and 2 can be followed

3. Statements : No years is a month

: Some months are weeks

Conclusions 1. No week is a month

2. A few weeks are months

A) Conclusion 1 can be followed

B) Conclusion 2 can be followed

C) conclusions 1 or 2 can be followed

D) Conclusions 1 and 2 can be followed

4. Statements : All animals are tigers

: A few tigers are horses

Conclusions 1. A few tigers are animals

2. All horses are animals

A) Conclusion 1 can be followed

B) Conclusion 2 can be followed

C) Conclusions 1 or 2 can be followed

D) Conclusions 1 and 2 can be followed

5. Statements : A few animals are cows

: All cows are horses

Conclusions 1. A few horses are animals

2. A few animals are horses

A) Conclusion 1 can be followed

B) Conclusion 2 can be followed

C) Conclusions 1 or 2 can be followed

D) Conclusions 1 and 2 can be followed

6. Statements : All pens are pencils

   : No pencil is a book

   Conclusions 1. No book is a pen

   2. No pen is a book

   A) Conclusion 1 can be followed

   B) Conclusion 2 can be followed

   C) Conclusions 1 or 2 can be followed

   D) Conclusions 1 and 2 can be followed

7. Statements : A few people are handsome

   : A few people are intelligent

   Conclusions 1. A few intellectuals are handsome

   2. A few handsome people are intellectuals

   A) Conclusion 1 can be followed

   B) Conclusion 2 can be followed

   C) conclusions 1 or 2 can be followed

   D) Conclusions 1 and 2 can be followed

8. Statements : All clocks are watches

   : A few watches are blue

   Conclusions 1. All watches are clocks

   2. A few clocks are blue

   A) Conclusion 1 can be followed

   B) Conclusion 2 can be followed

   C) Conclusions 1 or 2 can be followed

   D) Conclusions 1 and 2 can be followed

9. Statements : No phone is a ship

   : All buses are ships

   Conclusions 1. No bus is a phone

   2. At least a few ships are phones

   A) Conclusion 1 can be followed

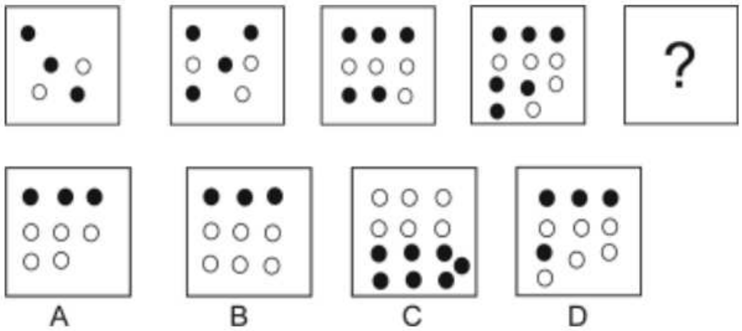
   B) Conclusion 2 can be followed

   C) conclusions 1 or 2 can be followed

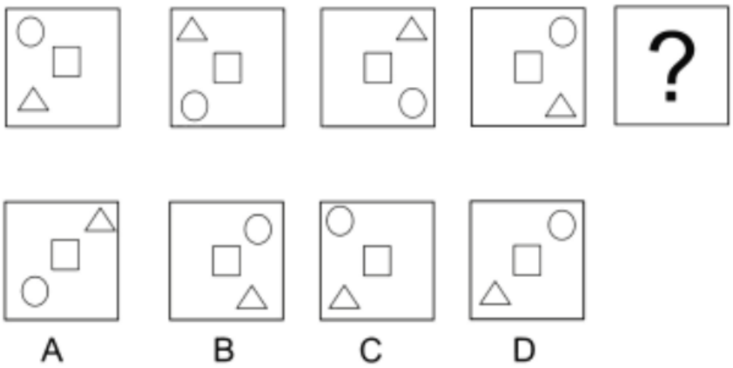
   D) Conclusions 1 and 2 can be followed

IV. Fill in the blanks in each of the following questions with the appropriate picture.

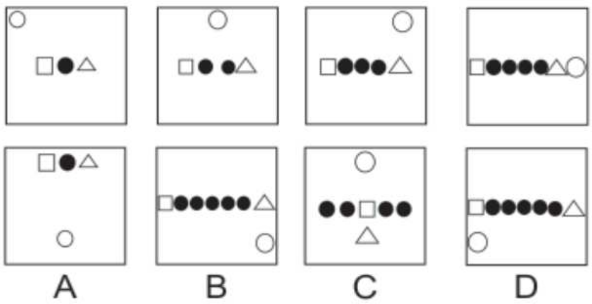
1.



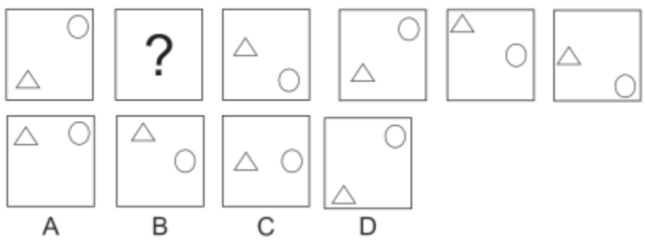
2.



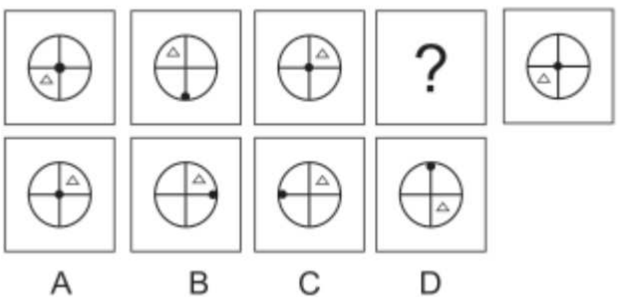
3.



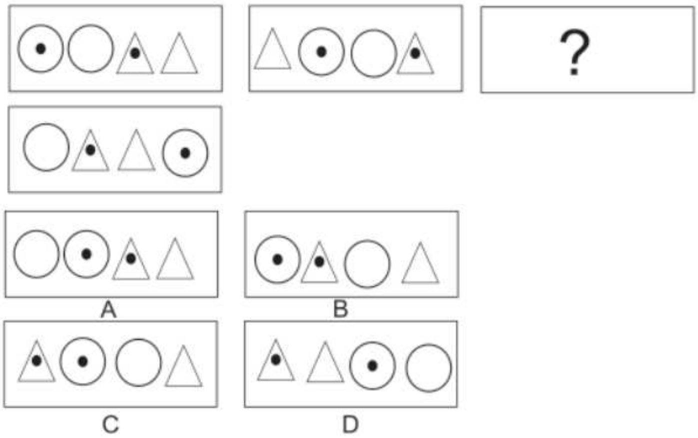
4.



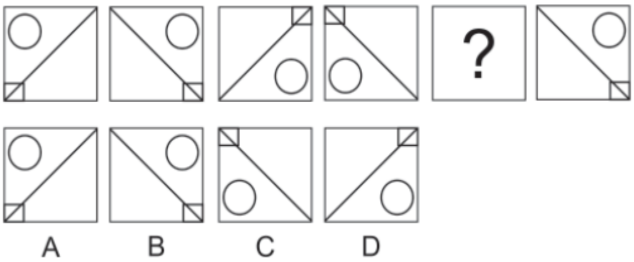
5.



