

**A STUDY OF THE SCIENTIFIC PRODUCTIVITY AND
INFORMATION USE PATTERN OF SCIENTISTS
IN THE CONTEXT OF NEW INFORMATION
TECHNOLOGY WITH SPECIAL REFERENCE
TO UNVERSITIES IN KERALA**

Thesis Submitted to the University of Calicut for the
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in Library and Information Science

by
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CERTIFICATE

This is to certify that this thesis is an authentic record of the bonafide research work carried by Sri. Soman K.N. under my supervision and guidance and that neither this thesis nor any part of it has previously formed the basis for the award of any degree or diploma.



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DECLARATION

I, Soman. K.N., do hereby declare that this thesis “**A STUDY OF THE SCIENTIFIC PRODUCTIVITY AND INFORMATION USE PATTERN OF SCIENTISTS IN THE CONTEXT OF NEW INFORMATION TECHNOLOGY WITH SPECIAL REFERENCE TO UNIVERSITIES IN KERALA**” has not been previously formed the basis for the award of a Degree, Diploma or Recognition.

Calicut University,

25-06-2001


Soman. K.N.

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CHAPTER I

INTRODUCTION

- 1.1 Need and Significance of the study
- 1.2 Statement of the Problem
- 1.3 Definition of the Terms
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- 1.5 Objectives
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CHAPTER I

INTRODUCTION

Information is one of the fundamental resources indispensable for development in all the vital spheres of life of the civilized society. Modern society can rightly be designated as information society in which information has become the strategic import for all major societal activities and the outcome of these activities result in the generation or creation of new information. In other words, information has acquired the status of a commodity for consumption and production. The informatization of a society depends on its ability to treat information as a resource.

Fritz Machlup (1962) indicated that the United States was the major player in the production of information in the four main sectors—Education, Communication Media, Information Machinery and Information Services. In 1958, they accounted for 29% of the U S Gross National Product (GNP). Peter Drucker (1968) pointed out that the difference between advanced and less developed nations lies in the ability to generate and use knowledge resources in the form of experts, scientists, libraries, information centres and new technologies.

The economic growth enjoyed by the developed nations in the world today has been spearheaded by scientific and technological discoveries and their development and applications. A solid foundation for development is found in the country's tradition of research and scholarship passed on to younger generations in the form of scholarly publications and patents.

Currently scientific and technical publications from the developed countries have a predominant place in the world of science and technology research. The less developed countries depend on the developed ones for scientific information to propel research and the development of the nation. Hence the governments of developing countries must pay more attention to information production, i.e., research and development activities to be passed on to the future generation and reduce the dependence on the information import.

In the process of the scientific information production, or output, the information consumption is the essential input. Hence in these input-output processes, we have to increase the output of information and knowledge by the optimum use of the available information and knowledge. Hence for the purpose of maximum output of information/knowledge certain strategies and policies at the national level have to be formulated. The two knowledge theories, put forth by Mathew, (1985) on the information consumption-production of the scientists have greater importance in the context of this input-output processes and also to increase the output of scientific information of the nation for the overall development. In the process of the national productivity of scientific and technological information, the Universities could play an important role.

There are various theories of knowledge expounded in Epistemology, Metaphysics, Philosophy of Science, Cognitive Psychology, and Cybernetics etc. that explain the nature, origin, meaning, purpose and limits of knowledge. The theories of knowledge and information are also dealt in the Philosophy, Psychology, Computer

Science besides Library and Information Science. They have become highly complex and multidisciplinary in nature.

The complex process of information consumption (input) and information production (output) needs to be studied in detail with sound theoretical and methodological foundations. However this question of developing theories and methodology poses a great challenge to Information Scientists and Information Technologists at international level. This specific area of research remains as an almost virgin field, with a lot of challenges and possibilities. Information Scientists are still now reluctant to explore this area of research even though information generation and use are the very basis of modern Information Science. The present study is a major pioneering attempt in this regard. Being a pioneering study it could not rely much on any of the existing models and approaches and there is a need to develop original models and approaches of its own.

1.1 Need and Significance of the Study

In the developing countries, Universities have to play an active role in transforming traditional society into the modern information society by creating the information consciousness and sustained demand for information, a critical source for development, and finally by meeting the information needs of the society. Universities have the social obligation for producing specific, technical and skilled manpower required for the society. Universities have a major role in information generation since major part of scientific and technical publications are from the Universities. (Mathew, 1981)

Productivity in scientific and technological information of a country determines its overall development. Having a population of more than 100 crores and gifted with high intellectuals and diversified resources in India, the scientific and technological productivity is not upto the desired level. Our scientists, who were not so productive and creative in India, have become highly productive with their valuable creations when they are employed in Western countries. This phenomenon needs to be studied in depth.

The very survival and growth of India, in this age of globalization and cutthroat competition, depends on its ability to increase scientific and technological information productivity, especially at university level. This is the basic task of Universities that they have to train younger generation of scientists and technologists with information handling abilities coupled with advanced level of scientific and technical information consumption and production.

Information consumption is a general function that every individual performs while information production of advanced nature is a complex one and performed by a few. They are responsible for the nation's overall development through their scientific and technological contributions. The Universities with courses and curricula at the post graduate level and advanced research programmes develop information handling skills and expertise that will lead to advanced level information consumption and production of the scientists.

The scientific and technological productivity of the Universities in Kerala is at low level, in spite of acquiring different systems and components of modern technologies especially with the assistance from

University Grants Commission and Government of India. The basic reasons for such low productivity are still now unearthed. There is an urgent need for the study of the basic factors that lead to the high level information consumption and production of scientists in the Universities in Kerala, including the application of Information Technology for this purpose. The present study is a theory-based application study quite different from the conventional bibliometric study. The present study also aims at formulating policies and strategies so that India could improve its scientific information productivity, which leads to the overall development. An attempt has been made to integrate information technology and scientific productivity so as to formulate correct policies. The present study also aims at the testing of the validity of the knowledge theories formulated by Mathew (1985) and the role of the information technologies in augmenting the information consumption production processes. The present study is on the scientific productivity of physical scientists of Universities in Kerala measured in terms of their information production.

The investigator's back ground in Physical Sciences, Information Science and familiarity on Information Technology applications on the research processes helped him to pursue the present study, that too with an interdisciplinary approach. The theoretical basis of the research guide especially in the areas of theory, strategy and policies and in areas related to information technology also helped the investigator in conducting the present study.

It may be noted that no study of this kind has so far been conducted in the specific context of the Third World. However a comparison of

information generation of different faculties of the University of Calicut was made by Adiyodi in 1993. There is no useful model to assess the efficiency of scientific community with regard to their increased information productivity. It is believed that the study enables to assess the present University Education System for fulfilling its function of equipping individual with expertise in the generation of scientific information and increasing the information generation capacity of university teachers and researchers through the wider application of information technology.

1.2 Statement of the Problem

The study is entitled as **“A study of the Scientific Productivity and Information Use Pattern of Scientists in the context of New Information Technology with special reference to Universities in Kerala.”**

1.3 Definition of the Terms

The word ‘study’ means the careful examination or observe carefully (Oxford English Dictionary, 1970).

‘Productivity’ means the quality or fact of being productive, capacity to productiveness (Oxford English Dictionary, 1990). The productivity of the scientists in the context of scientific research is measured by his/her output on publications. This is a hypothesis, which has been accepted since the beginnings of the twentieth century, says Voos (1974). Hence the concept of scientific productivity has been used in the same sense as the number of publications especially research papers published in journals by scientists.

‘Information’ is defined as the communication or reception of knowledge or intelligence, something obtained or received through informing, the process by which the form of an object of knowledge impressed up on the apprehending mind so as to bring about the status of knowing (Webster’s Third International Dictionary of the English Language, 1968)

‘Use’ means utilisation or employment for or with some aim or purpose (Oxford English Dictionary, 1970).

‘Pattern’ is mode, design, plan etc from which something can be made (Oxford English Dictionary, 1970).

‘Scientists’ in the context of the present study are the teachers and research scholars working in the physical sciences teaching and research departments of Universities in Kerala.

‘Information Use Pattern of Scientists’, refers to the use of various information sources by the Scientists. The various information sources in the present study are research journals, abstracting/indexing books/monographs, reprints/pre-prints, consultation with others, attending seminars and membership in learned societies etc.

‘Information Technology’ according to UNESCO is “the scientific, technological and engineering disciplines and management techniques used in information handling and processing their applications, computers and their interaction with men and machines and associated social, economic and cultural matters”. Information Technology in its wider sense can be defined as any technology related to recording, presentation, and communication of information and knowledge emerged from time

immemorial. On the other hand “New Information Technology” connotes the massive application of electronic or digital technologies for the recording presentation and communication of information and knowledge. The new information technologies include online services, optical storage of information, electronic publishing, electronic mail, networks, artificial intelligence, expert systems etc.

Universities in Kerala: Universities in Kerala comprises the four main Universities in Kerala, viz., Calicut, Kerala, Mahatma Gandhi Universities and Cochin University of Science and Technology. All these universities have well-established physical sciences teaching departments.

1.4 Variables of the Study

The study has been designed with the major independent variables, the personal characteristics such as age, sex, designation, experience in teaching and research, subjects, doctoral theses produced, information consumption time and the use of various information sources and the dependent variable, namely, number of papers published.

1.5 Objectives

1. To assess the level of scientific productivity of physical scientists measured in terms of published works including new inventions and guiding doctoral research works as information production in the Universities in Kerala.

2. To explore the various factors that affect the information productivity of physical scientists in the Universities under study.

3. To examine whether there exists a direct correlation between information productivity of physical scientists and use of library and information resources and services termed as information consumption so as to test the validity of the generalised theory of information/knowledge consumption-production correlation.

4. To identify the various stages of information consumption growth for information production, among the scientists, so as to test the validity of the stage theory of information/knowledge consumption growth.

5. To examine the role of information technology in augmenting the scientific information consumption and information production.

6. To suggest the ways and means for increasing the efficiency of Physical scientists with regard to use of library and information resources, and thereby information consumption and production.

1.6 Hypotheses

- 1) There exist differences with regard to information consumption and information production for different categories of physical scientists in the Universities of Kerala.
- 2) There exist similarities in the pattern of information use among the different category of physical scientists.
- 3) The proper application of information technology could augment the information consumption production processes of the physical scientists in the Universities in Kerala considerably.

1.7 Methodology in Brief

The study is very much based on the theoretical aspects with practical implications. It is hoped that the present study provides basic methodological and theoretical explanation for Information Science especially with regard to information or knowledge consumption and production by the scientific community and also the role of Information Technology in their tasks.

The data for the study has been collected by administering the specially developed questionnaires and conducting interviews among physical scientists of the four major Universities in Kerala, namely University of Calicut, University of Kerala, Mahathma Gandhi University and Cochin University of Science and Technology. In the categories of physical scientists both the teachers and research scholars of these universities have been taken into account. The data collected has been analysed using appropriate statistical techniques for interpretations.

CHAPTER II

THEORETICAL OVERVIEW

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- 2.7 The Theories of Knowledge
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 - 2.7.2 Meta physics
 - 2.7.3 Philosophy of Science
 - 2.7.4 Cognitive Psychology
 - 2.7.4.1 Problem solving and creativity
 - 2.7.5 Cybernetics

CHAPTER II

THEORETICAL OVERVIEW

Since the present study is basically a theoretical one with a lot of practical implications a conceptual frame work for information/knowledge, communication, information use, information generation and information technologies are essential to have clear idea about information/knowledge, consumption and production and its relationship. The knowledge particularly human knowledge are explained in Epistemology, Metaphysics, Philosophy of Science, Cognitive Sciences and Cybernetics, etc and hence a brief discussion of these theories are also given in the present chapter. Considering the importance of the above concepts and theories for conducting the present study, this topic of theoretical overview has been taken as a chapter, though this is an integral part of review of literature.

2.1 Information

According to Norman (1986) “Information in one form or another, has constantly been of significant element in the development of human society and it has shaped over a long period of time, the way in which we think and act”.

The word 'Information is derived from the verb to 'inform', that a message of some sort has been issued, received and understood. When knowledge is put to use it becomes information.

Viswanathan (1976) defines, "Information is the product of human brains in action and may be abstract or concrete". McDonough (1963) states, "Information is the measure of the net value obtained from the process of matching the elements of a present problem with appropriate elements of data". He further adds "information is a process which occurs within a human mind when a problem and data used for its solution are brought into productive union". This indicates that information is the product of human thinking caused when the problem is solved using the data related to it. Brooks (1981) believe that information implies in knowledge.

Information is defined in different ways in the linguistic dictionary (Webster's Third International Dictionary of the English Language, 1968). They are as follows.

1. The communication or reception of knowledge or intelligence.

Examples (a) the function of a library is information

(b) we enclose a price list for your information

2. Some thing received or obtained through informing as

- a) Knowledge communicated by others or obtained from investigation, study or instruction. Example: That is all the information that could be obtained by conducting the investigation.
 - b) Knowledge of a particular event or situation, (in this sense it is synonymous with 'intelligence news' and 'advises') Examples (a) The latest information from the battle field or front did not reach yet (b) Securing information about the conditions in the upper atmosphere has become very difficult (c) Please contact the information bureau for further advise.
 - (c) Facts and figures ready for communication or use as distinguished from those incorporated in a formally organised branch of knowledge, (in this sense it is synonymous with data) example: This is indeed a reliable source of information so far as the population of Ethiopia is concerned.
 - (d) A signal (as one of the digits in dialing a telephone number) purposely impressed up on the input of a communication system or a calculating machine. Example: Most of the information produced by this device is wrong.
3. The act of informing against a person or a part. Example: His information against his colleague was ridiculous.

4. (a) A formal accusation of a crime made by a prosecuting officer on information brought to his attention as distinguished from an indictment presented by grand jury, (in this sense it is synonymous with complaint) Example: The verdict of the grand jury was bit guilty, even though the prosecutor's information sounded quite convincing.

(b) A pleading by an Attorney General or some public or another public officer setting forth a civil case of relief in which some public right of the state is asserted. Example: Attorney General's information worked ultimately; and the relief was granted to him.

(c) The document containing the depositions of the witnesses against one accused of crime. Example: That information, now made accessible to the public by the court bears testimony to the fact that he committed a serious crime.

5. The process by which the form of an object of knowledge is impressed up on the apprehending mind so as to bring about the state of knowing. Example: The information used by him was adequate enough to develop an appropriate conception of a system.

6. A logical quantity belonging to propositions and arguments as well as terms and comprising the source of the synthetical proposition in which the term, proposition, or argument taken enters as subject or predicate, antecedent or consequent; (in this sense it is synonymous

with quantity, in the context of formal logic, that is, Logical quantity),
 Example: Here it appears to be quite difficult to find out the
 information of this sum of the synthetical propositions.

7. A numerical quantity that measures the uncertainty in the outcome of an experiment to be performed, Examples: (a) when an event occurs whose probability was P , the event is said to communicate an amount of information. $\log(I/P)$; (FW Brown) (b) the amount of information is defined, in the simplest cases to be measured by the logarithm of the number of available choices (Shannon and Weaver) (Webster's third International Dictionary of the English Language, 1968).

By analysing the term 'Information used' Bhattacharya (1997) arrived at the conclusion that it is primarily used to denote either an entity or an action. Information in the sense of an action means an act of informing where the informing is a derivative of the verb form. The act of informing is, no doubt, relevant to an information scientist. In some of the senses, it refer to (a) a 'signal in relation to hardware communicated system (2) a 'document' in relation to constant crimes (3) a logical quantity in relation to symbolic or mathematical logic and (4) a numerical quantity in relation to Shannon's information theory. There are few more cases where information refers entities. Here the entity referred to is knowledge of an event (3) knowledge of a situation and (4) facts and figures, which are only knowledge units.

According to Barlow (1996) information is by its nature, intangible and hard to define. As per properties, he described information by the following statements.

- (1) Information is an activity
- (2) Information is a life form
- (3) Information is a relationship

(1) Information is an activity

Information is not a thing: In fact it is something that happens in the field of interaction between minds or objects of other piece of information. Hence information is a verb not a noun. Information is experienced not possessed. Even when it has been encapsulated in some static form like a book or a hard disk information is still something that happens to you as you mentally decompress it from its storage code.

Information has to move: Information that is not moving ceases to exist as anything but potential at least until it is allowed to move again. Information is conveyed by propagation, not distribution. It moves more like some thing from nature than from a factory. It doesn't simply move on. It leaves a trail of itself everywhere it's been. The central economic distinction between information and physical property is the ability of information to be transferred without leaving the possession of the original owner.

(2) Information is a life form

Information self reproduce, interact with their surroundings and adapt to them, they mutate, they persist. Like any other life form they evolve to fill the possible spaces of their local environments, which are, in this case, the surrounding belief systems and cultures of their hosts. The more universal resonant an idea or image or song, the more minds it will enter and remain within. Information wants to change. If ideas and other interactive patterns of information are indeed life forms they can be expected to evolve constantly into forms that will be more perfectly adapted to their surroundings. Information is perishable. Most information is like farm produce. Its quality degrades rapidly both over time and in distance from the source of production. But even here, value is highly subjective and conditional. Yesterday's papers are quite valuable to the historians. In fact, the older they are, the more valuable they become.

(3) Information is a relationship

In most cases, we assign value to information based on its meaningfulness. The place where information dwells, the holy moment where transmission becomes reception, is a region that has many shifting characteristics and flavours depending on the relationship of sender and receiver, the depth of their interactivity. Each such relationship is unique. Receiving information in even in broadcast medium is often as creative as

act as generating it. The value of what is sent depends entirely on the extent to which each individual receiver has the receptors-shared terminology, attention, interest, language, paradigm, necessary to render what is received meaningful. Understanding is a critical element increasingly overlooked in the effort to turn information in to a commodity. Data may be any set of facts useful or not, intelligible or inscrutable, germinae or irrelevant. Computers can crank out new data all might long without human help, and the results may be offered for sale as information. They may or may not actually be so. Only a human being can recognise the meaning that separates information from data. In fact, information, in the economic sense of the word, consists of data that have been passed through a particular human mind and found meaningful within the mental context. One tells as information is all just data to some one else. Familiarity is an important asset in the world of information.

Information has always existed. It is an inherent part of the human being (Curras E, 1985, 1987). Without information we cannot develop. Nor would society evolve. The information produced in large quantities and circulated due to discoveries and inventions of last two centuries, gives rise to new inventions and discoveries, which again, produce more information (Curras, E, 1995).

Mchale (1981) assumes that information is stored in the brain and processes for further use. Berg Strom (1989) compared the brain to a machine that processes information. Buckland (1991) makes a distinction

between information as thing, information as knowledge and information as process based on the analysis of dictionary meaning given in the Oxford English dictionary (1989).

- (a) **Information as process:** when some one is informed that they know is changed, in this sense information “the act of informing... communication of knowledge or news of some fact or occurrences the actions of telling or fact of being told of something.”
- (b) **Information as thing:** The term ‘information’ is also used attributively for objects, such as data and documents that are referred to as ‘information’ because they are regarded as being informative, as having the quality of importing knowledge or communication information, instructive.
- (c) **Information as knowledge:** Information is only produced in our brain when we perceive, analyse and judge it according to the intentionality we believe it to have (Curras, E, 1988). Information does not exist itself despite linguistic laxners and traditional terminological customs that lead us to believe the contrary. In addition to that ontogenetic information that is often subconsciously perceived and processed in the brain, there is information that we want and look for, that has to be prepared from data, documents and objects. Information should therefore be considered in two ways as a phenomenon and as a process. Curras, E (1995) diagrammatically summarises the definition of information in figure 2.1 and 2.2.

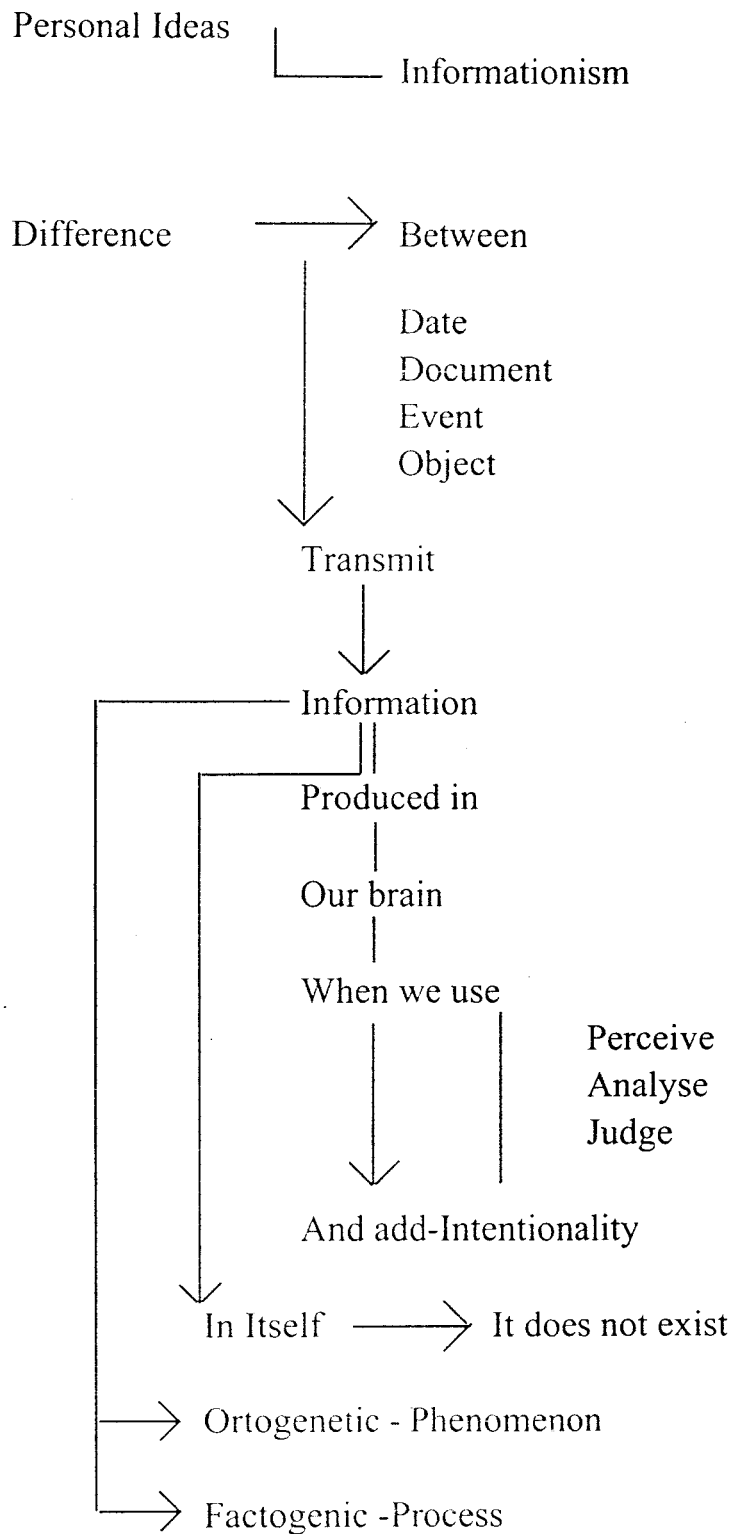


Fig 2.1
Definition of information

Source: Cursas, E. Information Science - Information as a Dialéctic Interactive Systems, International Forum on Information and Documentation, 20(1), 1995, p. 34.

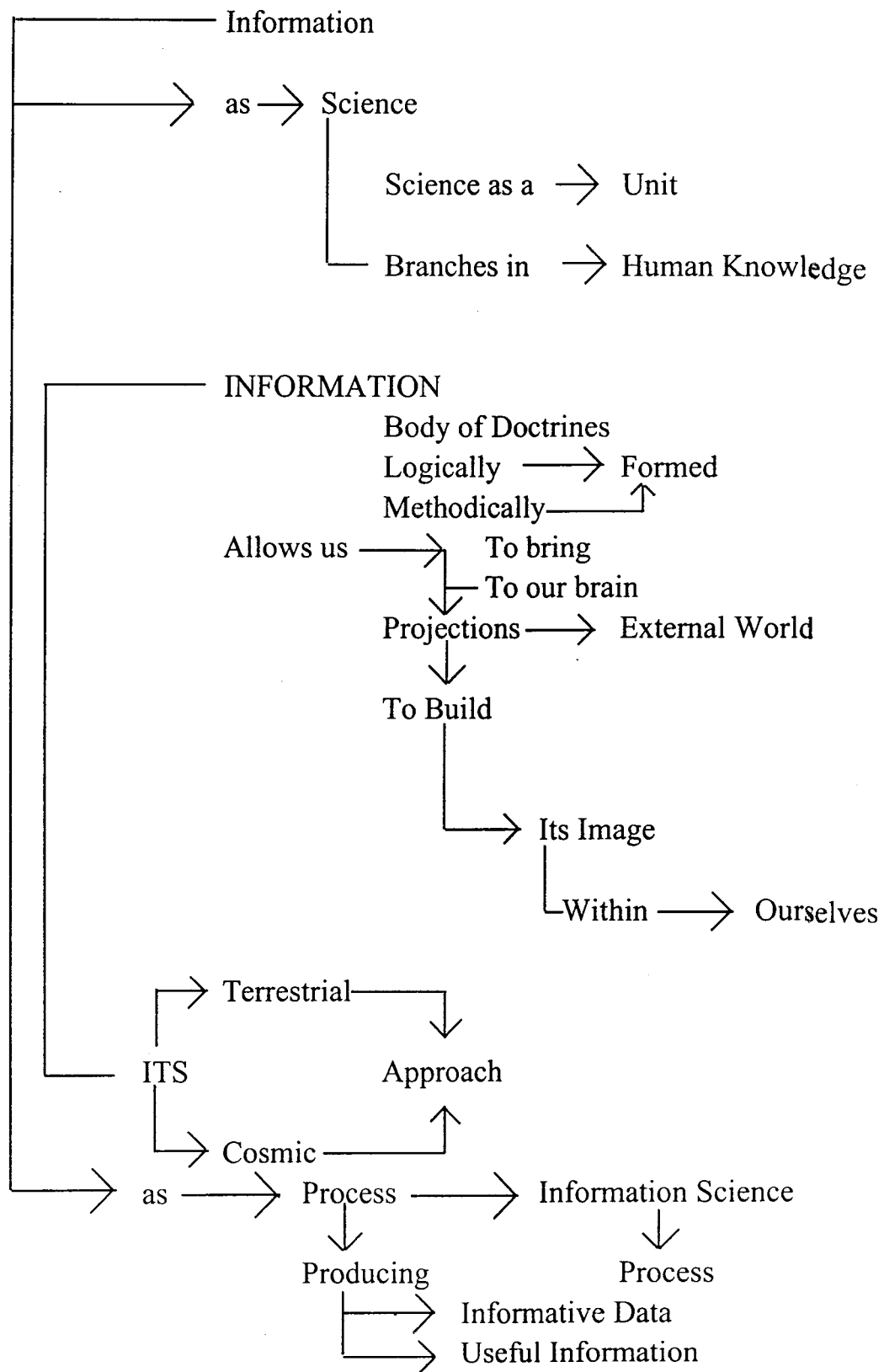


Fig. 2.2
Definition of Information

Source: Cursas, E. Information Science - Information as a Dialectic Interactive Systems, International Forum on Information and Documentation, 20(1), 1995, p. 35.

The change in the social structures evolves a transmutation process and taking place that is affecting all scientific manifestation. Information, regards as vital element is also affected by present day transmutations. The concept of information is being modified and expanded. It is not merely the act of stating what happens or is known in a human activity. Behind information there is process appertaining to living beings to adjust their existential meditation to the medium in which they live. It acquires very specific annotation in human beings; being both ontological and intelligent. In other words intelligence, as a purely human faculty, plays an important decisive role as regards information.

The present moment should be considered as a period of scientific integration in which all specific and special science, or all branches of human knowledge, are going to connect. Through out the development of mankind, periods of scientific integration have alternated with periods in which the sciences have become distanced. Information as a phenomenon and as a process, acquire a new dimension that goes from being to the environment and from the environment to the being. It is an inevitable vehicle in this process among scientific areas to form an interconnecting common whole that should induce human beings to build a better world. For this they will use the means they have materials, tools and gadgets according to the dictates of the economy and industry. The information industry likewise procures a relevant position in the scientific integration process. Curras, E, (1997).

According to Curras (1997) information as a phenomenon is independent of us. It exists in its own right and accordingly function, consciously or unconsciously, within ourselves to produce a reaction that eventually modifies our attitudes and state of knowledge, with all its ontological, social and moral connotations, information as a process is developed consciously from data, documents or events. It is looked for and, therefore, accepted, appraised and used. It produces an identical reaction to that of information as a phenomenon. Information, which is as subtle as time and as essential as our daily sustenance, has been presented here under varying aspects.

- innate to human beings
- a principle for the formation of knowledge
- a primary means for reaching science through research
- a guide to scientific methods
- a phenomenon produced in our sphere of relation
- a conscious, or unconscious, modifier of brain development
- a means of power
- a raw material in creative process

2.2 Information and communication

When knowledge is put to use it becomes information. Information is that one which can be communicated either by animate or inanimate things (Raj Gopal, 1995). The communication in any term conveys information. Where there is communication there is information

associated with it. The concept of information is associated with concepts of communication.

Tulving (1972) explains information in terms of communication as,

1. The process by which meanings are exchanged between individuals through a common system of symbols such as language, signs and gestures and exchange of thoughts and opinions, and
2. An art that deals with expressing and exchanging ideas effectively in speech or writing or through graphic or dramatic arts and that is taught as an integrated programme at various level of education in distinction to traditional courses in composition and speech.

The first sense above refers what gets exchanged is obviously information which has been expressed here as ideas, thoughts and opinions. The term communication refers to the following also.

1. Facts or information communicated.
2. A letter, note, or other instances of written information
3. Means of communicating, such as telephone or telegraph system for communicating information and order
4. A medium through which information as carried
5. The function in an industrial organisation that transmits ideas, policies, and orders
6. Personnel engaged in communicating and
7. Close or intimate rapport that is sometime intellectual and affective

Self Communication and Communication with Others

The term communication in common understanding stands essentially for communication with others. It refers specifically to the process in which two distinct parties are readily recognizable the communicator and the communicatee. The communicator conveys his information through a common system of symbols such as, language natural or artificial and the communicatee receives that information by his powers of hearing, seeing etc. Here communication does not refer to the process in which one gets fully involved in the process of exchanging ideas, thoughts, opinions, facts, meanings, information etc. with one self in the simultaneous two roles of a communicator or it is called thinking. Thinking is used to comprehend its several instances, such as perception, 'analysis', classification, 'consolidation', 'integration', interpretation, conclusion, conception, 'organisation', and 'association'. These instances are all intellectually carried out mental operation. The results or products of thinking are no doubt the products of self-communication.

Communication with others is carried out by two distinct modes, namely (1) the spoken mode, and (2) the written mode. For these two modes to be operative, the existence of two distinct parties is to be assumed, that is the existence of (1) a communicator and (2) a communicatee. What is communicated by the communicator is the product of his thinking, that is his self-communication. What is received

by the communicatee is again the product of his thinking (self communication) initiated by the product of the thinking of the communicator.

The process of communication with others is always based and governed by the product or process of self-communication already carried out by the communicator prior to his communication with others. The more systematic the later process is the more precise the communication with others is, the more accurate is, the understanding of its message by the communicatee. The understanding of the message of a piece of communication is again a product of self-communication carried out by the communicatee. (Meredith, 1961).

Now we can examine the process of self-communication. The human body and mind (brain) are endowed with certain distinct kinds of power. They are called powers of body of physical powers of mind or mental power. Among the power of seeing, hearing, smelling, testing and touching which are carried out by the power of body, there are five different kinds of primary senses namely by eyes, ears, nose, tongue and skin respectively what ever happens in the outside world is perceived by one or more of these senses and creates an impression in the brain and it is made meaningful by the brain by its powers of understanding through recognition. The meaningful impressions in the brain are precepts; and the mental operation responsible for their generation or formation is

carried out by the faculty of perception. The thinking starts with the operation of the initial meaningful impressions get stored in the store of already existing percepts in the brain. In storing the percepts in the brain, the mental faculties of organisation and association become operative. In organisation, the hierarchical relationship such as, super-ordinate, subordinate, co-ordinate, and collateral relationships among the percepts are considered.

On the other hand, in association with the non-hierarchical associative relationship among the percept are considered. Now they warrant further mental operations and the other instances of thinking become operative. These instances are analysis, classification or categorization, consolidation, integration, interpretation, evaluation and conclusion. In carrying out these operations logic, reflection, imagination and some times intuition, play the most vital role. They become operative as and when the problems in mind warrant them. Now the newly formed concepts get stored on the already existing store of concepts in the brain. Here again, in storing the concepts, the mental faculties of organisation and association become operative. (Tulving and Donaldson, 1972).

Knowing, Remembering and Learning

The process of thinking is synonymous with process of self-communication. The stage of self-communication is the stage of the conception. The concept of 'conception' is learning. The concept of

learning implies knowing, conception is learning, and learning is knowing; if and only if it is remembered. Therefore remembering is one of the most important psychological phenomenon. Now the psychological phenomena, 'knowing', remembering, and learning may be defined as follows.

Knowing

Knowing an existent refers to the mental process by which one is in state of mind in which given, time one can answer any reasonable question about the existent concerned.

Remembering

Remembering an existent, refers to the mental process by which one is in a state of mind in which one can immediately, reproduce existent if required to do so.

Learning

Learning is a generic concept. It comprehends the concepts of (1) learning for remembering and (2) learning for knowing.