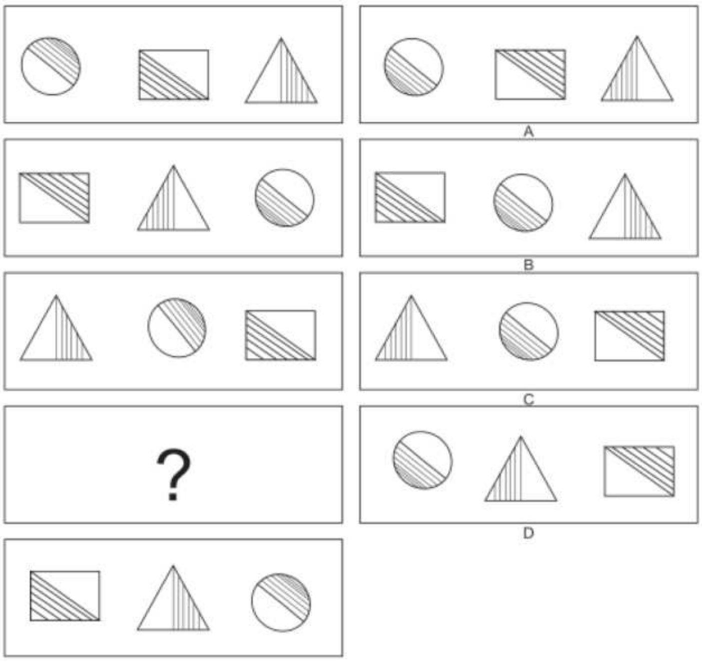
6.



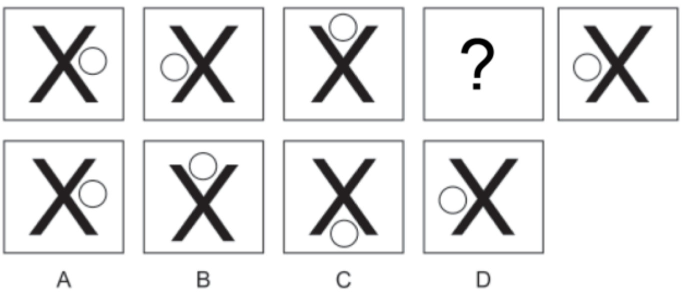
7.



8.



9.



Appendix XIII

FAROOK TRAINING COLLEGE
Research Centre in Education

LOGICAL REASONING TEST

Standard VIII

RESPONSE SHEET

Radhika T.
Research Scholar

Dr. Niranjana K.P.
Assistant Professor

PERSONAL DETAILS

Name:..

School: ....

Class:..Div.: ....

Sl. No.	A	B	C	D
I				
1				
2				
3				
4				
5				
II				
1				
2				
3				
4				
5				
6				
7				
8				

Sl. No.	A	B	C	D
III				
1				
2				
3				
4				
5				
6				
7				
8				
9				
IV				
1				
2				
3				
4				
5				
6				
7				
8				
9				

Appendix XIV

FAROOK TRAINING COLLEGE
Research Centre in Education

LOGICAL REASONING TEST

Standard VIII

SCORING KEY

Radhika T. Research Scholar

Dr. Niranjana K.P. Assistant Professor

PERSONAL DETAILS

Name: ....

School:...

Class: .... Div.:..

Sl. No.	A	B	C	D
I				
1	A			
2		B		
3			C	
4				D
5			C	
II				
1			C	
2		B		
3				D
4	A			
5		B		
6	A			
7				D
8	A			

Sl. No.	A	B	C	D
III				
1	A			
2		B		
3		B		
4	A			
5				D
6				D
7		B		
8				D
9	A			
IV				
1			C	
2			C	
3		B		
4		B		
5				D
6				D
7	A			
8	A			
9			C	

Appendix XV

FAROOK TRAINING COLLEGE
Research Centre in Education

MATHEMATICS ANXIETY SCALE

(Malayalam – Final)

Radhika T.
Research Scholar

Dr. Niranjana K.P.
Assistant Professor

PERSONAL DETAILS

Name: ....

School:..

Class: .... Roll No.: ....

നിർദ്ദേശങ്ങൾ :-

ഗണിതവുമായി ബന്ധപ്പെട്ട ഉത്കണ്ഠയെ സൂചിപ്പിക്കുന്ന പ്രസ്താവനകളാണ് താഴെ തന്നിരിക്കുന്നത്. ഓരോ പ്രസ്താവനക്കും 'എല്ലായ്പ്പോഴും', 'പലപ്പോഴും', 'ചിലപ്പോൾ', 'അപൂർവ്വമായി', 'ഒരിക്കലുമില്ല' എന്നീ അഞ്ചു വീതം പ്രതികരണങ്ങൾ നൽകിയിട്ടുണ്ട്. ഓരോ പ്രസ്താവനയും ശ്രദ്ധാപൂർവം വായിച്ച്, അതിൽ പറയുന്ന കാര്യങ്ങൾ നിങ്ങളെ സംബന്ധിച്ചിടത്തോളം എത്രമാത്രം ശരിയാണെന്ന് തീരുമാനിക്കുക. ഓരോ പ്രസ്താവനക്ക് നേരെയും നിങ്ങളുടെ പ്രതികരണം '✓' ചിഹ്നം ഉപയോഗിച്ച് രേഖപ്പെടുത്തുക. നിങ്ങളുടെ പ്രതികരണങ്ങൾ രഹസ്യമായി സൂക്ഷിക്കുന്നതും ഗവേഷണാവശ്യത്തിനുമാത്രം ഉപയോഗിക്കുന്നതുമാണ്.

ക്രമ നം.	പ്രസ്താവനകൾ	എല്ലായ്പ്പോഴും	പലപ്പോഴും	ചിലപ്പോൾ	അപൂർവ്വമായി	ഒരിക്കലുമില്ല
1.	കൂട്ടുകാരുമൊത്ത് സാധനങ്ങൾ വാങ്ങിയതിന് ശേഷം ഓരോരുത്തരും പങ്കിട്ടെടുക്കേണ്ട തുക കണക്കാക്കേണ്ടി വരുമ്പോൾ എനിക്ക് അസ്വസ്ഥത തോന്നാറുണ്ട്.					
2.	സാധനങ്ങൾ വാങ്ങിയതിന് ശേഷം മൊത്തം വില കണക്കാക്കേണ്ടി വരുമ്പോൾ എനിക്ക് പ്രയാസം തോന്നാറുണ്ട്.					
3.	സാധനങ്ങൾ വാങ്ങിയ ബില്ലിലെ വിലവിവരങ്ങൾ പരിശോധിക്കുമ്പോൾ എനിക്ക് പരിഭ്രമം തോന്നാറുണ്ട്.					