Learning for remembering, an existent, refers to the mental process by which one is acquainted with the existent concerned in such a way that it can be retained and reproduced whenever required.

Learning for knowing, an existent, refers to the mental process by which one is acquainted with the existent concerned in such a way that it is understood, and retained, and that it can be sooner or later, reproduced if required, either partly or fully.

Remembering requires retaining and reproducing. When we come across a name forget it for a moment and a moment later it comes to our mind is called the phenomenon of retaining. Reproducing is based on recalling. Learning for remembering, an existent there fore, requires one to be acquainted in such a way that one can both retain and recall the existent concerned whenever one wishes. It requires drilling. Drilling consists of repeated acquaintances for retaining and repeated testing for recalling.

Learning for knowing an existent involves two process (1) Understanding and (2) Retaining. One can remember without always understanding and one can know without always remembering. In the mind the stored items contributes memory. It is the stored sketches, which constitute understanding. (Meredith, 1961).

2.3 Information and Knowledge

Knowledge is the sum total of known and unknown entities and is the result of human endeavours and past experiences accumulated through generation. Infact knowledge is dynamic in character, multi

dimensional in size and ever growing in its range and scope. According to Brookes (1980) knowledge is a sum of many bits of information and when more information is added the existing knowledge structure gets modified.

Knowledge is acquired from generation to generation, civilization to civilization. It is an admitted fact that the increasing demands of man have led him to learn more. Man is continuously making research for inventing new things and discovering the means to have his daily needs fulfilled. It had been a perpetual desire in man since the remote past to know more about the Universe and things around him. Man made experiments and learned about the Universe through them. Machlup and Mansfield (1983) defined information and knowledge as, “information is a flow of message, where as knowledge is a stock largely resulting from the flow, in the sense that input of information may affect the stock of knowledge by adding to it, restructuring it or changing it in any way.”

The meaning of word, ‘knowledge’ is wisdom which enlightens brain and mind. Though brain and mind are two different units in human being. The former stands for understanding and the later is an idea of sentiment yet their relation in reciprocal towards growth of knowledge. Further knowledge is an impact of two things, i.e. knower and ‘knowee’. The former is a subject or person and the later is object, entity place or a thing.

The concept of knowledge is quite divergent in nature, it varies from man to man, subject to subject, period to period and still more from region to region; with the passage of time, it took various phases and thus a number of definitions of knowledge are now available in literature few of them are given as under.

1. "It is a sum total of information conserved by civilization" (Dr. Ranganathan).
2. "Knowledge is the consequence of filtered process through intellectual system" (Dr. Shera).
3. The Webster's New International Dictionary of English language defines knowledge as, "Familiarity gained by actual experiences, practical skill, technical acquaintance". It also been defined by Webster's as "Acquaintance with facts; the state of being aware of something or of possessing information; hence scope of information.
4. Oxford English Dictionary of English Language defines knowledge in various ways but the most relevant definitions to this study are the following.
 - (a) "Intellectual acquaintance with perception of, fact or truth; cleared certain mental apprehensions, the fact, state or condition of understanding"

- (b) Acquaintance with a branch of learning a language or the life; theoretical or practical understanding of an art, science, industry etc”.
5. The Random House Dictionary of the English language, defines knowledge as (a) acquaintance with facts, truths or principles, as from study or investigations (b) as familiarity or convenience as with a particular subject, branch of learning, etc”.
 6. In scientific terms knowledge is the totality of facts gained by human labour, experience and experiments; as well as fiction or mythological or artistical production learnt irrationally through the use of mental and spiritual powers.
 7. The simplest definition of knowledge is “the sum of what is known”. Or knowledge can be stated as “assured belief” for detailed definitions of knowledge it is worthwhile to read Mortimer J Adlers learned article “Knowledge becomes self conscious” published in the New Encyclopaedia Britannica. He classifies the knowledge of the Universe into ten parts, each of which is broken down in to divisions and sectors.

What is known to us as human beings is called knowledge. Thus there can be no knowledge without a knower and knowee. Knowledge does not and cannot exist in abstract sense. One can doubt the existence of knowledge without some one to know it. Knowledge is always relative

to the knower. Knowledge is the creation of human mind and it has to be evolved.

The knowledge is the totality of what is known. The whole body of truth, facts, principles, belief or other objects acquired by mankind, knowledge may be false or true, fact or fiction, within the reach or beyond the reach of senses. It is still knowledge has various characteristics. It is dynamic and ever growing. It is multidimensional and continuous. It can be arranged in a variety of ways. It is hard to analyse it in morphological terms. (Tulving and Donaldson, 1972).

Because of its divergent nature, philosophers have assigned many synonyms to the term "Knowledge", such as understanding, learning, lore, erudition scholarship, wisdom, science, etc.

Knowledge is the collected and stored information about any subject of study objects, events or any mental construct that can be used at late date (Woosely, 1976). Knowledge development denotes the increasing dimensions of knowledge through growth process. The body of knowledge increases either by deriving relation between different units of information i.e., by adding information the existing information (knowledge) or by collecting new information (Swarupanandam, 1996).

There are three types of knowledge in existence identified as personal knowledge, as social continuity knowledge (which passes on

cultural patterns and as abstracted knowledge or information (Shriedder, 1992).

Information retrieval is synonymous with knowledge in some substantive senses. (Bhattacharyya, 1997) Examples are

1. Knowledge that is possessed and communicated by a communicator to a communicatee is information.
2. Knowledge that is received by a communicatee from a communicator through the process of self-communication, or the knowledge that is possessed by communicatee is information.
3. Knowledge that is obtained by a communicatee out of his study, investigation, and experience, through the process of self-communication and possessed by him is information.
4. Knowledge of an event or of a situation that is possessed, communicated or received or obtained through the process of self communication is information and
5. Facts and figures, which are only knowledge units, are information and they are normally referred to as data.

In addition, it is also found that when a piece of information that undergoes mental processing (Physiological and intellectual operation) for the purpose of generating another piece of information, the former

also is referred to as data. Another fact that emerges out of this analysis is that persuaded information is always referred to by the term knowledge.

Knowledge is durable, general, abstract, theoretical, objective, context free rule like, expressed in the relationship between variables (the model) (Schreinemakers, 1996). Information is transient, specific, concrete, practical, subjective, context dependent, case like, and expressed in the value of variables (the input/output).

Information is a tangible representation of data or knowledge within a specific context. The key success factor is the effectiveness of the representation in communicating the information. Knowledge is information in the context of an individual's role, learning, behaviour and experience. The key success factors includes the congruity between the information and the individual's prospective. The major steps that occur in the transforming of information into knowledge are learning, knowing, filtering, evaluating and balancing (Chen, 1998).

2.4 Information Use

The information explodes into power only when it is transferred and communicated. In other words information is activated by communication. The purpose of transfer and communication of information is use. Without the intention on the part of the ultimate receiver or beneficiary of information to use it, the whole exercise of

transfer and communication, becomes futile and information transferred becomes redundant. Seeking and communicating information are two sides of same coin from the viewpoint of individuals concerned. Both have the same purpose.

Information is defined in terms of experiences where by people are linked with one another in mutually useful ways where it is created, shared and used by two or more persons acting up on together, rather than its existence in symbolic terms in books, data banks, files, etc. No information is worth having unless it has use; Use of information is wide and varied. It may be to gain knowledge, may be understanding already known one, or it even be stimulating new ideas or triggering a research project and confirming the already known ideas.

Use of information make the information kinetic and generate new information. The applications of information technology make the information more kinetic, increases in use and hence help the generation of information. The use of information, by collecting, grasping, assimilating and analysing for concept formulation and clarification for questions or understanding problems to be solved is termed as information consumption.

According to Mathew (1984) 'information consumption is the process of acquiring or collecting data or information, on the one hand and grasping, assimilating or analysing them to concept formulation,

classification, formulating, questions or understanding the problems to be solved or arriving at conclusion.

2.5 Information generation

Information is “the resulting intellectual work product when data elements are organised and communicated in a successful form to reduce uncertainty, example to help answer a question, to solve a problem or to inform the basis of action”. This definition is developed by Information Association in the United States. Hence information is a product, i.e. the result product of information production.

Information production is the creation or invention of new ideas, theories, facts, devices or machines, finding new relationships between variables, or phenomena or providing new interpretations or explanations for known phenomena or facts or innovation and application of theories and principles or ideas in real world situations which are brought to light by communication (Mathew, 1984).

Every new information is produced on the foundations of existing information. Without consumption of existing knowledge, no new information can be generated. Hence we can say that active use of current knowledge only can create new ones. The advancement of science and technology resulted in the exponential growth of literature in science and technology information explosion. In order to handle the vast quantum of

information, the conventional method is very ineffective. Hence for collecting, processing, storing and transfer of information, new technologies of computers and telecommunications are applied.

2.6 Information Technology

The impact of information explosion reveals that the needed information at any moment appears to be diverse and diffuse. It should be processed i.e. analysed, synthesised and tailored for easy assimilation and consumption. Thus the capacity to handle and disseminate information to pertinent users is an important activity. It is noteworthy that the possession of the capacity to handle information and knowledge become the means of access to and source of power and the potential for material wealth, as a society tends towards technological and industrial growth. The developments in microelectronics, computerised and image processing and optical character recognition, electronic transmission systems, satellite telecommunication and television technology have provided us with the means to deal with the information flow. (Karisiddhappa & Padhi, 1989).

Information Technology (IT) is the product of fusion of information science and high technology. Information Science comprises of set of practices and related disciplinary studies, which is concerned with the collection, organisation, storage retrieval, discrimination and use

of Information Technology is the branch of knowledge that deals with industrial arts, applied science, engineering etc.

Information Technology represents an assemble of technologies. These technologies are the computer ability to store and process information, the communication technology which represents transmitting information to location where it may be needed (Gopinath: 1985). Information technology is in fact an emergence of three strands of technologies, computer, microelectronics and communication.

UNESCO has defined Information Technology as “the scientific, technological and engineering disciplines and the management techniques used in information handling and processing, their application, computer and their interactions with men and machines and associated social, economic and cultural matters”.

Information technology in its wider sense can be defined as any technology related to recording presentation and communication of information or knowledge emerged from time immemorial. On the other hand new information technology connotes the massive applications of electronic or digital technologies for the recording presentation and communication of information and knowledge.

The essential requirements of information production are the information use and efficient communication. IT has an important role in

rapid and proper use of library and information services. Computer technology, satellite technology; and CD-ROM Technology have contributed to information technology.

In this age of knowledge explosion, large amount of information is being generated at every moment. To collect, store and disseminate this large amount of information needs the application of new technologies. In addition, the exponential growth of literature in all fields of human knowledge and ever increasing number of documents in subject area due to advancement of science and technology in past few years also have been creating problems in selection, acquisition, organisation and services in libraries.

The main features of recent development in information technology can be summed up as follows. (Fjall brant, 1990)

- Increased computer power leading to speedier and cheaper computer processing.
- Cheaper data storage - for example, optical storage media.
- Digitization of information – text, graphics, photographs, speech, sound, video, etc.
- Better data transfer between different system and media.
- Improved telecommunications, such as ISDN, with greatly increased capacity for data transmission.
- *Decreased size of equipment.*
- Increased reliability of hardware and software.

These have led to the development of international, national and local online systems, automated library system, public access catalogues, (OPACS), the electronic journals, electronic knowledge 'banks' and expert systems, CD-ROM (Compact Disk Read Only – Memory) Optical digital disks, and interactive video for storage of databases, journals, reference publications and picture data banks.

Due to modern development in the IT, information is now instantly available all over the globe and may be stored and retrieved as long as electricity is available. Time and space no longer restrict the exchange of information (Lunendjk, 1994).

Information technology has affected the research process profoundly. Creating opportunities for scientific exploration through new instrument and analytical capabilities; permitting research collaborations to extend cheaply and efficiently across the globe and improving the capacity for displaying results as visual images. New technologies, as well as integration of existing technologies into national and global systems, offer further opportunities to enhance the productivity of research. (Clement, 1990).

The introduction of the computer and its peripheral devices, as well as new data transmission, techniques (laser technology, optical and video disc technology etc) have multiplied seven fold ability of library and information services to store, process and retrieve data and information,

while at the same time drastically reducing the time required for carrying out such procedures. (Alemna, 1993).

Some of the new developments in information technology may be summed as follows.

2.6.1 Online Services

Information is stored in computer databases, the user access through a computer terminal at his own locations, which is connected to the computer store by a telephone or data line (Natarajan and Kaliyaperumal, 1989).

The major implication of IT in this context is sharing by developing a small sharable database. EBSCO, subscription service in Europe estimates that there are about 2,00,000 Scientific and technical and medical (STM) libraries in more than 145 countries. The January 1994 edition of Gale Directory of Data Bases lists the existence of

- 1) 5412 online database
- 2) 2261 database producers
- 3) 884 online services
- 4) 116 gateways. (Lunendijk, 1994).

2.6.2 Electronic Mail

E-mail provides a semi formal method of direct communication which can be extremely useful in that it is quick and relatively cheap. In contrast to telephone messages the recipient does not have to be at the receiving terminal, thus global time difference are of little or no importance. The term electronic mail or e-mail covers the transfer of digital messages from one computer terminal to another.

E-mail can be used to provide electronic conferencing facilities between users interested in specific field or topic. This allows the users to exchange news and views and seek advice from others with similar interests. (Fjallbrant, 1990).

2.6.3 Optical storage of information

Recent developments in optical storage technology have provided a cheap storage medium for information. Compact Disc-Read Only Memory (CD-ROM) is an optical storage system. A CD ROM can store 5,50,000,000 bytes of information (Fjallbrant, 1990) Read only memory means data permanently written on disc and it cannot be added or erased, rewritten or altered (Oppenheim, 1992) CD ROM has the advantage of versatility, high storage density, ease of use, durability, fixed cost of searches etc (Subramaniam, 1995).

2.6.4 Electronic publishing

It may be considered as preparation, storage, dissemination of information, primarily textual and graphic, using computer and telecommunication. Electronic publishing may be in magnetic tape/disc, CD-ROM and Videocassettes etc. (Natarajan and Kaliyaperumal, 1989 Asoka Kumar and L Udaya Sankar, 1992).

2.6.5 Electronic journals

Electronic journals can be in a variety of forms, but one central characteristic is the use of electronic network communication as an aid in preparing, submitting and referring papers and other activities, associated with the compilation of electronic journals.

2.6.6 Desk Top Publishing (DTP)

The entire publishing is done on one's desktop, which is quite possible at present. The author creates the documents on computer using word processing software, edits and makes pages, adds graphics, designs cover and pages, on a single desk and the documents produced on laser printer which may be then use as camera ready copy for printing large number of copies through conventional means. (Ashok Kumar and Udayasankar, 1992).

2.6.7 Networks

Berger and Arnotsky (1973) have defined networks as a “mode for sharing resources and linking otherwise incomparable procedures and formats; of different systems and organisation”. This increase of networks accelerated the increased and more rapid information sharing and new types of collaborative arrangement among researchers, increasing independent of geographic location and local time schedules (Clement, 1990). It facilitate to access information at great speed high reliability and reduced cost (Varalaksmi 1992). The three types of networks are wide area networks, local area networks, and metro politan area networks.

2.6.8 Video text

Videotext is computer aided telecommunication system intended to transmit text graphic stored on a computer database for display on television screen via ordinary telephone line (Rajasekaran, 1997).

2.6.9 Tele text

Tele text is a non interactive form of Videotext, designed for general and mass communication. Unlike interactive videotext, tale text is broadcasted, received and displayed by a teletext set which is essentially an adopted television receiver (Rajasekaran, 1997).

2.6.8 Facimile Services

It means the faithful transmission of an original document via satellite links to remote locations. It can scan and transmit complete letters and produce paper copies of letters and messages for the recipient.

Fax is one possible technology for electronic delivery of documents from the library and information centres to the needy users. (Rajeseakaran, 1997).

2.6.11 Expert Systems

Artificial intelligence is being heralded as one of the breakthroughs in computer users that will drastically change the information dissemination process. The most practical application of artificial intelligence is an expert system.

The expert system (ES) is a computer programme designed to reason like a human expert in a given situation. It can solve problems in a way similar to that of a human expert and communicate the decision or conclusion with blinding speed.

The development of expert system coupled with increasing availability of low cost computers provide new potential for dissemination of expert knowledge in a digestible form direct to the users. The technique is now extensively used in many areas like medical

diagnosis, commercial accounting and increasingly in agriculture research, extension and farming activities.

2.7 The Theories of Knowledge

The knowledge, particularly human knowledge is dealt in philosophy, psychology, computer science etc. The nature, origin, meaning, purpose and limits of knowledge are explained in epistemology, metaphysics, philosophy of science, cognitive psychology, cybernetics etc. For the study of information consumption-production pattern, the theories of knowledge have been employed. A brief description of these theories are given below.

2.7.1 Epistemology

Epistemology is the study of origin, nature and limits of human knowledge. The name is derived from the Greek word 'episteme' (knowledge) and logos (reason). Along with metaphysics, logic and ethics, it is one of the four main fields to the literature on this topic.

It was Plato, who can be said to be the real originator of epistemology, for he attempted to deal with the basic questions, what is knowledge? Where is knowledge generally found and how much of what we ordinary think we know is really knowledge? Do the senses provide knowledge? What is the relation between knowledge and belief?

What is knowledge: Knowledge is justified true belief. This definition looks plausible because at the very least it seems that to know something one must believe it, that the belief must be true, and that one's reason for believing it must be satisfactory in light of some relation for one could not be said to know some thing if one's reasons for believing it were arbitrary or hamphazard, so each of the three parts of the definition appears to express a necessary condition for knowledge and that the claim is that taken together they are sufficient.

There are however, serious difficulties with this idea, particularly about the nature of the justification required for true belief to amount to knowledge. In parallel with the debate about how to define knowledge is acquired. In the history of epistemology there have been two chief schools of thought about what constitutes the chief means to knowledge. One is the rationalist schools, which hold that reason plays this role. The other is the empiricist which holds that it is experience principally the use of senses, aided when necessary by scientific instruments does so.

The paradigm of knowledge for rationalists is mathematics and logic, where necessary truths are arrived at by intuition and rational inference. Questions about the nature of reason, justification of inference, and the nature of truth, especially necessary truth, accordingly press to answered. The empiricists paradigm is natural science where observation and experiment are crucial to enquiry. The history of science in the

modern era lends support to empiricism case, but precisely for that reason philosophical questions about perception, observation, evidence and experiment have acquired great importance. But for both traditions in epistemology the central concern is whether we can trust the routes to knowledge they respectively nominate. Sceptical arguments suggest that we cannot simply assume them to be trustworthy.

2.7.2 Meta physics

The word ‘metaphysics’ derives from the Greek word *meta* to *physika* (literally. “After the things of nature”), an expression used by Hellenistic and later commentators to refer to Aristotle untitled group of texts that we still call the metaphysics. Aristotle himself called the subject of these texts first philosophy theology, or sometimes wisdom, classical and medieval philosophers took this title to mean that the subjects discussed in the *Metaphysics* came “after the things of nature” because they were further removed from sense, perception and therefore more difficult to understand. They used Aristotle’s frequent contrast of things “prior and better known to us” with things “prior and better known in themselves” to explain why the treatises on first philosophy should come “after the books on physics”. In medieval and modern philosophy, “metaphysics” has often meant a priori speculation on questions that cannot be answered by scientific observation and experiment. In modern philosophical usage “metaphysics” refers generally to the field of

philosophy dealing with questions about the kinds of things there are and their modes of being. Its subject matter includes the concept of existence, thing, property, event, the distinctions between particular and universals individuals and classes, the nature of relations, change, causation, and the nature of mind, matter, space and time. In the eighteenth and nineteenth centuries “metaphysics” was used broadly to include questions about the reality of the external world, the existences of other minds, the possibility of a priori knowledge and the nature of sensations, memory abstraction and soon.

Main features of metaphysicians traditionally practiced are the following.

1. Metaphysicians have constantly aspired to say what there is in the world or to determine the real nature of things, they have been pre-occupied, that is with the concepts of existence and reality.
2. Metaphysics has been commonly presented as the most fundamental and also the most comprehensive of inquiries. Metaphysics is comprehensive just because of its extreme generality. Where as sciences like physics and mathematics are departmental studies each of which deals only with a part or particular aspect of reality, metaphysics by contrast is concerned with the world as a whole. It is said that inquiries in the individual sciences are carried out under assumptions which it is the business of metaphysics to make explicit

and either to justify or correct. Metaphysics by contrast, proceeds without assumption and is thus fully self critical when where the particular sciences are in past credulous.

Metaphysics includes the analysis and syntheses of the experience of all the field in the Universe of knowledge. But it does not deal with the structure and development of universe of subjects. The main branches of the metaphysics are cosmogony, study of creation of world, ontology, study of ultimate reality and cosmology main problem of which is that the world is one or many.

2.7.3 Philosophy of Science

This branch of philosophy is concerned with the philosophers examination of the postulates and conclusions of different sciences.

The philosophy of science can usefully be divided into the broad areas. On the one hand is the epistemology of science, which deals with issues relating to the justification of claims to scientific knowledge. Philosophers working in this area investigate such questions, as whether science ever uncovers permanent truths, whether objectives decisions between competing theories are possible and whether the results of experiment are clouded by prior theoretical expectations. On the other hand are topics in the metaphysics of science, topics relating to philosophically puzzling features of the natural world described by

science. Here philosophers ask such questions as whether all events are determined by prior causes, whether everything can be reduced to physics and whether there are purpose in nature. We can think of the difference between the epistemologists and the metaphysicians of science in this way. The epistemologists wonder whether we should believe what the scientists tell us. The metaphysicians worry about what world is like, if the scientists are right.

2.7.4 Cognitive Psychology

Cognitive Psychology deals with how people perceive. Learn, remember and think about information. Cognitivism is roughly the view that (1) psychologists may and must advert to inner states and episodes in explaining behaviour so long as the states and episodes are construed throughout as physical (2) human beings and other psychological organisms are best viewed as in some sense information processing systems and (3) the vehicle of information processing is internal representation, a repertoire of brain states that represent features of the external world. In cognitive psychology the question take the form, 'How does this organism receive information through its sense organs, represent the information, process it and store the result and then mobilize its total information in such a way as to result in intelligent behaviour.

2.7.4.1 Problems solving and Creativity

Knowledge, particularly expert knowledge, greatly enhances problems solving. Chase and Simon (1973) set out to discover what experts know and do by determining what distinguishes expert from novice chess players. They suggested that what differentiated the experts from the novice was the organisation and use of knowledge. Both chess tasks whether with a random array of pieces or with a meaningful arrangement of pieces required the expert to use heuristic for storing and retrieving information about the positions of the pieces on the chess board. According to these investigators, the key difference was that chess experts had stored in memory tens of thousands of particular board positions. What differentiated experts from novices was their schemas for showing problems within their own domains of expertise (Gaser & Chi, 1988). The schemas of experts involve large, highly interconnected units of knowledge, which are organised according to underlying structural similarities among knowledge units. In contrast, the schemas of novices involve relatively small and disconnected units of knowledge, which are organised according to superficial similarities.

Experts have not only more knowledge, but also better organised knowledge which allows them to use their knowledge more effectively. The schemas of experts involve not only greater declarative knowledge about a problem domain, but also more procedural knowledge about

strategies relevant to that domain. Perhaps, because of their better grasp of strategies required, experts more accurately predict the difficulty of solving problems than do novices (Lesgold & Lajove, 1991). Experts also monitor their problem solving strategies more carefully than novices do (Schoenfeld, 1981).

2.7.4.2 Creativity

It is the process of producing something that is both original and worthwhile. The something could be a theory, a dance, a chemical, a process or procedure, a story, a symphony of almost nothing else. Creative individuals show creative productivity producing inventions, insight full discoveries (artistic, work, revolutionary paradigms, or other creative products that are both original and worthwhile.

The difference between creative individuals and less remarkable persons are in their expertise and commitment to these creative endeavour. Highly creative individuals work long and hard studying the work of their predecessors and their contemporaries to become thoroughly expert in their fields. They then build on and diverge from what they know, to create innovative approaches and products.

A creative individual needs not only a suitable environmental context, but also suitable knowledge, motivation, personality variable and intellectual processes as well as intellectual style that facilitates creativity.

2.7.5 Cybernetics

Cybernetics is the study of communication in human and machine and combines the concepts from information theory, feedback control systems (both biological and machine) and electronic computers (Karisiddappa and Prasad, 1995).

Weiner (1948) defined cybernetics as the science of control and communication in the animal and machine. This definition relates to cybernetics closely first of all with the theory of automatic control and with physiology, particularly the physiology of nervous system, subsequently the computers and areas of mathematics related to it. Mathematical logic had a great influence on the developments of cybernetics. The reason is that computer can be used not only for automatic calculation but also for conversions of information including various types of information processing passes in control systems.

CHAPTER III

REVIEW OF RELATED STUDIES

- 3.1 Information Generation and Higher Education
 - 3.1.1 Research and Information
- 3.2 Scientific Productivity and Information Consumption
 - 3.2.1 Mathew's Theories of Knowledge
 - 3.2.1.1 Rate and Level
 - 3.2.1.2 Information Consumption
 - 3.2.1.3 Information Production
 - 3.2.1.4 Theory of Information Consumption Production Correlation
 - 3.2.1.5 Stage Theory of Information/Consumption Growth
 - 3.2.1.6 Implications of the Mathew's Theories of Knowledge
- 3.3 New Information Technology and Productivity of Scientists

CHAPTER III

REVIEW OF RELATED STUDIES

Review of related studies forms a major aspect of research report. The literature in any field forms the foundation upon which all the future works are built. Familiarity with the literature in problem area helps the researcher to discover what is already known, what others have attempted to find out, what methods of attack have been promising or disappointing and what problems remain to be solved.

During the survey of literature it reveals that nobody has conducted similar study of finding out the basic relationship between information consumption and production and the role of information technology. However some of the relevant studies are presented below. The related studies have been centered on universities and knowledge production, scientific productivity and information consumption and role of new information technology in scientific productivity.

3.1 Information Generation and Higher Education

The basic task of Universities in developing countries is to become active partners in transforming traditional society to the modern information society. By creating information consciousness and effective and sustained demand for information, by making information a critical

source for development and finally by meeting the information needs of the society. The recognised aim of the University is to provide and sustain an environment conducive to sharing, extending and critically examining knowledge and values and to furthering research for wisdom has been sanctified by years of experience (Ahluwalia, 1981).

In the higher educational context, Universities are the highest academic institutions, which have social obligation for producing scientific and skilled manpower required for the country. Universities are the major centers of information production. Production of information is carried out by the teachers and researchers by their research and published works.

In a study conducted by Sudhier (1997) revealed that the contribution of Universities and Colleges in the total research output of Kerala is 66.44% in 1979, 42.34% in 1984, 61.28% in 1989 and 61.72% in 1994. This indicates that Universities have a main role in the generation of scientific information.

In order to increase the information production capacity of an individual or group is to transform him it to the high level information consumption from low level information consumption by well planned and calculated course of actions, including, imparting information handling skill and application of information technology. That is the main function that must be carried out by the Universities (Mathew, 1981).

3.1.1 Research and Information

The basic aim of research is to find solution to the problems confronted in course of human activities in variety of situations and in the midst of available information on accomplished work and output (Kasisiddappa & Padhi, 1989). In our day to day life where problems arise, solutions are found, the value of the results in terms of quality and quantity depends on the new information. Man exhibits his supremacy over the control of information, but still the information has become evasive. What is conceived is not perceived permanently. Every concept suffers at the hands of time, loses its identity and merges with another new concepts. Information is pervading all through the universe awaiting chance of its perception. Time alone will decide the deciphering of a new knowledge at a length of constant profit No effort of seeking information goes in vain. Scientists and technologists are both consumers and producers of knowledge. They consume new information and generate newer information. This is an unending process. Scientist's mind is restless, like an atom, which always engaged in ceaseless thinking and producing prolific output of information.

3.2 Scientific Productivity and Information Consumption

Scientific productivity is a measure of scientific information production. It is measured in terms of the ratio of output to inputs. Here the outputs are taken as the publication outputs plus the academic achievements. The inputs are the information consumption. It includes

the information use, collecting, or acquiring data, grasping, assimilating or analysing them for concept formulation, clarification, formulating questions or understanding problems to be solved or arriving at conclusions (Mathew, 1984).

The ways adopted in measuring the success, performance, productivity and creativity of scientists can be classified to two types. Subjective measure based on judgement of oneself or peers/workers, supervisors or a panel of experts or management team against given attributes like contribution of knowledge in the field, achieving the desired results in field, carrying out the responsibilities in the organisation or by sensitising the raters/jurors to the rating task. The other measure called objective measure is based on quantifiable outputs and or incidents like papers published, patents held, technical reports prepared, Ph.D. students guided, professional service records and other academic achievements (Maizel, 1960).

If we study the characteristics, productivity, creativity, performance and communication and information use, a sort of inverse relation exists that only few scientists have high scientific productivity or are highly creative (Lokta, 1926).

In a study about the relationship of organisational factors to scientific performance in an industrial laboratory, Smith (1966) found that formal internal meetings did not stimulate high performance. Infact there existed a negative correlation between contacts with outside consultants

and lectures and level of performance. Further informal contacts with colleagues within the organisation had no material effect on performance.

Pelz and Andrews (1976) found that high performance was related to a high level of communication with colleagues and there existed a correlation between performance and dissimilarity in research style and interest among colleagues of work team. Maizel (1960) found that most creative chemists are characterised by spending more time by reading scientific and technical literature, visiting companies, more often, examining more number of journals, consulting more often materials from broader and related areas that too as their own and more often stimulated to ideas by reading than by others. Further creative chemists found the older literature of more value and also found the technical information services offered by the library only modestly important. Maizel recommended that 'spoon feeding' of technical information to both creative and non creative scientists is not useful consideration should be given to most creative users separately based on their information gathering patterns. Paisely and Parker (1966) almost confirmed this by showing that individual productivity of research correlates strongly with the amount and diversity of information inputs of the individual, by and large, high performance and high academic achievements are also correlated with the high use of library.

Allen (1970) found that the use of organisational colleagues as a source of information is strongly and positively correlated with

performance and he believed that high communication is a cause of high performance and not vice versa. In a study about innovative role of information it was found that successfully innovating firms understood user requirements better, had better relationship with outside experts, benefited from outside technology and better communication (University of Sussex, 1972). Frost and Whitely (1971) confirmed Allen's finding by observing that good performance leads to effective communication. Maizel (1960) identified that information-gathering habits and creativity are related.

According to Gupta (1993), author productivity is a function of many causes and might be grouped into the following major conceptual areas.

1. Personal characteristics of individual authors like his intelligence, personality, expectation and achievements etc.
2. Environmental factors like authors field of specialisation, problems of investigation, influences of members, colleagues, motivation, external factors, facilities and accessibility and availability of information etc.

Mathew (1985) has formulated his theories namely, the theory of information consumption production correlation and the stage theory of information consumption growth. Mathew has formulated the above two theories during the study of the strategic problems of developing countries.

Dreyfus and Dreyfus (1986) put forth five stage model of skill acquisition in general context. They identified the five stages as novice, advanced beginner, competence proficiency and expertise. According to Dreyfus and Dreyfus the careful examination of the skill; acquisition process shows that a person usually passes through atleast above five stages of qualitatively different perception of his task and or mode of decision making as his skill improves. Not all people achieve an expert level on their skills.

In the present study Mathew's theories have high significance in the input /output process of scientific information. Hence the theories are dealt in detail.

3.2.1 Mathew's theories of knowledge

The theory putforth by Mathew is relevant in the context of University Scientists. His theory concerns about the information consumption and information generation. The following basic concepts are to be explained before discussing the theories in detail.

3.2.1.1 Rate and level

Information use has two qualities. The quantitative aspect of information use or production could be called the rate of information consumption or production. The qualitative aspect could be represented by level of information use or consumption or production.

3.2.1.2 Information consumption

Information consumption is process of acquiring or collecting data or information in the one hand and grasping, assimilating or analysing them for concept formulation, classification, arriving at conclusion.

High level information consumption is the process of acquiring or collecting highly specialized or technical information or the latest development in particular area, for problem solving or application for specific or predetermined purpose including planning, decision making, advanced level teaching or research or publication or making new information.

Low level information consumption is the process of acquiring or collecting elementary information to get some basic idea or understanding which are of broad and general in nature. The purpose may be examination or tests, curiosity or entertainment or mere reproduction.

3.2.1.3 Information production

Information production is the creation or invention of new ideas, theories, facts, devices or machines; finding new relationships between variables or phenomena or providing new interpretations or explanations for known phenomena or facts or innovation and application of theories and principles or ideas in real world situations, which are brought to light by communication.

Before the statement of theory Mathew put forth the following propositions.

- i) High level information consumption is a precondition for high level information production, for the motive of high level information consumption is the high level information production. Consuming critical minimum information is an essential condition for producing high level information. Even the most gifted brain or the genius makes outstanding contribution only after consuming critical minimum information of high level.
- ii) Acquiring a minimum level of information skill is an essential condition for high level information consumption/production Informatics or information technology may act as a catalyst for high level information consumption/production.
- iii) High level information consumers are consuming information at higher rate too, but higher rate of information consumer need not be high level information consumers.

3.2.1.4 The theory of information consumption production correlation

“There exists a direct correlation between high level information consumption and high level information production. Such kind of correlation may or may not exist in the case of low level information consumption”.

3.2.1.5 The Stage theory of information consumption growth

The process of transformation from the low level information consumption to the high level information consumption takes place through various stages. The theory states that there are following four stages.