ക്രമ നം.	പ്രസ്താവനകൾ	എല്ലായ്പ്പോഴും	പലപ്പോഴും	ചിലപ്പോൾ	അപൂർവ്വമായി	ഒരിക്കലുമില്ല
4.	കൈയിലുള്ള പൈസ ഉപയോഗിച്ച് വാങ്ങാവുന്ന സാധനങ്ങളുടെ കണക്കു തയാറാക്കുമ്പോൾ എനിക്ക് പരിഭ്രമം തോന്നാറുണ്ട്					
5.	പരിപാടികൾ സംഘടിപ്പിക്കേണ്ടി വരുമ്പോൾ അതിന്റെ വരവ് ചെലവ് കണക്കുകൾ കൈകാര്യം ചെയ്യുന്നതിൽ എനിക്ക് ബുദ്ധിമുട്ടുതോന്നാറുണ്ട്.					
6.	ഗണിത പരീക്ഷക്ക് തയാറെടുക്കുമ്പോൾ എനിക്ക് അസ്വസ്ഥത തോന്നാറുണ്ട്					
7.	പ്രയാസമേറിയ ഗണിതപ്രശ്നങ്ങൾ പരിഹരിക്കേണ്ടി വരുമ്പോൾ എനിക്ക് പരിഭ്രമം തോന്നാറുണ്ട്.					
8.	ഗണിതപരീക്ഷയുടെ തലേ ദിവസം എനിക്ക് ശാരീരിക ബുദ്ധിമുട്ട് തോന്നാറുണ്ട്.					
9.	ഗണിതക്ലാസ്സിന്റെ സമയമാകുമ്പോൾ എനിക്ക് ഭയം തോന്നാറുണ്ട്.					
10.	പഠിച്ചതിൽ നിന്നും വ്യത്യസ്തമായ ചോദ്യങ്ങൾ ഗണിതപരീക്ഷയിൽ ഉണ്ടായാൽ എനിക്ക് പരിഭ്രാന്തി തോന്നാറുണ്ട്.					
11.	ഗണിതക്ലാസ്സിൽ പ്രശ്നങ്ങൾ പരിഹരിക്കേണ്ടി വരുമ്പോൾ എനിക്ക് പരിഭ്രമം തോന്നാറുണ്ട്.					
12.	ബ്ലാക്ക് ബോർഡിൽ ഗണിതപ്രശ്നം പരിഹരികേണ്ടിവരുമ്പോൾ എനിക്ക് പേടി തോന്നാറുണ്ട്.					
13.	ഗണിത ഗൃഹപാഠം ചെയ്യുന്നത് എനിക്ക് പ്രയാസമാണ്.					
14.	ഗണിതപരീക്ഷയിലെ പരാജയത്തെക്കുറിച്ച് ഞാൻ ചിന്തിക്കാറുണ്ട് .					
15.	ഗണിത പുസ്തകത്തിൽ സൂത്രവാക്യങ്ങൾ കാണുമ്പോൾ എനിക്ക് പേടിതോന്നാറുണ്ട്.					

Appendix

ക്രമ നം.	പ്രസ്താവനകൾ	എല്ലായ്പ്പോഴും	പലപ്പോഴും	ചിലപ്പോൾ	അപൂർവ്വമായി	ഒരിക്കലുമില്ല
16.	ഗണിതപ്രശ്നത്തിനു വിശദീകരണം നല്കേണ്ടിവരുമ്പോൾ എനിക്ക് അസ്വസ്ഥത തോന്നാറുണ്ട്.					
17.	ഗണിത ക്ലാസ്സിൽ ടീച്ചറുടെ ചോദ്യങ്ങൾക്ക് ഉത്തരം നൽകുമ്പോൾ എനിക്ക് പേടി തോന്നാറുണ്ട്.					
18.	മറ്റു വിഷയങ്ങളെ അപേക്ഷിച്ച് ഗണിതം പഠിക്കാൻ എനിക്ക് പ്രയാസമാണ്.					
19.	ഗണിതസമവാക്യങ്ങൾ ഉപയോഗിക്കാൻ എനിക്ക് പേടിയാണ്.					
20.	അറിയാവുന്ന ഗണിത പ്രശ്നങ്ങൾപോലും പരീക്ഷാസമയത്ത് ശരിയായി പരിഹരിക്കാൻ എനിക്ക് കഴിയാറില്ല.					
21.	ഗണിതപരീക്ഷയിൽ അറിയാവുന്ന സൂത്രവാക്യങ്ങൾ പോലും എനിക്ക് തെറ്റാറുണ്ട്.					
22.	ഗണിതപരീക്ഷ എഴുതുമ്പോൾ എനിക്ക് ഹൃദയമിടിപ്പ് കൂടാറുണ്ട്.					

Appendix XVI

FAROOK TRAINING COLLEGE
Research Centre in Education

MATHEMATICS ANXIETY SCALE

(English – Final)

Radhika T.
Research Scholar

Dr. Niranjana K.P.
Assistant Professor

PERSONAL DETAILS

Name: ....

School:...

Class: .... Roll No.: ....

Instructions

Statements given below are related to anxiety in Mathematics. Five responses are given for each statements viz., 'Always', 'Often, 'Sometimes', 'Rarely', and 'Never'. Read each statement carefully and decide the appropriate response. Mark your response to each statement using a '✓' mark. Your response will be kept confidential and used only for research purposes.

Sl. No.	Statements	Always	Often	Sometimes	Rarely	Never
1.	I feel discomfort while calculating the share of each one after buying items with friends.					
2.	I find it difficult to calculate the total amount of purchase after buying items.					
3.	I feel discomfort while checking the price of bought items in the bills.					
4.	I feel discomfort to find how much I can buy using the cash in my hand.					
5.	I felt difficult to estimate the income and expenses while organising a program.					

Appendix

Sl. No.	Statements	Always	Often	Sometimes	Rarely	Never
6.	I feel discomfort while preparing for mathematics exam.					
7.	I feel nervous when I have to solve difficult mathematics problems.					
8.	I feel physical discomfort on the previous days of mathematics exam.					
9.	I feel frightened just before mathematics class.					
10.	I feel panic when mathematics test include different questions than what I have learned.					
11.	I feel panic while solving problems in mathematics class.					
12.	I feel anxious while solving mathematics problems on blackboard.					
13.	I felt difficult while doing mathematics homework.					
14.	I thought of failure in mathematics exam.					
15.	I feel embraced when I see formulas in mathematics book.					
16.	I feel discomfort when I need to explain mathematics problems.					
17.	I feel anxious while answering the questions on mathematics teacher.					
18.	I feel difficult to learn when comparing to other subjects.					
19.	I am afraid of using mathematics equations.					

Sl. No.	Statements	Always	Often	Sometimes	Rarely	Never
20.	I am unable to solve even the known problems in mathematics properly during the exam.					
21.	I make mistakes in known formulas during mathematics exam.					
22.	My heartbeat raises when I attend mathematics exams.					

Appendix XVII

FAROOK TRAINING COLLEGE
Research Centre in Education

SCALE ON ACHIEVEMENT MOTIVATION IN MATHEMATICS

(Malayalam – Final)

Radhika T.
Research Scholar

Dr. Niranjana K.P.
Assistant Professor

PERSONAL DETAILS

Name: ....

School:..

Class: .... Roll No.: ....

നിർദ്ദേശങ്ങൾ :-

ഗണിതശാസ്ത്രവുമായി ബന്ധപ്പെട്ട നിങ്ങളുടെ അഭിപ്രേരണ അറിയുവാനുള്ള ചോദ്യങ്ങളാണ് താഴെ തന്നിരിക്കുന്നത്. ഓരോ പ്രസ്താവനക്കും 'എല്ലായ്പ്പോഴും', 'പലപ്പോഴും', 'ചിലപ്പോൾ', 'അപൂർവ്വമായി', 'ഒരിക്കലുമില്ല' എന്നീ അഞ്ചു വീതം പ്രതികരണങ്ങൾ നൽകിയിട്ടുണ്ട്. ഓരോ പ്രസ്താവനയും ശ്രദ്ധാപൂർവം വായിച്ച്, അതിൽ പറയുന്ന കാര്യങ്ങൾ നിങ്ങളെ സംബന്ധിച്ചിടത്തോളം എത്രമാത്രം ശരിയാണെന്ന് തീരുമാനിക്കുക. ഓരോ പ്രസ്താവനക്ക് നേരെയും നിങ്ങളുടെ പ്രതികരണം '✓' ചിഹ്നം ഉപയോഗിച്ച് രേഖപ്പെടുത്തുക. നിങ്ങളുടെ പ്രതികരണങ്ങൾ രഹസ്യമായി സൂക്ഷിക്കുന്നതും ഗവേഷണാവശ്യത്തിനുമാത്രം ഉപയോഗിക്കുന്നതുമാണ്.