- i) **Backward or low level information stage:** The user or the society as a whole consumes and produces low level information at low rate too. Information has no value or important at this stage, even if they are available. Consumption of information is quite casual and not purposive. Information literacy is the dominant feature of this stage. Use of libraries, if any is for entertainment or for elementary information and material.
- ii) **Pre-condition to Take off stage:** Consuming low level of information at a higher rate mainly from text books, class notes, popular materials or media, developing reading habits using libraries in a traditional sense, inculcating awareness of the value of information feeling the need for advanced library services and simple information technology are the characteristic of pre-condition to take off stage or in brief, pre-take-off-stage.
- iii) **Critical or take off stage:** Consuming fundamental and basic information in depth, increasing specialization in selected areas (s) familiarising with the state of art, attaining full mastery

information skill, greater dependence on highly advanced library services and information technology so as to get the latest development in the area of specialisation are some of the essential features of this stage. At this stage information is considered as an input or raw material. In other words, information is for application, for which the user acquires essential skill, including techniques of presenting or writing technical notes, reports, papers in standard style and format in an effective manner. This is a critical stage in the sense that only if one enters in this stage can survive at high level information consumption.

- iv) **Advanced stage or stage of affluenceⁱⁿ information consumption:**
 At this stage the user is noted with developing his information production capacity and to make assessment of the present trend of information growth and to visualise future trend too. The already attained high level information consumption resulted in high level information production. The major activity of life has been reduced into high level information consumption and production, information technology has become the part and parcel of day to day life so as to minimise communication gap at international level.

3.2.1.6 Implications of the Mathew's Theories of Knowledge

The theories help in formulating alternative strategies and policies for the development of educational system and augmenting the scientific

productivity of the individual and the society by the effective application of Information Technology Education ultimately aims at human resources development. In a highly competitive global economy, the survival and development of a nation as a society depend on its ability to develop highly specialised and strategic human resources especially in the field of Science and Technology in a very short span of time. The theories suggest that individuals with certain intellectual caliber could become specialists provided they are made high level information consumers.

Mathew's theories of knowledge imply that the high level information consumption and information production can be attained through different stages and they are directly correlated. This means that the high level information consumption is an essential factor. Thus in order to create high level information producers or highly productive scientists, the individual shall be made high level consumers of information.

Defects of University level Scientific Research

The basic defect of the Indian higher education system is that attaining high level information consumption or expertise is not an explicit objective of Universities. Creating adequate number of experts in Science or high level Scientific Information Consumers is not an explicit objective. Large number of University level higher degree holders could not become experts inspite of their high educational credentials or caliber. Creating an expert is an accidental coincident of Universities.

Explicit Objectives

On the other hand, high level information consumption that too within a short span of time is made as a basic objective of Universities, they could have produced sufficiently large number of experts within a specified time. The society wants experts where as individual wants qualifications. In order to produce high level information consumers within a specified time, Universities have to restructure their teaching and research methods and redesign their curriculum for attaining the objective of high level information / knowledge consumption / production.

Information Technology (IT) as a Catalyst

These theories also high lighted the strategic role played by IT in augmenting the process of high level information consumption and information production that too within a specified time. IT could be applied in different stages of information consumption and production by shortening the time span for each stage. As a policy implication these theories strongly advocate for speedy and effective introduction and application of IT in the entire spectrum of scientific research, so that the scientific productivity could be increased substantially and tremendously. Now IT has become an effective tool in handling over information and wisdom rather than the old data and information, thanks to the advancement in the designing and management of web based services and technologies.

3.3 New Information Technology and Productivity of Scientists

The New Information Technology is the product of the fusion of information science and technology, practices and related disciplinary studies concerned with the production or generation, storage, retrieval, transmission and use of information. Information Technologies are employed in the complex processes of computing and obtaining, storing, organising, manipulating and exchanging information. 'Information technology includes hardware and software, telecommunication devices and networks besides brainware and orgware. Brainware means theories, strategies and policies in the development and social application of IT and orgware concerned with the organisational and management aspects of application of IT (Mathew, 1985). In short both brainware and orgware ensure the proper application of IT in the specific social context and without this, hardware and software become ineffective. The study of all these diverse aspects of IT becomes the subject matter of modern Informatics.

In a study, computer application among scientists in South Eastern Nigeria by Okocha (1995), respondents exhibited a high level preference for the computer (23.4%) over their information technology devices. Developments in information technology influenced (36.8%) in the use and transfer of scientific communication. The conclusion of the study was that information technology devices are recognised as a necessary tool for effective scientific and technological information dissemination.

Due to the advent of applications of information technology information is now instantly available all over the globe and may be stored and retrieved as long as electricity is available. Time and space are no longer restricting the exchange of information (Lunendijk, 1994).

Clement (1990) considered research as an information management process. It has three steps, data collection and analysis, communication and collaboration among researchers, and information storage and research. The committee on Science, Engineering and Public policy (COSEPUP), a unit of National Academy of Science and Engineering and Institute of Medicine had identified various applications of information technology devices such as computer controlled instruments, computer linked networks, computer driven communication, document transmission and remote editing and new type of collaborative arrangement among researchers independent of geographic locations.

Clement (1990) in his review on the COSEPUP report on the application of information technology in conduct of research commented that it affected the research process profoundly creating opportunities for scientific exploration through new instrumentation and analytical capabilities permitting research collaboration to extent cheaply and efficiently across the globe and improving the capacity for displaying results as visual images. New technologies as well as the integration of existing technologies in to national and global systems, offer further opportunities to enhance the productivity of research.

Information and Communication Technology (ICT) infrastructures generalised as the most dominant paradigm of development in the recent years. The economic advancement of the majority of developed nations has been attributed to their fast and widespread diffusions of ICT (Surya, and Abdul Raheem, 1998).

The United States have the publication out put of 36% of world share during 1985-89 and UK have 8.7%, Japan has 7.5% and Russia has 5.7% of world share in publication out put. (Abdulla, Zarina, 1995) these countries have the most development in the information technologies. Recent advances in computer and communication technologies and their wide social applications in almost all production processes and sociocultural activities, in the Third world, resulted in the emergence of an information economy at international level crossing the geographical boundaries of nations. Knowledge for the first time in the human history, has now assumed the status of a strategic resource and wealth to increase all around efficiency and competitiveness. Now all activities are dominated by knowledge and controlled by those who possess and capitalise knowledge (Mathew, 1998). This implies that information technology increases information generation and emerges towards overall development.

CHAPTER IV

METHODOLOGY

- 4.1 Basic Assumptions of the study
- 4.2 Propositions of the study
- 4.3 Variables of the study
- 4.4 Hypotheses of the study
- 4.5 Methodology
 - 4.5.1 Population for the study
 - 4.5.2 Data collection
 - 4.5.3 Statistical Treatment of Data
- 4.6 Scope and Limitations of the study

CHAPTER IV

METHODOLOGY

India has the second largest number of scientific and technical manpower of the world after the U.S.A. However the scientific information productivity of India is very low compared to some of the small countries like Japan, Sweden, Switzerland and England measured in terms of the Nobel prizes and other international recognitions. The economic and social backwardness of India to a very great extent could be attributed to the low scientific information productivity of the country.

On these backgrounds it is highly essential to make proper attempt to assess the scientific information productivity of India on the basis of the set of sound theoretical framework so as to formulate correct strategies and policies by realising the practical constraints. It has been decided to limit the study in physical scientists working in four major Universities in Kerala. It is a fact that Universities are the greatest consumers and producers of scientific information through training and education programme, on the one hand and the theoretical and experimental research programme on the other hand (Mathew, 1989).

4.1 Basic assumptions of the study

Regarding the low scientific information productivity of physical scientists of Universities in Kerala, the following basic assumptions have been made.

1. The higher education system is not adequate to train the post graduate students in acquiring the skill of high level scientific information consumption – production and there by develop scientific expertise.
2. The research scholars, even after completing the doctoral work are not attaining high level scientific information consumption- production.
3. The scientific information productivity is not taken as basic criteria for the future placement and promotion of the scientists.
4. Most of the scientists are not getting enough facility to make use of modern technologies for easy access and consumption of high level scientific information.
5. The authorities are not giving appropriate importance for scientific research and their applications.

4.2 Propositions of the study

Scientific information productivity of physical scientists in the Universities in Kerala could be enhanced-augmented by:

1. Proper re-designing of higher education with new and innovative programmes of instruction and research.
2. The higher education curricula should be re-designed to develop or train the post graduate students to acquire the skill of high level scientific information consumption and production.

3. Research scholars must be made methodologically sound in acquiring the skill of high level information consumption-production during their period of doctoral research.
4. The Scientific Information Productivity must be made as the criteria for the placement and promotion of the scientists in Universities.
5. The existing IT facilities must properly be utilised and more facilities must be provided for the scientists.

4.3 Variables of the study

The study has been designed with seventeen independent variables, which can be grouped to three namely, personal characteristics, use of information sources and information consumption of the scientists. Scientific productivity has been taken as the dependent variable.

a. Personal Characteristics.

1. Sex
2. Age
3. Subject area of specialisation.
4. Designation
5. Experience
6. Doctoral theses produced

b) Use of information sources

7. Primary journals
8. Abstracting/Indexing journals
9. Conference proceedings
10. Review articles
11. Research Reports
12. Books/Monographs
13. Reprints/Preprints
14. Consultation with others
15. Attending Seminars/Conference
16. Membership in learned bodies/professional organisations

c) Information consumption

17. Hours spend per week

The significance of these variables on the dependent variable namely scientific productivity of physical scientists in the universities in Kerala is worked out.

4.4 Hypotheses of the study

The hypotheses set for the study are the following

- 1) There exist differences with regard to information consumption and information production for different categories of physical scientists in the Universities of Kerala.
- 2) There exist similarities in the pattern of information use among the different category of physical scientists.
- 3) The proper application of information technology could augment the information consumption production processes of the physical scientists in the Universities in Kerala considerably.

4.5 Methodology

The methodology of the study has been presented under the following major heads

- i) Population selected
- ii) Tools employed
- iii) Data collection procedures
- iv) Processing of the data and
- v) Analysis of the data

4.5.1 Population for the study

The population selected for the presented study has been drawn from the physical scientists of four Universities in Kerala. They are

1. Calicut University
2. Cochin University of Science and Technology

3. Mahatma Gandhi University

4. Kerala University

The scientists from the following physical science disciplines/ departments have been selected for the present study.

1. Physics
2. Chemistry
3. Electronics
4. Computer science
5. Mathematics
6. Statistics

Stratified sampling technique giving representation to all desirable strata in the proposed sample has been employed. The strata of the population are research scholars, postdoctoral fellows and teachers of the above physical science departments of all the four major Universities. These departments are well established with experienced teachers. In addition, all relevant characteristics such as sex, age, designation, experience, area of specialisation etc have provided a basis for choosing the stratified sample. The characteristics of entire population have carefully been considered together with the purpose of the study before stratified sample is decided upon.

While selecting the sample for the present study a number of decisions have to be taken. Three major decisions taken for the present study are

1. What should be the size of the sample.
2. Which should be the basal variables for which stratification needs to be attempted and proportionate representation to be given to such stratum.
3. Which geographic areas should be covered for obtaining the final sample.

The major consideration used for answering these questions are discussed below under the respective headings.

1. Size of the sample

The study proposed has been conducted among the scientists of the physical science departments of the four major universities in Kerala. They consist of research scholars, postdoctoral fellows and teachers. Some of these research scholars have published works. The total number of physical science teachers working in the four universities in Kerala has been limited to 105 at the time of conducting the present study. The total sample constitutes a sample population of 97. An interview followed by administering questionnaire has been employed for the collection of data.

The break up of the population in terms of sex, age group, subjects, designation and experience are given in Table 4.1 – 4.5.

Table 4.1

Break up of the sample in terms of sex

Sex	No. of Scientists
Male	71
Female	26
Total	97

Table 4.2

Break up of the sample in terms of age group

Age group	No. of Scientists
25 or less	3
26-30	16
31-40	29
41-50	32
Above 50	16
Not given	1
Total	97

Table 4.3

Break up of the sample in terms of disciplines/departments

Disciplines/Departments	No. of Scientists
Physics	30
Chemistry	35
Electronics	3
Computer science	2
Mathematics	20
Statistics	7
Total	97

Table 4.4

Break up of the sample in terms of designation

Designation	No. of Scientists
Lecturer	16
Reader/Lecturer Sr.	29
Professor	26
Research Scholar initial stage	6
Research Scholar final stage	16
Post Doctoral Fellow	4
Total	97

Table 4.5

Break up of the sample in terms of experience in years

Experience	No. of Scientists
3 years or less	10
3-5	15
6-10	16
11-15	18
16-20	20
21-25	10
26 and above	7
Not given	1
Total	97

4.5.2 Data Collection

The investigator, besides, administering the well prepared and detailed questionnaire, also conducted direct interview and discussion for data collection. The investigator spent more than three hours for each scientist to get the data. Most of the questions could not be answered by mere tick marking, as it involves detailed discussion. The scientists have even to spend time foregoing through their bio-data and personal records to provide relevant information. Hence there is a need for approaching the scientists two or three times to get the required data. The investigator also collected list of publications and their bio-data of the scientists to

ascertain their scientific productivity. Hence the investigator spent more than 4 weeks in each university to complete the data collection. The productivity is measured in terms of the research output of the scientists up to the period in which the study is conducted.

4.5.3 Statistical Treatment of Data

The data collected through questionnaires, interviews and discussions from the physical scientists has been analysed. The scientific productivity, information consumption time etc, values are taken by average and percentages wherever necessary.

To find the factors that affect the information productivity of Scientists, Y, the variables are selected from the questionnaire. Seventeen variables had been taken, as $x_1, x_2, x_3, \dots, x_{17}$. The multiplicative cause of independent variables ($x_1, x_2, x_3, \dots, x_{17}$) on the dependent variable Y, a relation for Y is established.

$$Y = a + b_1x_1 + b_2x_2 + \dots + b_{17}x_{17}$$

The multiple correlation is the simple correlation between Y and \hat{Y} where \hat{Y} is the estimate of Y using the above relation.

Multiple correlation R is given by

$$R = \frac{\sum_{i=1}^n (y_i - \bar{y})(\hat{y}_i - \bar{y})}{\sqrt{\sum_{i=1}^n (y_i - \bar{y})^2 \sum_{i=1}^n (\hat{y}_i - \bar{y})^2}}$$

Where \bar{y} is the mean of Y's Y_i is the productivity of i^{th} scientist, \hat{Y}_i is the estimate of Y_i using the above relationship.

Where $R = 1$, means $Y = \hat{Y}$ which is the maximum correlation. To find the significance of each of the 17 variables, the value of R is found by eliminating each variable.

4.6 SCOPE AND LIMITATIONS OF THE STUDY

The present study concentrates on the information or knowledge consumption and production of the scientific community. The present study is intended to provide a basic methodical and theoretical framework for giving an explanation for the process of knowledge/information consumption and production, especially of the physical scientists. The approach of the study is a multi disciplinary as it integrates the basic theories knowledge, epistemology, metaphysics, philosophy of science, cognitive sciences, cybernetics etc. The present study aims at validating the theories of information consumption production correlation and the stage theory of information/knowledge growth. It also aims at examining the application of information technologies in augmenting the process of consumption production.

The scientific productivity of the scientists of Universities in Kerala, compared to their counterparts elsewhere is not at the desired level, inspite of long traditions and investing a lot of resources for acquiring different systems and components of modern technologies. This

is more evident with regard to the various physical sciences departments in the universities such as Physics, Chemistry, Mathematics, Statistics, Electronics and Computer Sciences. The study has been conducted in the four main Universities in Kerala, namely, the Kerala University, the Mahatma Gandhi University, the Calicut University and the Cochin University of Science and Technology. The scientists include, the teachers and research scholars of these Universities. Here scientific information productivity is measured in terms of published research work. The productivity in terms of teaching, undertaking research projects, etc could not easily be measured and hence they have not been included in the present study.

The findings of the study may be useful to higher educational planners at national, state and university level, for formulating correct policies and strategies with regard to scientific research and post graduate studies and introduction and application of Information technology in higher education. This will be useful for library and information systems and network experts and managers in designing and implementing highly efficient and effective library and information systems. The study provides a theoretical explanation for the complex processes of information consumption and production of scientists and thereby augmenting the scientific information productivity of a country, especially a developing country like India.

CHAPTER V

ANALYSIS OF DATA

- 5.1 Findings of the Study
 - 5.1.1 Scientific Productivity and gender difference
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CHAPTER V

ANALYSIS OF DATA

The data collected from the physical scientists of the four major Universities of Kerala, Calicut, Kerala, Mahatma Gandhi Universities and Cochin University of Science and Technology gives detailed information regarding their personal characteristics such as age, sex, designation, experience, subject area, Ph.D. theses produced, information consumption and use of various information sources. They are analysed with regard to their information productivity.