ക്രമ നമ്പർ	പ്രസ്താവന	എല്ലായ്പ്പോഴും	പലപ്പോഴും	ചിലപ്പോൾ	അപൂർവ്വമായി	ഒരിക്കലുമില്ല
1.	ഗണിത ക്ലാസുകൾ നഷ്ടപ്പെടുമ്പോൾ എനിക്ക് വിഷമം തോന്നാറുണ്ട്.					
2.	ഗണിത ക്ലാസ്സിലെ പ്രവർത്തനങ്ങളിൽ ഞാൻ നന്നായി ശ്രദ്ധിക്കാറുണ്ട്					
3.	ഗണിത ക്ലാസ്സിൽ വൈകിയെത്തിയാൽ നഷ്ടപ്പെടുന്ന പാഠഭാഗങ്ങൾ മനസ്സിലാക്കുന്നതിന് ഞാൻ ശ്രമിക്കാറുണ്ട്.					
4.	അറിയാത്ത ഗണിത പാഠഭാഗങ്ങൾ മനസിലാക്കുന്നതിനായി കൂടുതൽ വായിക്കാൻ ഞാൻ ഇഷ്ടപ്പെടുന്നു.					

ക്രമ നമ്പർ	പ്രസ്താവന	എല്ലായ്പ്പോഴും	പലപ്പോഴും	ചിലപ്പോൾ	അപൂർവ്വമായി	ഒരിക്കലുമില്ല
5.	എനിക്ക് സ്വന്തമായി ഒരു ഗണിത ലൈബ്രറി ഉണ്ടാക്കാൻ താത്പര്യം ഉണ്ട്.					
6.	ഗണിത പഠനലക്ഷ്യങ്ങൾ നേടിയെടുക്കുന്നതിനായി ഞാൻ ശ്രമിക്കാറുണ്ട്.					
7.	ഗണിത പഠനവിജയത്തിനായി ഞാൻ ലക്ഷ്യങ്ങൾ നിശ്ചയിക്കാറുണ്ട്.					
8.	ഗണിതത്തിൽ എനിക്ക് താത്പര്യമുള്ള മേഖലയിൽ പ്രാവീണ്യം നേടാൻ ഞാൻ ആഗ്രഹിക്കുന്നു.					
9.	ഗണിത ക്ലാസ്സിൽ സമർത്ഥൻ/ സമർത്ഥയാകാൻ ഞാൻ ശ്രമിക്കാറുണ്ട്.					
10.	ഗണിതപഠനവുമായി ബന്ധപ്പെട്ട പരീക്ഷണ ങ്ങൾ നടത്താൻ എനിക്ക് ഇഷ്ടമാണ്					
11.	ഏറ്റെടുത്ത ഗണിതപ്രശ്നങ്ങൾക്ക് പരിഹാരം കണ്ടെത്താൻ കഠിനപ്രയത്നം ചെയ്യാറുണ്ട്					
12.	മറ്റുള്ളവർ പരാജയപ്പെടുന്ന ഗണിതപ്രശ്ന ങ്ങൾക്ക് പരിഹാരം കണ്ടെത്താൻ എനിക്ക് താത്പര്യമാണ്.					
13.	ഗണിതപഠനവുമായി ബന്ധപ്പെട്ട് മികച്ച നേട്ടങ്ങളുണ്ടാകാൻ ഞാൻ ആഗ്രഹിക്കുന്നു					
14.	ഗണിതം പഠിച്ചുകൊണ്ടിരിക്കുമ്പോൾ മറ്റു വിഷയങ്ങൾ പഠിക്കാൻ എനിക്ക് തോന്നാറില്ല.					
15.	ഗണിതപാഠഭാഗങ്ങൾ അർത്ഥവത്താണെന്നു എനിക്ക് തോന്നാറുണ്ട്					
16.	പഠിക്കുന്ന ഗണിതപാഠഭാഗങ്ങൾ ഞാൻ നിത്യജീവിതവുമായി ബന്ധപ്പെടുത്താറുണ്ട്.					
17.	സുഹൃത്തുക്കളുമായി സമയം ചിലവഴിക്കുന്ന തിനേക്കാൾ ഗണിതപഠനത്തിനു സമയം കണ്ടെത്താൻ ഞാൻ ശ്രമിക്കാറുണ്ട്.					
18.	ഗണിതാദ്ധ്യാപകർ ക്ലാസ്സെടുക്കുമ്പോൾ കഥകൾ, നോവലുകൾ എന്നിവ വായിക്കാൻ ഞാൻ ശ്രമിക്കാറില്ല.					

Appendix

ക്രമ നമ്പർ	പ്രസ്താവന	എല്ലായ്പ്പോഴും	പലപ്പോഴും	ചിലപ്പോൾ	അപൂർവമായി	ഒരിക്കലുമില്ല
19.	വെല്ലുവിളി നിറഞ്ഞ ഗണിത പ്രവർത്തനങ്ങൾ ഏറ്റെടുക്കാൻ എനിക്കിഷ്ടമാണ്.					
20.	ഗണിത ക്ലാസുകൾ എനിക്കിഷ്ടമാണ്.					
21.	ഗണിത പഠനവും പാഠ്യേതര പ്രവർത്തനങ്ങളും ഒരുമിച്ചുകൊണ്ടുപോകാൻ ഞാൻ ശ്രമിക്കാറുണ്ട്.					
22.	ഗണിത പഠന പ്രവർത്തനങ്ങൾ മികവുറ്റതാക്കാൻ സാധിക്കുന്നതിനാൽ ഗണിത ക്ലാസ്സിലിരിക്കാൻ ഞാൻ ഇഷ്ടപ്പെടുന്നു.					
23.	മികച്ച ഗണിത പഠപ്രവർത്തനത്തിലൂടെ ഗണിത പഠനം വിജയകരമാകാൻ സാധിക്കുമെന്ന് ഞാൻ വിശ്വസിക്കുന്നു.					
24.	ക്ലാസ്സിൽ വിനിമയം ചെയ്ത എല്ലാ ഗണിത പാഠങ്ങളുടെയും നോട്ടുകൾ ഞാൻ തയ്യാറാക്കാറുണ്ട്.					
25.	ഗണിത പരീക്ഷയിൽ ഉയർന്ന മാർക്ക് ലഭിക്കുന്നതിന് വേണ്ടി ഞാൻ തയ്യാറെടുപ്പുകൾ നടത്താറുണ്ട്.					
26.	കളികളേക്കാൾ പ്രാധാന്യം ഞാൻ ഗണിത പഠനത്തിന് കൊടുക്കുന്നുണ്ട്.					
27.	അടുത്ത ദിവസത്തെ ഗണിത ക്ലാസ്സുകൾക്കായി തലേദിവസംതന്നെ തയ്യാറെടുപ്പുകൾ നടത്താറുണ്ട്.					
28.	ഗണിതപുസ്തകങ്ങളിലെ പട്ടികകളും ചാർട്ടുകളും മനസിലാക്കി അവയെപ്പറ്റി കൂടുതൽ പഠിക്കാൻ ഞാൻ ശ്രമിക്കാറുണ്ട്.					
29.	എന്റെ ഗണിതാധ്യാപകർ കഴിവുള്ളവരാണെന്നു ഞാൻ കരുതുന്നു.					
30.	ഗണിതക്ലാസ്സിൽ വളരെ അച്ചടക്കത്തോടെയും ശ്രദ്ധയോടെയും ഇരിക്കാൻ ഞാൻ ശ്രമിക്കാറുണ്ട്.					
31.	പഠനവിജയത്തിലൂടെ ഗണിതാധ്യാപകരെ സന്തോഷിപ്പിക്കാൻ ഞാൻ ഇഷ്ടപ്പെടുന്നു					

ക്രമ നമ്പർ	പ്രസ്താവന	എല്ലായ്പ്പോഴും	പലപ്പോഴും	ചിലപ്പോൾ	അപൂർവ്വമായി	ഒരിക്കലുമില്ല
32.	ഗണിതപഠനത്തിൽ മറ്റുള്ളവർ എന്നെ മാതൃകയാക്കണമെന്ന ഞാൻ ആഗ്രഹിക്കുന്നു.					
33.	ഗണിതപഠനത്തിൽ ഒന്നാമനായിരിക്കാൻ ഞാൻ ശ്രമിക്കാറുണ്ട്.					
34.	അധ്യാപകരുടെയും രക്ഷിതാക്കളുടെയും വിമർശനത്തിലൂടെ എന്റെ തെറ്റുകൾ തിരുത്താൻ ശ്രമിക്കാറുണ്ട്.					
35.	ഗണിതപഠനം മറ്റ വിഷയങ്ങളുടെ പഠനത്തിന് സഹായിക്കുമെന്ന് എനിക്ക് ഉറപ്പുണ്ട്.					
36.	തടസ്സങ്ങളുണ്ടായാലും ഗണിതത്തിലെ എന്റെ പഠനലക്ഷ്യം നേടിയെടുക്കാൻ ഞാൻ ശ്രമിക്കാറുണ്ട്.					
37.	ഗണിതപഠനത്തിലൂടെ ജീവിതവിജയം നേടിയെടുക്കാമെന്ന് എനിക്ക് തോന്നാറുണ്ട്.					
38.	ഗണിതവുമായി ബന്ധപ്പെട്ട പ്രവർത്തനങ്ങൾ സംഘടിപ്പിക്കാൻ ഞാൻ ശ്രമിക്കാറുണ്ട്.					
39.	ഗണിതത്തിൽ ഉന്നതനിലവാരം പുലർത്തുന്ന വരുമായി കൂട്ടുകൂടാൻ ഞാൻ ആഗ്രഹിക്കുന്നു.					
40.	പ്രയാസമേറിയ ഗണിതപ്രവർത്തനങ്ങൾക്ക് ഉത്തരം കണ്ടെത്താൻ എനിക്ക് ഇഷ്ടമാണ്.					
41.	ഗണിത ഗൃഹപാഠം പൂർത്തീകരിക്കാൻ കഴിഞ്ഞില്ലെങ്കിൽ എനിക്ക് അസ്വസ്ഥത തോന്നാറുണ്ട്.					
42.	ഗണിതപരീക്ഷ ഇല്ലെങ്കിൽ പോലും ഗണിതപ്രവർത്തം ചെയ്യാൻ എനിക്ക് ഇഷ്ടമാണ്.					

Appendix XVIII

FAROOK TRAINING COLLEGE
Research Centre in Education

SCALE ON ACHIEVEMENT MOTIVATION IN MATHEMATICS

(English – Final)

Radhika T. Research Scholar

Dr. Niranjana K.P. Assistant Professor

PERSONAL DETAILS

Name: ....

School:...

Class: .... Roll No.: ....

Instructions

Statements given below are related to motivation in mathematics learning. Five responses are given for each statements viz., 'Always', 'Often, 'Sometimes', 'Rarely', and 'Never'. Read each statement carefully and decide the appropriate response. Mark your response to each statement using a '✓' mark. Your response will be kept confidential and used only for research purposes

Sl. No.	Statements	Always	Often	Sometimes	Rarely	Never
1.	I feel unhappy when I miss mathematics classes.					
2.	I attend learning activities in mathematics class properly.					
3.	I try to capture on missed lessons if I came late in mathematics class.					
4.	I love reading more to understand the unfamiliar mathematics topics.					
5.	I am interested in having my own mathematics library.					
6.	I try to achieve the learning objectives of mathematics.					
7.	I set objectives for successful in mathematics learning.					

Sl. No.	Statements	Always	Often	Sometimes	Rarely	Never
8.	I wish to get proficiency in interested area of mathematics.					
9.	I try to be smart in mathematics class.					
10.	I wish to conduct experiments related to mathematics					
11.	I work hard to solve the mathematics problems given to me.					
12.	I wish to solve mathematics problems in which others fail.					
13.	I wish to make good achievements in mathematics					
14.	When I am studying mathematics I do not feel studying other subjects.					
15.	I feel that the topics in mathematics I study are meaningful.					
16.	I relate the mathematics topics I learn to my daily life situation.					
17.	I prefer spending time for studying mathematics than spending time with friends.					
18.	I never read stories or novels during mathematics class.					
19.	I like to deal challenging mathematics problems.					
20.	I like mathematics classes.					
21.	I try to coordinate extracurricular activities with mathematics learning.					
22.	I like to attend mathematics classes as I can enrich learning activities.					

Sl. No.	Statements	Always	Often	Sometimes	Rarely	Never
23.	I believe that mathematics learning can be made useful through good learning activities.					
24.	I prepare notes of all mathematics lessons taught in the class					
25.	I prepare well for scoring high marks in mathematics exam.					
26.	I give more importance to mathematics learning than games.					
27.	I prepare for the next day's mathematics classes the day before.					
28.	I try to learn more about tables and charts in mathematics textbooks.					
29.	I think my mathematics teachers are talented.					
30.	I try to be well disciplined in mathematics class.					
31.	I wish to make mathematics teachers happy by being successful in studies.					
32.	I want others to model me in mathematics studies.					
33.	I try to be in the first position in mathematics performance.					
34.	I try to correct my mistakes by criticisms from my parents and teachers.					
35.	I believe that the study of mathematics will help in the study of other subjects.					
36.	I try to achieve my learning objectives in mathematics despite of obstacles.					
37.	I feel that success in life can be achieved through studying mathematics					

Sl. No.	Statements	Always	Often	Sometimes	Rarely	Never
38.	I try to organize programmes related to mathematics.					
39.	I would like to be with people who excel in mathematics.					
40.	I am interested to solve very tough mathematics problems.					
41.	I feel discomfort when I cannot complete my mathematics homework.					
42.	I like to do mathematics learning activities even if there is no mathematic exam.					

Appendix XIX

FAROOK TRAINING COLLEGE
Research Centre in Education

MATHEMATICAL BELIEFS INVENTORY

(Malayalam – Draft)

Radhika T.
Research Scholar

Dr. Niranjana K.P.
Assistant Professor

PERSONAL DETAILS

Name: ....