The data has been analysed to throw adequate light on the basic questions listed as objectives of the study, and also to provide evidence regarding the validity or otherwise of the various hypotheses set for the study. The analysis has been presented in the following sequence.

1. Scientific productivity of male and female physical scientists.
2. Scientific productivity and age difference
3. Scientific productivity and status
4. Scientific productivity and experience.
5. Scientific productivity and areas of study
6. Scientific productivity in terms of doctoral theses and research papers.
7. Scientific productivity and information consumption.
8. Information use pattern of physical scientists.

9. Comparison of scientific productivity in terms of research papers and doctoral theses.
10. Use of information technologies.
11. Self evaluation made by the scientists regarding their scientific productivity.
12. Factors of scientific productivity.

5.1 Findings of the Study

The analysis of the study provides the following major findings:

5.1.1 Scientific Productivity of male and female scientists

To find out whether there is any difference in productivity of male and female scientists, the average productivity of both groups in terms of research papers and doctoral theses have been analysed. It is shown in table 5.1

Table 5.1

Scientific productivity of male and female scientists

Sex	Scientific productivity	
	Research papers	Doctoral theses
Male	26.23	2.41
Female	18.11	1.54

The productivity of male scientists is more in number compared with female scientists and it is one and half times that of female scientists.

5.1.2 Scientific Productivity and age difference

The nature of productivity of scientists of different age groups has been analysed (Table 5.2).

Table 5.2

Average productivity of Scientists of different age groups

Age groups	Average productivity	
	Research papers	Ph.D. theses
25 or less	1	-
26-30	9.56	-
31-40	17.59	0.72
41-50	26.53	2.34
50 above	49.06	7.06

The scientists at the age 25 or less have average productivity of one research paper. The scientists of age group 25-30 have 9.56 as average productivity. That is 8.56 more for the five years increase of age. Then the scientists of age group 31-40 have 17.59. That is an increase of 8.03 in the average productivity from previous age group. Hence the rate of productivity is decreased. The increase is high around 30 years. At the age group 40-50 the average productivity is 26.53, which is 8.94 more than scientists of the 31-40 age group.

Up to the age group 30, the productivity is individual productivity. From the age group 31 onwards the scientists start productivity in Ph.D. theses or guiding research scholars. Hence the productivity is the combined work of research scholars and the individual scientist. The

productivity in doctoral theses increases from 2.34 to 7.06, at the age group 50 above and due to increase in the successful completion of doctoral theses, the average productivity in research papers increases to 49.06 from 26.53. The scientific productivity in terms of research papers with increase of age of physical scientists is graphically represented in figure 5.1.

Table 5.3

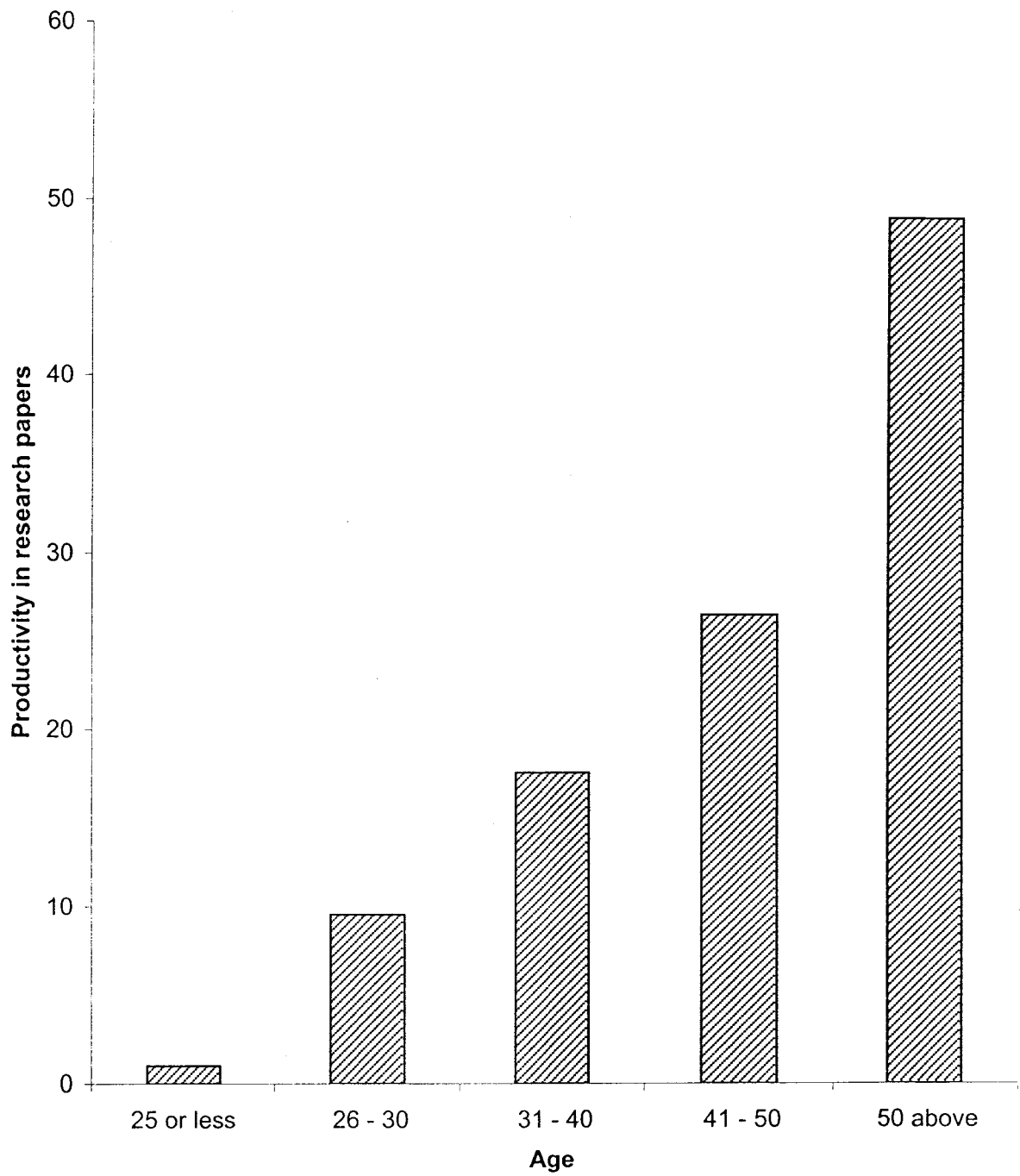
Average productivity of scientists guided doctoral theses

Age	Average paper productivity	
	Scientists guided doctoral theses	Scientists without guiding doctoral theses
25 or less	-	1
26-30	-	9.56
31-40	35.83	12.82
41-50	35.29	9.82
50 above	51.8	8

The paper productivity of scientists having doctoral theses productivity is far greater than the scientists not having doctoral theses productivity. Hence we can conclude that the productivity increases due to the successful completion of Ph.D. theses. The productivity of senior faculty members is the combined effect of the research scholars who are guided by him and his own research work. At age group 50 and above maximum number of Ph.D. theses are completed successfully and hence highest productivity is observed in the scientists who are above age 50. (Table 5.3).

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Figure 5.1
Productivity in research papers and age of physical scientists



At the age group 31-40 and 41-50, the productivity remains almost equal in the case of scientists having doctoral theses productivity. It may be because around age 35 years, the physical scientists are more productive and their productivity decreases afterwards. But above this age they have research students working under him and the higher productivity may be the result of the collaborative work of the research scholars and research assistants working under various projects. Hence the burn out phenomena cannot be identified in the University Scientist.

5.1.3 Scientific productivity and Status

The relation between the status and the productivity of physical scientists has been studied and tabulated in Table 5.4.

The productivity increases while going up in the designation. The increase rate is high from Research Scholar-initial to RS. Final and Reader to Professor. At the research scholar-initial stage, he is a beginner, more time is spent for consumption of basic information. But at the end of this period, the level and rate of consumption increases and develops skill in information consumption-production and starts publishing of research papers with the help of the research guide. On the other hand Lecturer to Reader stage the beginners are handicapped with lesser number of research scholars. Therefore in publishing research papers they heavily rely upon their own individual work or their own doctoral work. At the Professor stage he reaches the stage of expertise and then consumption and production are directly correlated. Most of the Senior

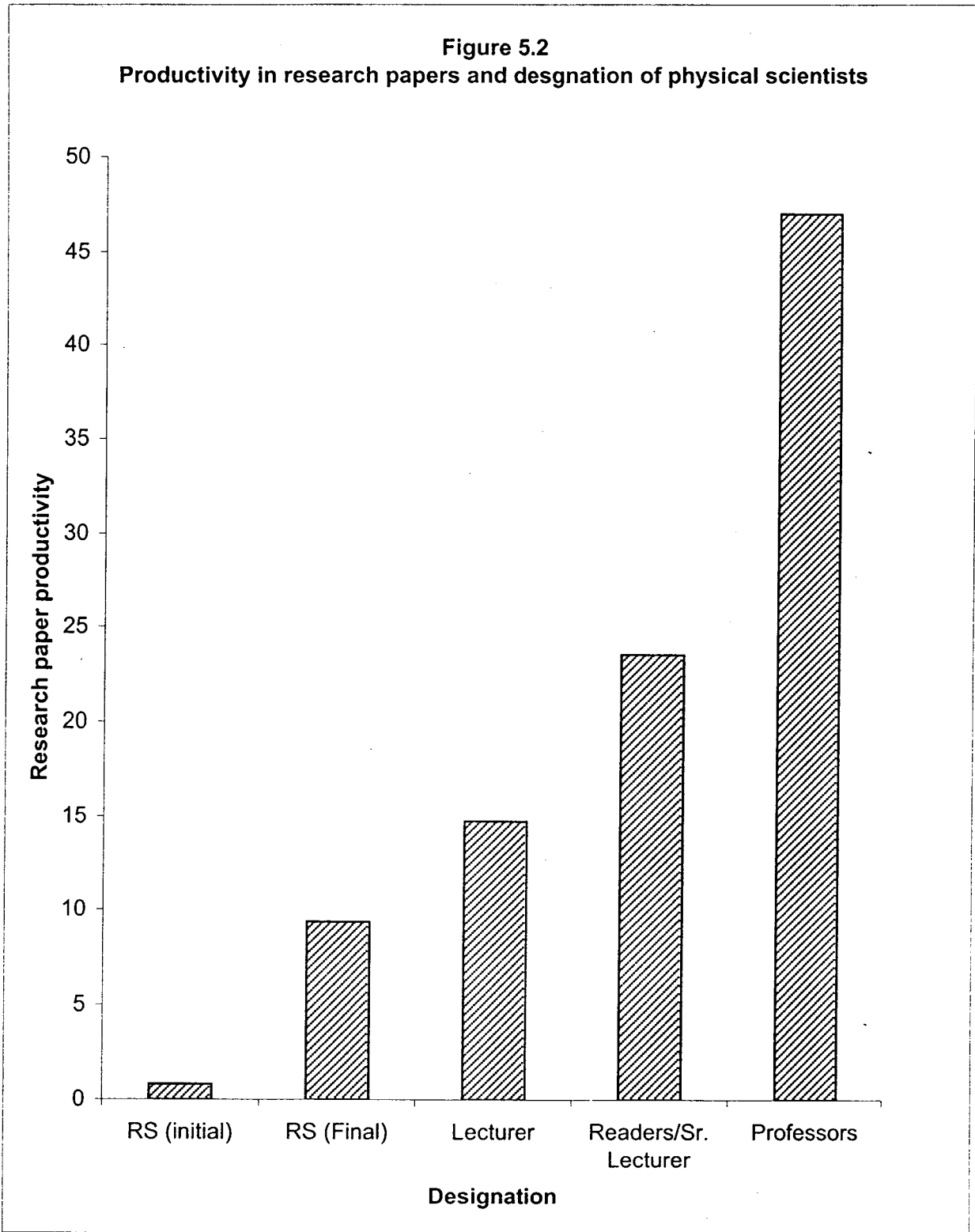
Professors rely heavily on their research students for getting new information and even for publishing the research papers. Graphical representation of productivity in research papers and the status of scientists are presented in figure 5.2.

Table 5.4
Productivity of Scientists and their status

Status/ Designation	Productivity in Research Papers		
	Average productivity of scientists	Scientists having Ph.D. production	Scientists not having Ph.D. production
Research Scholar Initial	0.83	No production	No production
Research Scholar final	9.375	No production	No production
Lecturer	14.81	10.33	15.85
Reader / Sr. Lecturer	23.62	36.57	11.53
Professor	47.04	47.04	-

The research paper productivity of lecturers who produce doctoral theses is less compared to those who do not produce doctoral theses. Since publications are essential conditions for appointment, most of the newly appointed teachers have considerable number of publications. The number of papers published by the senior teachers who do not produced Ph.D. theses are less and at the same time the productivity is higher in the case of senior lecturers who produced Ph.D. theses.

Figure 5.2
Productivity in research papers and designation of physical scientists



5.1.4 Scientific Productivity and Experience

The relation between scientific productivity and teaching/research experience of the scientists is presented in Table 5.5.

Table 5.5

Scientific productivity and teaching/research experience

Experience in years	Average Productivity			
	Ph.D. theses	Research papers	No. of research papers	
			Scientists who has produced doctoral theses	Scientists who has not produced doctoral theses
3 years or less	0	2.8	No	No
3 – 5	0	13	No	No
6 – 10	1	22.81	38	17.75
11 – 15	1.67	24.28	34.36	8.43
16 – 20	2.95	24.74	31.62	9.8
21 – 25	6.2	40.1	49	4.5
26 and above	7	61.86	61.86	-

The scientists upto 3 years of experience are in the incumbent stage or in the initial state of productivity and during this period they are high level information/knowledge consumers rather than producers. However during this period the average productivity is limited to 2.8 papers. These

works are the results of their doctoral work or the related subsequent works. The scientists with 3-5 years experience have more productivity in terms of research papers to the extent of 13 papers on an average. The scientists of 6-10 years experience have more productivity in terms of research papers to the extent of 22.81 papers consequent on his own research work.

The marginal growth to the extent of 1.47 papers can be noticed for the scientists having experience for 11-15 years. There is no considerable difference with regard to the productivity in terms of research papers between scientists with experience of 11-15 and 16-20 years.

Observation

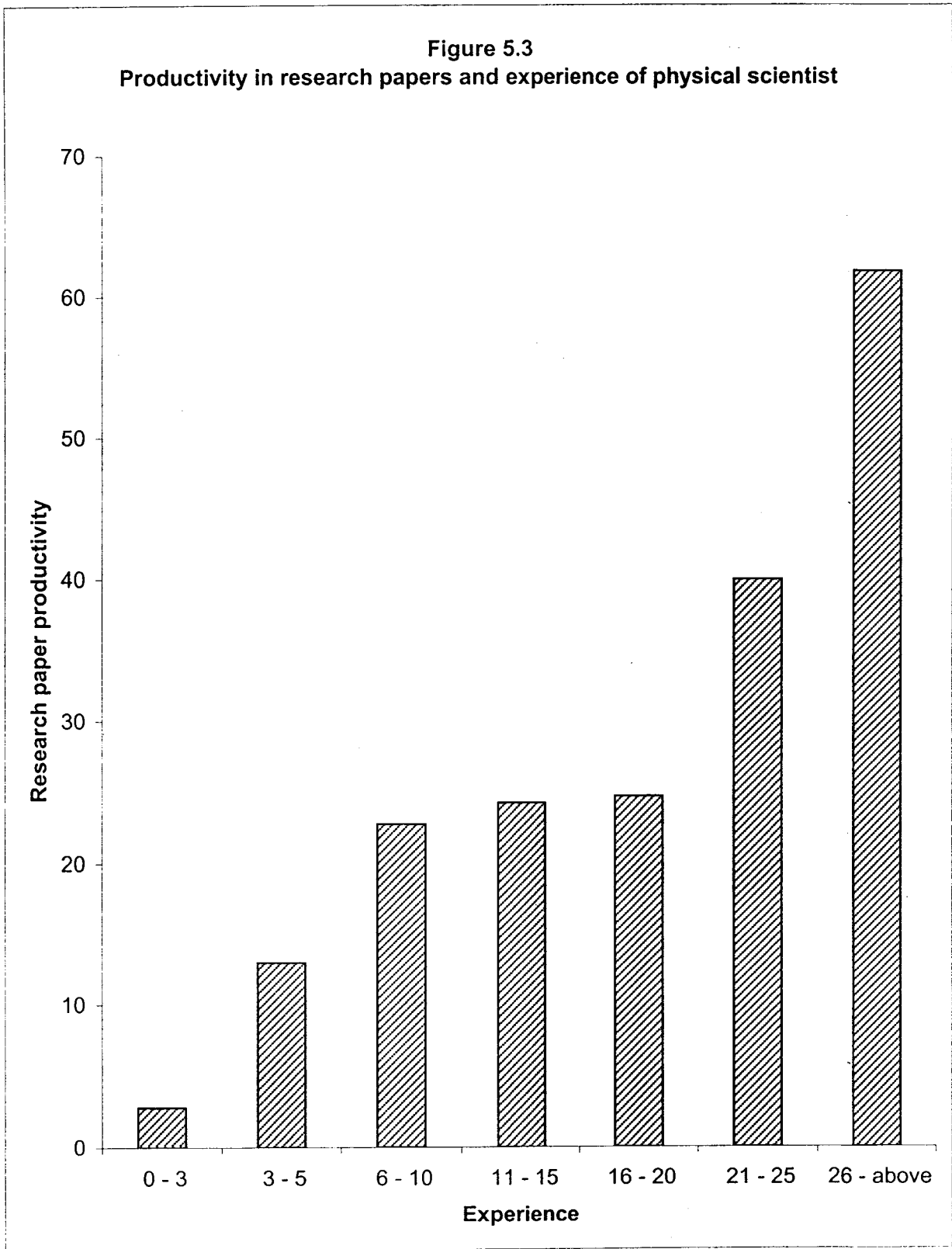
The period of productivity of scientists can be categorized into two: (1) Dependent period (2) Independent period. The scientists mainly dependent on his own research supervisor or the senior scientists for producing research papers during the dependent period. During the independent period the work is the result of his own independent work. The scientists during later period in his experience mainly depend on his own research students or junior scientists for productivity.