School:...

Class: .... Roll No.: ....

നിർദ്ദേശങ്ങൾ :-

ഗണിതശാസ്ത്രവിഷയവുമായി ബന്ധപ്പെട്ട പ്രസ്താവനകളാണ് താഴെ തന്നിരിക്കുന്നത്. ഓരോ പ്രസ്താവനക്കും 'യോജിക്കുന്നു', 'വിയോജിക്കുന്നു' എന്നീ പ്രതികരണങ്ങൾ നൽകിയിട്ടുണ്ട്. ഓരോ പ്രസ്താവനയും ശ്രദ്ധാപൂർവം വായിച്ച്, അതിൽ പറയുന്ന കാര്യങ്ങൾ നിങ്ങളെ സംബന്ധിച്ചിടത്തോളം എത്രമാത്രം ശരിയാണെന്ന് തീരുമാനിക്കുക. ഓരോ പ്രസ്താവനക്ക് നേരെയും നിങ്ങളുടെ പ്രതികരണം '✓' ചിഹ്നം ഉപയോഗിച്ച് രേഖപ്പെടുത്തുക. നിങ്ങളുടെ പ്രതികരണങ്ങൾ രഹസ്യമായി സൂക്ഷിക്കുന്നതും ഗവേഷണാവശ്യത്തിനുമാത്രം ഉപയോഗിക്കുന്നതുമാണ്.

ക്രമ നം.	പ്രസ്താവനകൾ	യോജിക്കുന്നു	വിയോജിക്കുന്നു
1.	ശാസ്ത്രപഠനത്തിന്റെ താക്കോൽ ആണ് ഗണിതം		
2.	യുക്തി ചിന്താവികാസത്തിനു സഹായിക്കുന്ന വിഷയമാണ് ഗണിതം.		
3.	എല്ലാ ഗണിത പ്രശ്നങ്ങൾക്കും കൃത്യമായ ഉത്തരം ഉണ്ടായിരിക്കും.		
4.	ഒരേ ഒരു രീതിയിൽ മാത്രമേ ഗണിതപ്രശ്ങ്ങൾ പരിഹരിക്കാൻ സാധിക്കൂ.		
5.	കായികമത്സരങ്ങളിൽ ഗണിതശാസ്ത്രത്തിനു പ്രാധാന്യം ഉണ്ട്.		
6.	ഗണിത പ്രശ്നങ്ങൾക്കു പരിഹാരം കണ്ടെത്തുന്നത് പ്രയാസമേറിയ കാര്യമാണ്.		

ക്രമ നം.	പ്രസ്താവനകൾ	യോജിക്കുന്നു	വിയോജിക്കുന്നു
7.	കഠിനപ്രയത്നത്തിലൂടെ ആർക്കും ഗണിതശാസ്ത്രത്തിലെ പ്രശ്നങ്ങൾക്കു പരിഹാരം കണ്ടെത്താൻ കഴിയും.		
8.	പഠിച്ചെടുക്കാൻ പ്രയാസമുള്ള ആശയങ്ങൾ ഉൾകൊള്ളുന്ന വിഷയമാണ് ഗണിതം.		
9.	ഗണിത ചോദ്യത്തിന് ശരിയായ ഉത്തരം നൽകേണ്ടത് എങ്ങിനെയാണെന്ന് ഗണിതശാസ്ത്ര അധ്യാപകർക്ക് മാത്രമേ കാണിച്ചുതരാൻ സാധിക്കുകയുള്ളൂ.		
10.	ഓരോരുത്തർക്കും ക്രിയാത്മകമായ കഴിവുകൾ വളർത്താൻ ഗണിതശാസ്ത്ര പഠനത്തിലൂടെ സാധിക്കും.		
11.	അധ്യാപകരുടെ സഹായത്താൽ മാത്രമേ ഗണിതപ്രശ്നങ്ങൾക്ക് പരിഹാരം കണ്ടെത്താനാകൂ.		
12.	കൃത്യമായ പഠനപ്രവർത്തനങ്ങളിലൂടെ ഗണിതശാസ്ത്രത്തിലെ അവഗാഹം വർധിപ്പിക്കാം.		
13.	ഗണിതശാസ്ത്ര പ്രശ്നങ്ങളുടെ ഉത്തരങ്ങൾ ശരിയാണോയെന്ന് എളുപ്പത്തിൽ പരിശോധിക്കാവുന്നതാണ്.		
14.	ശാസ്ത്രചിന്തകളുടെ വികാസത്തിന് ഗണിതപഠനം സഹായിക്കുന്നു.		
15.	കൃത്യതയുള്ള ഒരു വിഷയമാണ് ഗണിതം		
16.	ഗണിതശാസ്ത്രം അറിയുന്നത് ഉപജീവനത്തിന് സഹായിക്കും.		
17.	യഥാർത്ഥലോകത്തെ പ്രതിനിധീകരിക്കുന്ന സ്വഭാവം ഗണിതശാസ്ത്രത്തിനുണ്ട്.		
18.	ഗണിതപഠനം മറ്റുവിഷയങ്ങളുടെ പഠനത്തെ സഹായിക്കുന്നു.		
19.	നിത്യജീവിതത്തിൽ ബാങ്കിടപ്പാടുകൾ നടത്താൻ ഗണിതം കൂടിയേ തീരൂ.		
20.	ഗണിതശാസ്ത്രപഠനം കുട്ടികളെ സ്വയം കാര്യങ്ങൾ കണ്ടെത്താൻ സഹായിക്കുന്നു.		
21.	കഠിനപ്രയത്നത്തിലൂടെ ഗണിതശാസ്ത്രത്തിലെ ആശയങ്ങൾ ഗ്രഹിക്കാൻ സാധിക്കും.		
22.	ഗണിതശാസ്ത്രം പഠിപ്പിക്കുന്നതിനു ഒന്നിലേറെ രീതികൾ ഉപയോഗിക്കുന്നു.		

Appendix

ക്രമ നം.	പ്രസ്താവനകൾ	യോജിക്കുന്നു	വിയോജിക്കുന്നു
23.	സജീവമായ പ്രക്രിയയിലൂടെയാണ് ഗണിതം പഠിക്കുന്നത്.		
24.	ശരിയായ രീതി അറിഞ്ഞാൽ മാത്രമേ ഗണിതശാസ്ത്ര പ്രശ്നം പരിഹരിക്കാൻ സാധിക്കൂ.		
25.	വിദ്യാർത്ഥിക്കുള്ള വിനിമയതന്ത്രങ്ങൾ രൂപപ്പെടുത്താൻ ഗണിതപഠനം സഹായിക്കുന്നു.		
26.	ശാസ്ത്രത്തിന്റെ ഉന്നത ഭാഷയാണ് ഗണിതം.		
27.	ഗണിതശാസ്ത്രത്തിനു അതിന്റെതായ സൂത്രവാക്യങ്ങളും, ചിഹ്നങ്ങളും നിയമങ്ങളും ഉണ്ട്.		
28.	എല്ലാവർക്കും ഒരുപോലെ കൈകാര്യം ചെയ്യാൻ സാധിക്കുന്ന വിഷയമാണ് ഗണിതം.		
29.	വൈവിധ്യമാർന്ന പ്രവർത്തനങ്ങൾക്ക് സാധ്യതയുള്ള വിഷയമാണ് ഗണിതം.		
30.	പെട്ടെന്ന് ഗ്രഹിക്കാൻ കഴിയുന്ന ആശയങ്ങളാണ് ഗണിതശാസ്ത്രത്തിൽ ഉള്ളത്.		
31.	ചിട്ടയോട്ടുകൂടിയ പഠനത്തിലൂടെ ഏതു പ്രയാസമേറിയ ഗണിതപ്രശ്നങ്ങൾക്കും ഉത്തരം കണ്ടെത്താൻ സാധിക്കും.		
32.	ഗണിതപ്രശ്നങ്ങൾ പരിഹരിക്കാൻ വിവിധ മാർഗ്ഗങ്ങൾ ഉപയോഗിക്കാം.		
33.	ആസ്വാദ്യകരമായ രീതിയിൽ പഠനപ്രവർത്തനങ്ങൾ ക്രമീകരിക്കാൻ ഗണിതപഠനത്തിലൂടെ സാധിക്കുന്നു.		
34.	വിമർശനാത്മക ചിന്ത വളർത്തുന്നതിന് ഗണിത പഠനം സഹായിക്കുന്നു.		
35.	ചിന്താശേഷി വർധിപ്പിക്കാൻ സഹായിക്കുന്ന വിഷയമാണ് ഗണിതം.		
36.	വസ്തുനിഷ്ഠതക്ക് പ്രാധാന്യം ഉള്ള വിഷയമാണ് ഗണിതം.		
37.	സ്വയം പഠിക്കാനുള്ള കഴിവുണ്ടാക്കിയെടുക്കലാണ് ഗണിതശാസ്ത്ര പഠനത്തിന്റെ കാതലായ ലക്ഷ്യം.		
38.	കൃത്യതയോടെ കാര്യങ്ങൾ ചെയ്യാൻ ഗണിതപഠനം സഹായിക്കുന്നു.		
39.	മന:പാഠം പഠിക്കാൻ പറ്റുന്ന ആശയങ്ങളാണ് ഗണിതത്തിലുള്ളത്.		

ക്രമ നം.	പ്രസ്താവനകൾ	യോജിക്കുന്നു	വിയോജിക്കുന്നു
40.	കഠിന പ്രയത്നം കൊണ്ട് ഗണിതപരമായ കഴിവുകൾ വർധിപ്പിക്കാൻ സാധിക്കും.		
41.	കാര്യകാരണബന്ധങ്ങൾ വിശകലനം ചെയ്യാൻ ഗണിതപഠനം സഹായിക്കുന്നു.		
42.	വസ്തുതകൾ വിശകലനം ചെയ്ത് പൊതുതത്വങ്ങൾ രൂപീകരിക്കാനുള്ള കഴിവ് ഗണിതപഠനത്തിലൂടെ സാധ്യമാകുന്നു.		
43.	തുടർച്ചയായി വികസിച്ചുകൊണ്ടിരിക്കുന്ന ഒരു വിഷയമാണ് ഗണിതം.		
44.	സമയമെടുത്ത് പഠിച്ചാൽ ഗണിതശാസ്ത്രത്തിലെ ഏത് ആശയവും പഠിക്കാൻ സാധിക്കും.		

Appendix XX

FAROOK TRAINING COLLEGE
Research Centre in Education

MATHEMATICAL BELIEFS INVENTORY

(Malayalam – Final)

Radhika T. Research Scholar

Dr. Niranjana K.P. Assistant Professor

PERSONAL DETAILS

Name: ....

School:...

Class: .... Roll No.: ....

നിർദ്ദേശങ്ങൾ :-

ഗണിതശാസ്ത്രവിഷയവുമായി ബന്ധപ്പെട്ട പ്രസ്താവനകളാണ് താഴെ തന്നിരിക്കുന്നത്. ഓരോ പ്രസ്താവനക്കും 'യോജിക്കുന്നു', 'വിയോജിക്കുന്നു' എന്നീ പ്രതികരണങ്ങൾ നൽകിയിട്ടുണ്ട്. ഓരോ പ്രസ്താവനയും ശ്രദ്ധാപൂർവം വായിച്ച്, അതിൽ പറയുന്ന കാര്യങ്ങൾ നിങ്ങളെ സംബന്ധിച്ചിടത്തോളം എത്രമാത്രം ശരിയാണെന്ന് തീരുമാനിക്കുക. ഓരോ പ്രസ്താവനക്ക് നേരെയും നിങ്ങളുടെ പ്രതികരണം '✓' ചിഹ്നം ഉപയോഗിച്ച് രേഖപ്പെടുത്തുക. നിങ്ങളുടെ പ്രതികരണങ്ങൾ രഹസ്യമായി സൂക്ഷിക്കുന്നതും ഗവേഷണാവശ്യത്തിനുമാത്രം ഉപയോഗിക്കുന്നതുമാണ്.

ക്രമ നം.	പ്രസ്താവനകൾ	യോജിക്കുന്നു	വിയോജിക്കുന്നു
1.	യുക്തി ചിന്താവികാസത്തിനു സഹായിക്കുന്ന വിഷയമാണ് ഗണിതം.		
2.	ഒരേ ഒരു രീതിയിൽ മാത്രമേ ഗണിതപ്രശ്നങ്ങൾ പരിഹരിക്കാൻ സാധിക്കൂ.		
3.	കായികമത്സരങ്ങളിൽ ഗണിതശാസ്ത്രത്തിനു പ്രാധാന്യം ഉണ്ട്.		
4.	ഗണിത പ്രശ്നങ്ങൾക്കു പരിഹാരം കണ്ടെത്തുന്നത് പ്രയാസമേറിയ കാര്യമാണ്.		
5.	കഠിനപ്രയത്നത്തിലൂടെ ആർക്കും ഗണിതശാസ്ത്രത്തിലെ പ്രശ്നങ്ങൾക്കു പരിഹാരം കണ്ടെത്താൻ കഴിയും.		