Even during the independent period only a handful of scientists could take independent areas of research other than what he has done at his doctoral level.

It is observed that scientists with 6-10 years of experience have considerable number of publications, irrespective of the fact of producing or not producing Ph.D. theses. But in the case of scientists who could not produce Ph.D. theses a drastic decline of research papers produced can also be seen from 11th year onwards compared to those who produce Ph.D. theses.

In figure 5.3 the increase of scientific productivity in terms of research papers with respect to the experience of the scientists is illustrated.

Figure 5.3
Productivity in research papers and experience of physical scientist



5.1.5 Scientific Productivity in different disciplines

The average productivity of scientists in different disciplines/ subjects is given in the Table 5.6

Table 5.6

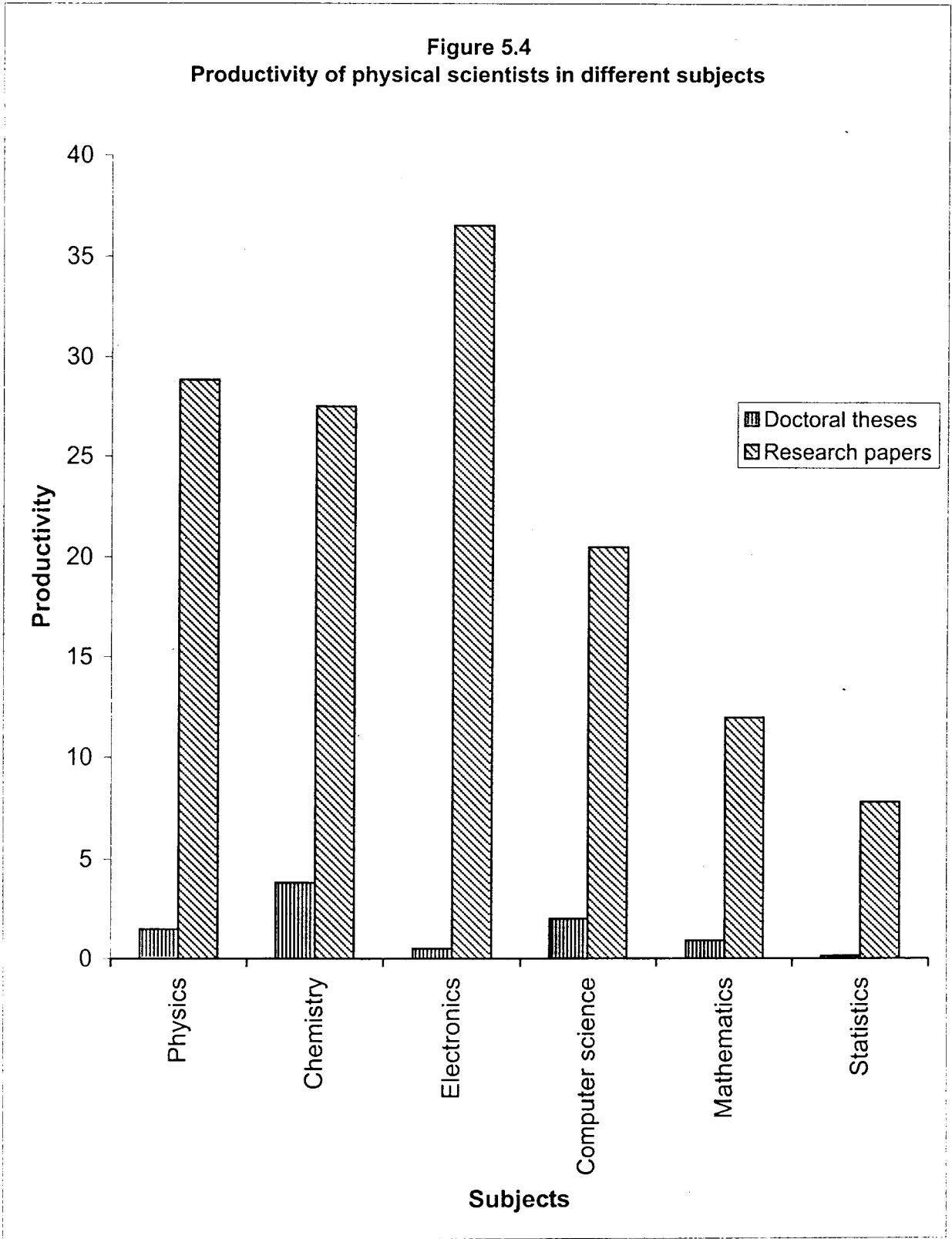
Subject wise productivity of scientists

Subjects	Scientific Productivity	
	Doctoral theses	Research papers
Physics	1.47	28.83
Chemistry	3.82	27.5
Electronics	0.5	36.5
Computer Science	2	20.5
Mathematics	0.9	12
Statistics	0.14	7.86

Electronics, Physics, Chemistry and Computer Science have greater productivity compared Mathematics and Statistics. Electronics, and Computer Science are fast developing disciplines and scientists produced more research papers. In Mathematics and Statistics most of the works are of theoretical nature and hence number of papers are less. In the fastly growing subjects and in experimental areas in Physics and Chemistry, more research work could be done and hence more output will be possible.

The doctoral productivity is more in Chemistry, than Physics. In Computer Science, Mathematics, Electronics and Statistics, doctoral works are very less. But in Electronics, though the doctoral productivity is very low, the research paper productivity is comparatively high. The relation between the scientific productivity and the discipline or subject of study is illustrated in figure 5.4.

Figure 5.4
Productivity of physical scientists in different subjects



5.1.6 Relationship between productivity of research papers and doctoral theses

Productivity in doctoral theses and research papers of scientists and their relationship are given in Table 5.7

Table 5.7

Research Paper and Doctoral productivity of scientists

No. of doctoral theses of scientists	No. of papers published by the scientists
1-2	15.375
3-5	51.21
6-7	37.2
8-10	59.2
11-15	107
Above 15	107

Scientists are categorised in six groups based on number Ph.D. theses produced, varying from 1-2 to 15 as above. The number of papers is the minimum or low (15.375) for scientists who produced 1-2 Ph.D. theses. But in the case of scientists who produced 3-5 Ph.D. theses, a quantitative leap with regard to paper of publication to the extent of 51.21 could be noticed. Maximum productivity of papers found among

scientists of doctoral productivity of 3- 5 numbers. Hence peak value is observed among this category, then their paper productivity is less in 6- 7 group and again it increase among scientists of productivity in doctoral theses eight or more. There is stagnation in paper productivity among the scientists having 15 or more doctoral theses.

The maximum productivity of scientists having productivity of 3-5 doctoral theses is due to their own increased productivity during that period. (The maximum productivity among physical scientists is observed at the age range of around 35 years). This may be due to the burn out stage of scientists, whose individual productivity becomes less. At this stage, though there is increase in successful doctoral theses, no much research papers are published because of the burnout phenomena among the scientists.

However a decline to extend of 37.2 is noticed in the case of scientists who produced 6-7 Ph.D. theses. This phenomenon may due to the fact that at the state most of scientists stopped their own work and concentrating on guiding research scholars.

In the next two stages of producing Ph.D. theses to the extent of 8-10 and 11-15, a considerable increase with regard to research papers

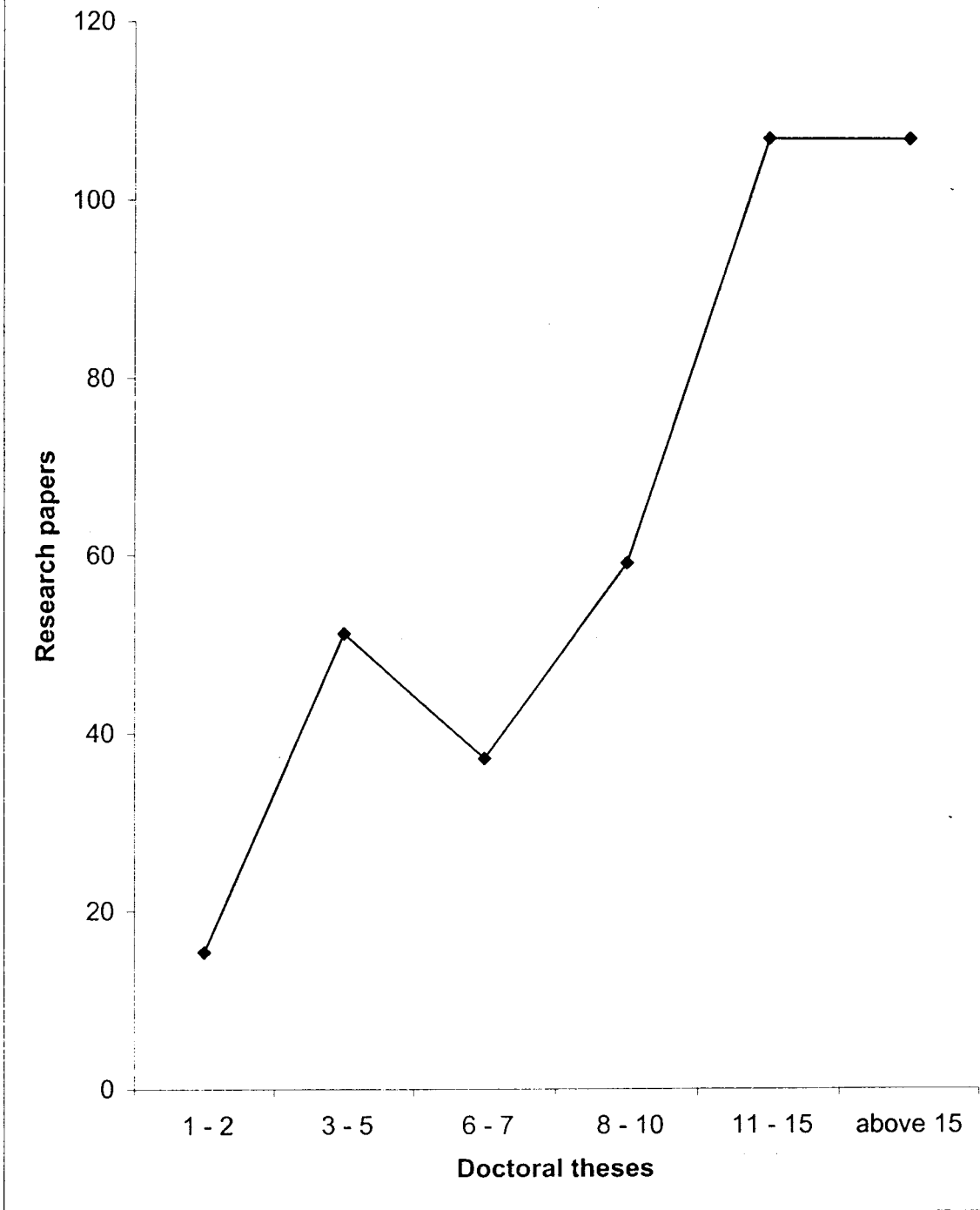
published has been taken place. This is due to the fact that the scientists in publishing research papers are utilizing the research work of their research scholars.

In the last stage stagnation with regard to research papers publications can be noticed. This may be due to burn out stage of scientists, whose individual productivity becomes less. At this stage, though there is increase in successful doctoral theses, no much research papers are published because of the burn out phenomena among the scientists.

The scientific productivity in terms of research papers and doctoral theses is graphically represented in figure 5.5.

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Figure 5.5
Research paper productivity and doctoral theses productivity of
physical scientists



5.1.7 Scientific Productivity and Information Consumption

The scientists under study are classified into two groups, productive and unproductive. The scientists having at least three research papers or one Ph.D. thesis produced are classified as productive scientists. Scientists having less than three are classified as unproductive scientists. The information consumption in its qualitative and quantitative aspect of the scientists can be measured in terms of the time spent by them per day or week for the present study it is measured in terms of time spent per week.

The consumption time has been taken as the time spent in a week for information search, reading and research. The information consumption time of scientists according to their sex, age, discipline/subjects, designation and experience have been studied.

a) Sex

In table 5.8 the information consumption time of male and female scientists has been analysed.

Table 5.8

Information Consumption time of Male and Female Scientists

Sex	Consumption Time of Scientists			
	Productive in research papers	Unproductive in research papers	Productive in Ph.D. theses	Unproductive in Ph.D. theses
Male	34.88	70.3	34.13	45.77
Female	38	41.05	43.28	37.5

It can be seen that the male scientists who are productive in terms of research papers their average information consumption time in a week is 34.88 while their female counterparts spends 38 hours per week. The productive male scientists with regard to Ph.D. theses spent 34.13 hours per week whereas female scientists spent 43.28 hours per week. The scientist who are categorized unproductive with regard to research papers and Ph.D. theses are also belonged to beginners and research scholars who are consuming more informations in terms of hours per week. The unproductive senior scientists with regard to research papers and Ph.D. theses including male and female scientists are spending lesser time for information consumption. On an average all the unproductive scientists with regard to research papers including research scholars and beginners spent 70.3 hours per week. This is far greater than the time spent by the productive scientists. As explained earlier productive scientists heavily depend on their juniors or research scholars with regard to information collection or handling. Hence they could be highly productive eventhough they spent lesser hours per week for information consumption. Since the study is primarily concerned about highly productive scientists, the findings with regard to unproductive scientists do not effect the present study. Among the scientists $\frac{2}{3}$ constitutes the male and the remaining $\frac{1}{3}$ constitutes the female. Then most of the female scientists could not spend either in the early morning or late evening for information consumption due to their own limitations indicated at the time of personal interview conducted by the investigator.

b) Age

The consumption time decreases on increase of age. The scientists become experts in information handling when age goes up.

Table 5.9

Consumption time with respect to age

Age	Consumption time of Scientists			
	Productive in papers	Un productive in papers	Having doctoral theses	Not having doctoral theses
25 or less	38	60.9	-	120.66
26 – 30	35.51	69.61	-	52.4
31 – 40	36.31	41.67	41.50	35.66
41 – 50	36.17	17	38.72	23.09
50 above	30.66	20	29.34	40

It can be observed that there exists an inverse relationship between age and information consumption time. That is at the younger age scientists consume more information measured in term of hours spent for information consumption. At the later stage after attaining high level information consumption scientists are concentrating on information production measured in terms of research papers published or Ph.D. theses produced besides spending some time for advanced level teaching.

It can be seen that scientists without the minimum research papers upto the age of 40 are spending a lot of time for information consumption varying from 41.67 to 69.61 hours per week.

It can be seen that most of the research scholars are in the age group of below 25. Further the unproductive scientists above 40 age group remain as unproductive throughout their life and they also spent longer time for information consumption to the extend of 17 or 20 hours per week.

On the other hand in the case of productive scientists with regard to research papers have been constantly spending over 30 hours per week varying from 30.66 to 36.31 hours per week.

In the case of scientists who have produced doctoral theses there exists an inverse relationship with regard to age and information consumption time while scientists in the age group 31 to 40 spending 41.50 hours per week. The scientists in the above 50 age group are spending 29.34 hours per week. This phenomenon can be explained in terms of the stage theory of information growth propounded by Mathew (1985). That is to attain critical stage or take over stage of information production scientists have to consume a lot of qualitative information and after that they could easily turn into high level information producers measured terms of research paper, guiding Ph.D. theses and advanced level teaching.