ക്രമ നം.	പ്രസ്താവനകൾ	യോജിക്കുന്നു	വിയോജിക്കുന്നു
6.	ഗണിത ചോദ്യത്തിന് ശരിയായ ഉത്തരം നൽകേണ്ടത് എങ്ങിനെയാണെന്ന് ഗണിതശാസ്ത്ര അധ്യാപകർക്ക് മാത്രമേ കാണിച്ചുതരാൻ സാധിക്കുകയുള്ളൂ.		
7.	ഓരോരുത്തർക്കും ക്രിയാത്മകമായ കഴിവുകൾ വളർത്താൻ ഗണിതശാസ്ത്ര പഠനത്തിലൂടെ സാധിക്കും.		
8.	അധ്യാപകരുടെ സഹായത്താൽ മാത്രമേ ഗണിതപ്രശ്നങ്ങൾക്ക് പരിഹാരം കണ്ടെത്താനാകൂ.		
9.	കൃത്യമായ പഠനപ്രവർത്തനങ്ങളിലൂടെ ഗണിതശാസ്ത്രത്തിലെ അവഗാഹം വർധിപ്പിക്കാം.		
10.	ഗണിതശാസ്ത്ര പ്രശ്നങ്ങളുടെ ഉത്തരങ്ങൾ ശരിയാണോയെന്ന് എളുപ്പത്തിൽ പരിശോധിക്കാവുന്നതാണ്.		
11.	ശാസ്ത്രചിന്തകളുടെ വികാസത്തിന് ഗണിതപഠനം സഹായിക്കുന്നു.		
12.	ഗണിതശാസ്ത്രം അറിയുന്നത് ഉപജീവനത്തിന് സഹായിക്കും.		
13.	യഥാർത്ഥലോകത്തെ പ്രതിനിധീകരിക്കുന്ന സ്വഭാവം ഗണിതശാസ്ത്രത്തിനുണ്ട്.		
14.	ഗണിതപഠനം മറ്റുവിഷയങ്ങളുടെ പഠനത്തെ സഹായിക്കുന്നു.		
15.	നിത്യജീവിതത്തിൽ ബാങ്കിടപ്പാടുകൾ നടത്താൻ ഗണിതം കൂടിയേ തീരൂ.		
16.	ഗണിതശാസ്ത്രപഠനം കുട്ടികളെ സ്വയം കാര്യങ്ങൾ കണ്ടെത്താൻ സഹായിക്കുന്നു.		
17.	കഠിനപ്രയത്നത്തിലൂടെ ഗണിതശാസ്ത്രത്തിലെ ആശയങ്ങൾ ഗ്രഹിക്കാൻ സാധിക്കും.		
18.	ഗണിതശാസ്ത്രം പഠിപ്പിക്കുന്നതിനു ഒന്നിലേറെ രീതികൾ ഉപയോഗിക്കുന്നു.		
19.	സജീവമായ പ്രക്രിയയിലൂടെയാണ് ഗണിതം പഠിക്കുന്നത്.		
20.	ശരിയായ രീതി അറിഞ്ഞാൽ മാത്രമേ ഗണിതശാസ്ത്ര പ്രശ്നം പരിഹരിക്കാൻ സാധിക്കൂ.		
21.	വിദ്യാർത്ഥിക്കുള്ള വിനിമയതന്ത്രങ്ങൾ രൂപപ്പെടുത്താൻ ഗണിതപഠനം സഹായിക്കുന്നു.		

Appendix

ക്രമ നം.	പ്രസ്താവനകൾ	യോജിക്കുന്നു	വിയോജിക്കുന്നു
22.	ഗണിതശാസ്ത്രത്തിനു അതിന്റേതായ സൂത്രവാക്യങ്ങളും, ചിഹ്നങ്ങളും നിയമങ്ങളും ഉണ്ട്.		
23.	എല്ലാവർക്കും ഒരുപോലെ കൈകാര്യം ചെയ്യാൻ സാധിക്കുന്ന വിഷയമാണ് ഗണിതം.		
24.	വൈവിധ്യമാർന്ന പ്രവർത്തനങ്ങൾക്ക് സാധ്യതയുള്ള വിഷയമാണ് ഗണിതം.		
25.	പെട്ടെന്ന് ഗ്രഹിക്കാൻ കഴിയുന്ന ആശയങ്ങളാണ് ഗണിതശാസ്ത്രത്തിൽ ഉള്ളത്.		
26.	ചിട്ടയോടുകൂടിയ പഠനത്തിലൂടെ ഏതു പ്രയാസമേറിയ ഗണിതപ്രശ്നങ്ങൾക്കും ഉത്തരം കണ്ടെത്താൻ സാധിക്കും.		
27.	ഗണിതപ്രശ്നങ്ങൾ പരിഹരിക്കാൻ വിവിധ മാർഗ്ഗങ്ങൾ ഉപയോഗിക്കാം.		
28.	ആസ്വാദ്യകരമായ രീതിയിൽ പഠനപ്രവർത്തനങ്ങൾ ക്രമീകരിക്കാൻ ഗണിതപഠനത്തിലൂടെ സാധിക്കുന്നു.		
29.	മന:പാഠം പഠിക്കാൻ പറ്റുന്ന ആശയങ്ങളാണ് ഗണിതത്തിലുള്ളത്.		
30.	കഠിന പ്രയത്നം കൊണ്ട് ഗണിതപരമായ കഴിവുകൾ വർധിപ്പിക്കാൻ സാധിക്കും.		
31.	കാര്യകാരണബന്ധങ്ങൾ വിശകലനം ചെയ്യാൻ ഗണിതപഠനം സഹായിക്കുന്നു.		
32.	വസ്തുതകൾ വിശകലനം ചെയ്തു പൊതുതത്വങ്ങൾ രൂപീകരിക്കാനുള്ള കഴിവ് ഗണിതപഠനത്തിലൂടെ സാധ്യമാകുന്നു.		
33.	തുടർച്ചയായി വികസിച്ചുകൊണ്ടിരിക്കുന്ന ഒരു വിഷയമാണ് ഗണിതം.		
34.	സമയമെടുത്ത് പഠിച്ചാൽ ഗണിതശാസ്ത്രത്തിലെ ഏത് ആശയവും പഠിക്കാൻ സാധിക്കും.		

Appendix XXI

FAROOK TRAINING COLLEGE
Research Centre in Education

MATHEMATICAL BELIEFS INVENTORY

(English – Final)

Radhika T.
Research Scholar

Dr. Niranjana K.P.
Assistant Professor

PERSONAL DETAILS

Name: ....

School:..

Class: .... Roll No.: ....

Instructions

Statements given below are related to Mathematics. Two responses are given for each statements, viz., 'Agree', 'Disagree'. Read each statement carefully and decide the appropriate response. Mark your response to each statement using a '✓' mark. Your response will be kept confidential and used only for research purposes.

Sl. No.	Statements	Agree	Disagree
1.	Mathematics helps in the development of logical thinking.		
2.	There is only one way to solve mathematics problems.		
3.	Mathematics plays an important role in sports.		
4.	It is highly challenging to find solutions for mathematics problems.		
5.	Everyone can solve mathematics problems through hard work.		
6.	Only mathematics teacher can explain how to answer mathematics problems.		
7.	Mathematics study enhances creativity.		
8.	Mathematics problems can be solved only with the help of a mathematics teacher.		
9.	Mathematical understanding can be strengthened through appropriate learning activities.		

Sl. No.	Statements	Agree	Disagree
10.	Solutions of math problems can be easily verified.		
11.	Mathematics learning helps in the development of scientific thinking.		
12.	Understanding of mathematics helps to earn for livelihood		
13.	Mathematics represents the real world		
14.	Study of mathematics supports the study of other subjects.		
15.	Banking transactions in day-to-day life requires mathematics.		
16.	Mathematics learning helps students to discover things themselves.		
17.	Mathematics concept can be comprehended through hardwork.		
18.	More than one method is used to teach mathematics.		
19.	Mathematics is learned through an active process.		
20.	Mathematics problems can be solved only when we know the correct method.		
21.	Mathematics helps students to design their communication strategies.		
22.	Mathematics has its own symbols, formulae and principles.		
23.	Mathematics is a subject that everyone can handle in a same manner.		
24.	Mathematics is a subject that has opportunities for a wide variety of activities.		
25.	Mathematics consist of concept that can be easily grasped.		
26.	Any difficult mathematics problem can be solved through systematic learning.		
27.	Different methods can be used to solve Mathematics problems.		
28.	The study of mathematical activity can be used to organize learning activities in an enjoyable way.		
29.	Mathematics concepts can be byhearted.		

Sl. No.	Statements	Agree	Disagree
30.	Mathematical abilities can be enhanced through hardwork.		
31.	Mathematics learning helps to develop the ability to analyse cause and effect relationship.		
32.	Mathematics learning helps to analyze facts and form general principles.		
33.	Mathematics is an ever-evolving subject.		
34.	Any concepts in mathematics can be learned by spending more time.		