These interpretations are also almost applicable with regard to experience and designation of scientists with minor variation. Therefore separate explanations and interpretations are not provided with regard to designation and experience. Generally scientists with higher age have more experiences and are holding higher position except in very rare cases.

c) Subject

Table 5. 10

Consumption time of Scientists of different physical Science subjects

Subjects	Consumption time			
	Productive in research papers	Unproductive in research papers	Scientists who has produced Ph.D. theses	Scientists who has not produced Ph.D. theses
Physics	32	43	29.4	36.05
Chemistry	39.41	59.93	42.7	44.96
Electronics	35	-	45	25
Computer Science	36.5	-	53	20
Mathematics	35.36	69.67	24.78	59.52
Statistics	36.5	20	35	34

The entire scientists electronic and computer science are productive with regard to research papers or there is not a single scientist with out at least three research papers.

The discipline wise production of the scientists has already been given in Table 5.6, discussed earlier. However the productive scientists especially with regard to research papers irrespective of subject/discipline spent on average of 30 to 39.41 hours per week. However while the unproductive scientists in Chemistry and Mathematics spent above 59.93 to 69.67 hours per week. While scientists in Physics spent 43 hours per week, their counterpart is statistics is nearly 20 hours per week. It can be

seen that in Mathematics the scientists who produce Ph.D theses spent only 24.78 hours per week for information consumption. But the scientists who do not produce Ph.D. theses spent 59.52 hours per week.

Average Ph.D. productivity of scientists in the Mathematics is 0.9 only (Table 5.6). That means there are several scientists who could not produce single Ph.D. theses. Even the highly productive scientists produced are one or two Ph.D. theses. Also the average time spent for information consumption by the scientists who produce Ph.D. theses in Mathematics is seen very less. Hence they ceased to be high level consumers and producers of information.

d) Designation

Table 5.11

Consumption time of Scientists according to their designation

Designation	Consumption time of scientists			
	Productive in research papers	Unproductive in research papers	Productive in Ph.D. theses	Unproductive in Ph.D. theses
Research Scholar Initial	-	109.17	-	109.17
Research Scholar Final	44.72	40.5	-	43.4
Lecturers	32.44	-	29.67	33.07
Reader/Sr. Lecturer	31.56	18.33	33.78	24.2
Professors	37.6	30	37.3	-

The research Scholars-initial stage that is novice spent more time (109.17 hrs/week) for information consumption. Then it reduces in research scholar-final stage. In productive Lecturers, Readers and Professors, the consumption time is almost equal. The scientists who are not experts at the research scholar initial stage, develops information handling skill and decreases the consumption time during research scholar final stage. Then the scientists become experts at Lecturer/Reader stage, the consumption time becomes minimum. In the case of unproductive Reader and Professor, the consumption time is very low.

In the productive scientists having doctoral dissertations, who are experts in ICP, due to the guidance of more number of research students increase in time of information consumption is observed. The lecturers who are unproductive in doctoral dissertations spent more time than the scientists productive in doctoral dissertations. This may be either because of lack of expertise in ICP or for production of more number of research papers or Ph.D. theses.

e) Experience

Table 5.12

Consumption time and experience of physical scientists

Experience in years	Consumption time of scientists			
	Productive in research papers	Un productive in research papers	Productive in Ph.D. theses	Un productive in Ph.D. theses
3 years less	34	107.14	-	85.2
3 – 5	48.15	24.5	-	45
6 – 10	24	75	24	28.25
11 – 15	36.31	27.5	41.09	26.29
16 – 20	35.74	21	35.38	26.83
21 – 25	44.34	-	44.25	22.5
26 above	24.29	-	24.29	-

In the table 5.12 the scientists unproductive in research papers, of 3 years or less experience include the beginners in research. Hence their consumption time is more. The scientists who are productive in research papers become experts at the experience stage 6 – 10 years and they consume least time. Among the productive scientists, the scientists with 3–5 years and 21–25 years experience have maximum consumption time.

5.1.8 Information use pattern of physical scientists

The information use pattern of the physical scientists are shown in table 5.13. Totally 10 types of information sources have been taken for study. The scientists are instructed to mark their preference for each type

from 1 to 10. Arbitrary values from 10 to 1 were given for the first preference to tenth. By adding the values, for total scientists the weightage for the 10 sources were tabulated and the weightage in percentage is found out and tabulated in table 5.13.

Table 5.13
Information use pattern of scientists

	Information sources	Score	Weightage Percentage
1	Primary journals	811	16.94
2	Abstracting/indexing journals	745	15.56
3	Conference proceedings	498	10.40
4	Review articles	577	12.05
5	Research reports	478	9.98
6	Books/monographs	538	11.24
7	Reprints/preprints	419	8.75
8	Consultation with others	285	5.95
9	Attending Seminars/conferences	309	6.45
10	Membership in Learned/ Professional bodies	128	2.67
	Total	4788	100

The physical scientists give maximum preference (16.94%) to the primary journals, 15.56% weightage to the abstracting/indexing journals. 12.05% weightage to review articles 11.24% weightage to books/monographs.

a) Information use pattern of male and female scientists

Table 5.14

Information use pattern of male and female scientists

Information Sources	Weightage	
	Male	Female
1	16.8	17.26
2	16.10	14.09
3	10.27	10.76
4	12.16	11.76
5	9.70	10.76
6	11.53	10.45
7	8.55	9.29
8	5.98	5.88
9	6.09	7.43
10	2.80	2.32

Male scientists give more preference for abstracting/indexing journals and review articles. They less prefer primary journals. There is slight difference in the use of information sources between male and female scientists.

b) Information use pattern of scientists according to their age group.

Information use pattern of scientists of different age group are given in Table 5.15

Table 5.15

Information use pattern of scientists of different age group

Information Sources	Information use pattern Scientists of different age groups				
	1	2	3	4	5
1	13.74	17.93	17.05	16.47	17.24
2	12.64	12.83	14.44	16.05	15.64
3	4.39	10.09	11.43	11.63	11.58
4	13.19	11.33	12.17	12.40	13.30
5	11.54	7.60	10.49	8.69	9.61
6	10.44	11.83	8.89	10.58	8.62
7	12.64	9.84	10.16	9.11	6.90
8	10.44	9.09	6.62	6.03	6.28
9	5.49	7.35	6.42	6.38	7.76
10	5.49	2.12	2.34	2.66	3.08

The importance of abstracting/indexes journals increases from the age group 3 onwards. Similarly for review articles also the importance increase from the age group onwards.

c) Information use pattern of a scientists according to their area of specialisation

Table 5.16

Information use pattern of scientists of different Subjects

Information sources	Information use pattern of Scientists					
	Physics	Chemistry	Electronics	Computer Science	Mathematics	Statistics
1	18.07	18.75	14.55	17.27	17.49	24.66
2	15.07	16.96	10.91	15.45	12.42	13.94
3	11.65	10.69	17.27	10.91	10.04	11.53
4	12.35	13.95	10.91	12.73	10.91	10.19
5	10.33	0.61	9.09	12.73	9.18	6.70
6	9.49	9.71	9.09	12.73	11.23	10.19
7	7.89	10.39	15.45	7.27	9.72	9.92
8	5.86	8.36	6.36	4.55	8.53	5.63
9	6.91	7.31	4.55	4.55	7.88	4.56
10	2.37	3.26	1.82	1.82	2.59	2.68

d) Information use pattern of various information sources of scientists in terms of their designation

Table 5.17

Information use pattern of scientists of different designation

Information Sources	Information use pattern of Scientists						
	Lecturer	Reader	Professor	R.S. Initial.	R.S. final	Post Doctoral	Others
1	19.31	19.48	16.05	13.64	17.42	14.81	22.73
2	14.96	15.14	15.98	11.08	12.28	12.17	20.45
3	10.23	11.76	10.80	8.24	10.90	8.47	15.91
4	11.64	13.29	11.88	9.94	13.28	11.11	13.64
5	9.59	8.86	9.50	8.81	9.65	10.05	11.36
6	9.08	10.47	9.36	12.78	9.65	11.11	9.09
7	9.34	7.97	9.22	9.94	11.03	12.70	4.55
8	7.54	5.23	6.08	12.78	8.65	7.94	2.27
9	7.03	5.07	8.06	9.38	5.51	7.41	-
10	1.28	2.74	3.10	3.41	1.63	4.23	-

Table 5.18

Information use pattern of scientists according to their experience

Information Sources	Information use pattern of scientists						
	Below 3 years	3-5 years	6-10 years	11-15 years	16-20 years	21-25 years	26years above
1	15.66	17.65	19.85	17.2	18.04	16.42	17.49
2	13.40	13.59	15.23	13.83	15.22	17.48	15.57
3	10.19	10.07	12.53	9.52	12.51	8.32	11.75
4	10.75	12.94	12.48	11.33	11.72	11.51	12.84
5	8.49	11.76	8.24	8.73	9.81	8.53	9.84
6	12.08	9.28	7.74	12.02	9.58	9.59	8.74
7	9.25	10.33	9.74	10.88	9.24	8.53	4.92
8	9.43	8.24	5.62	7.14	4.85	8.96	4.92
9	8.11	4.31	6.74	6.24	5.86	8.32	10.93
10	2.64	1.83	2.12	3.17	3.16	2.34	3.00

From regression graph (fig 5.6 to 5.11) it can be seen that though there is slight differences in the weightage of use of the certain information sources the graph plotted is similar. Hence we can conclude that there is similarity in the use of information sources among the various categories of physical scientists.

Figure 5.6
Information use pattern of physical scientists

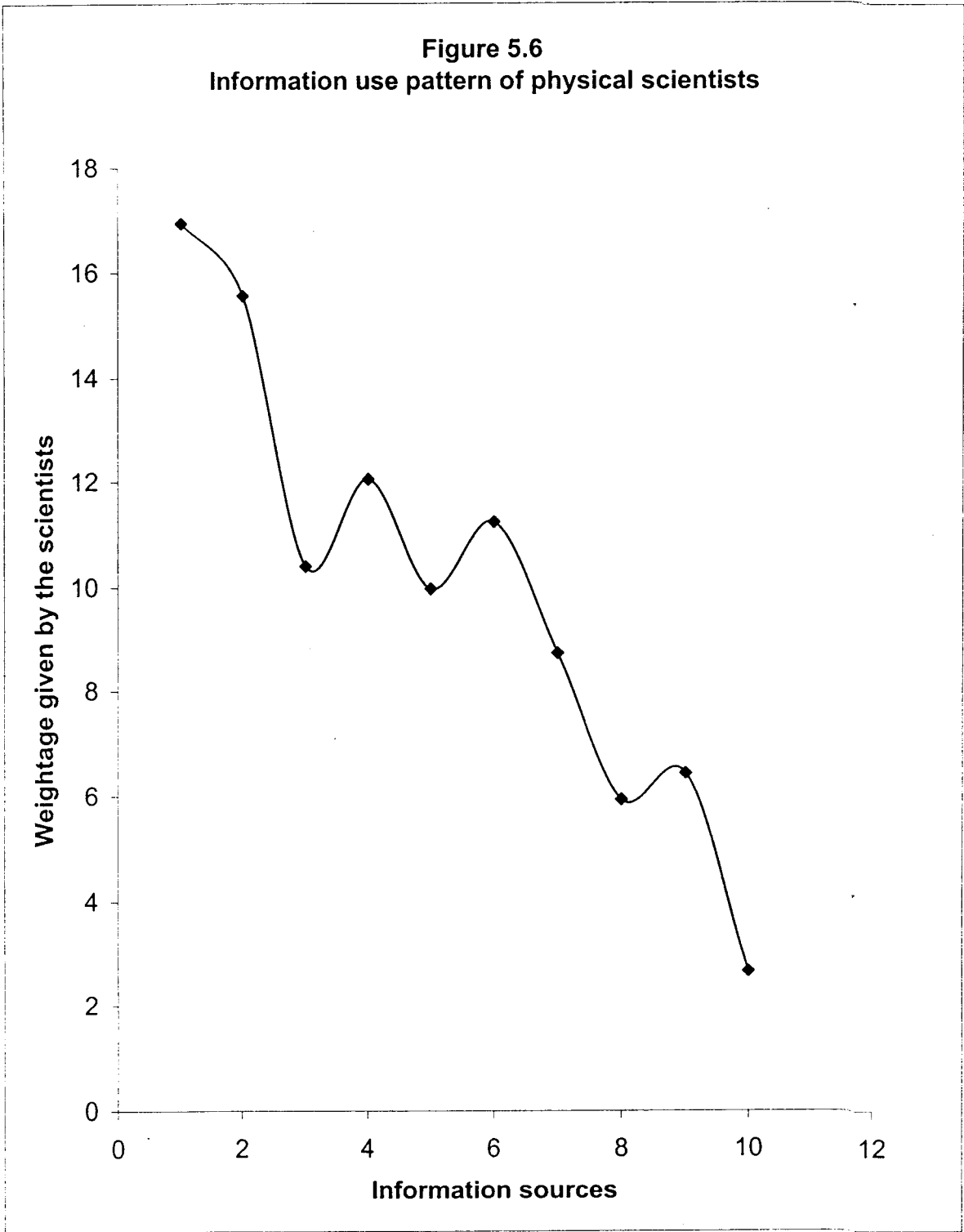


Figure 5.7
Information use pattern of Male and Female physical scientists

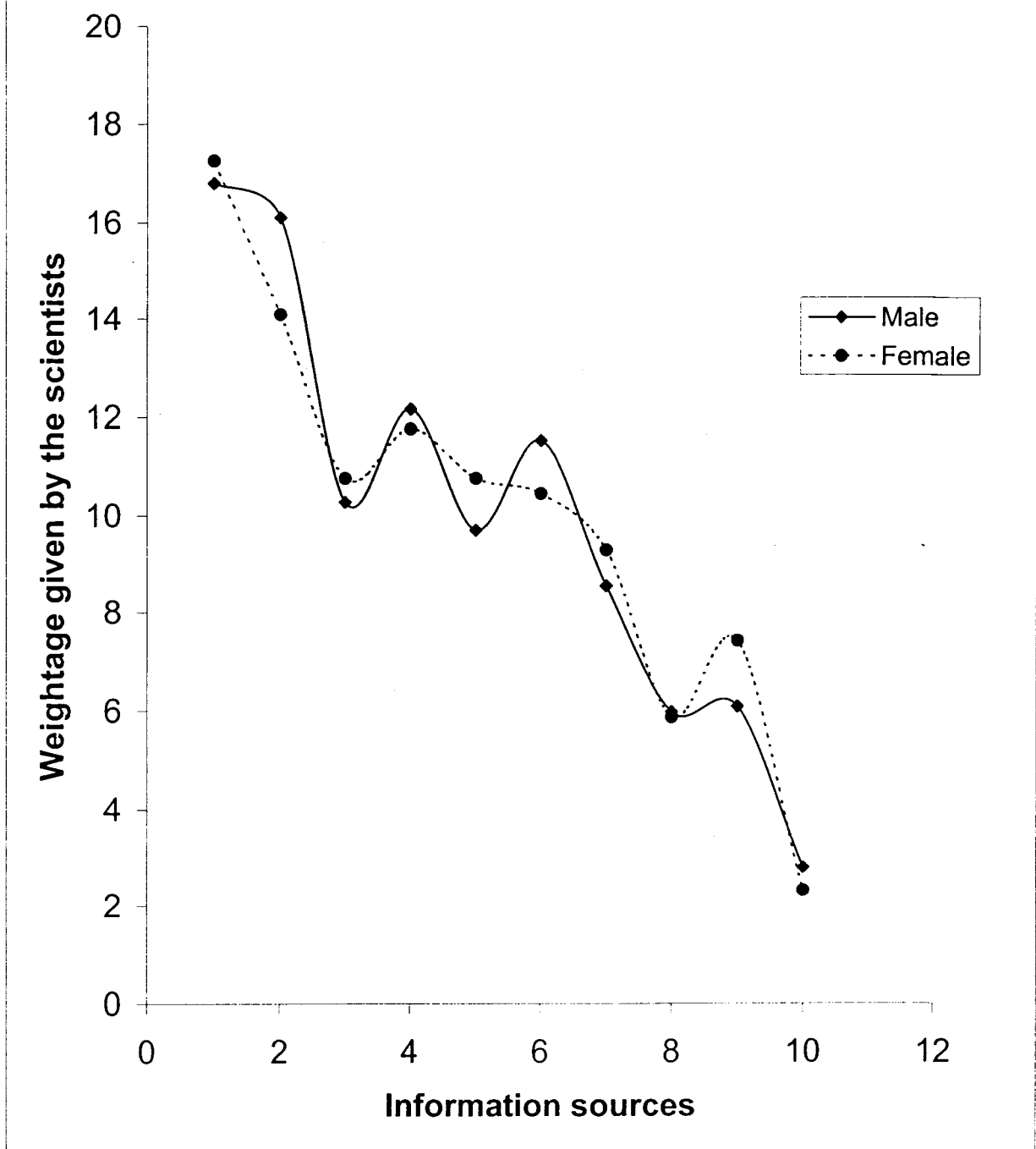


Figure 5.8
Information use pattern of physical scientists of different age groups

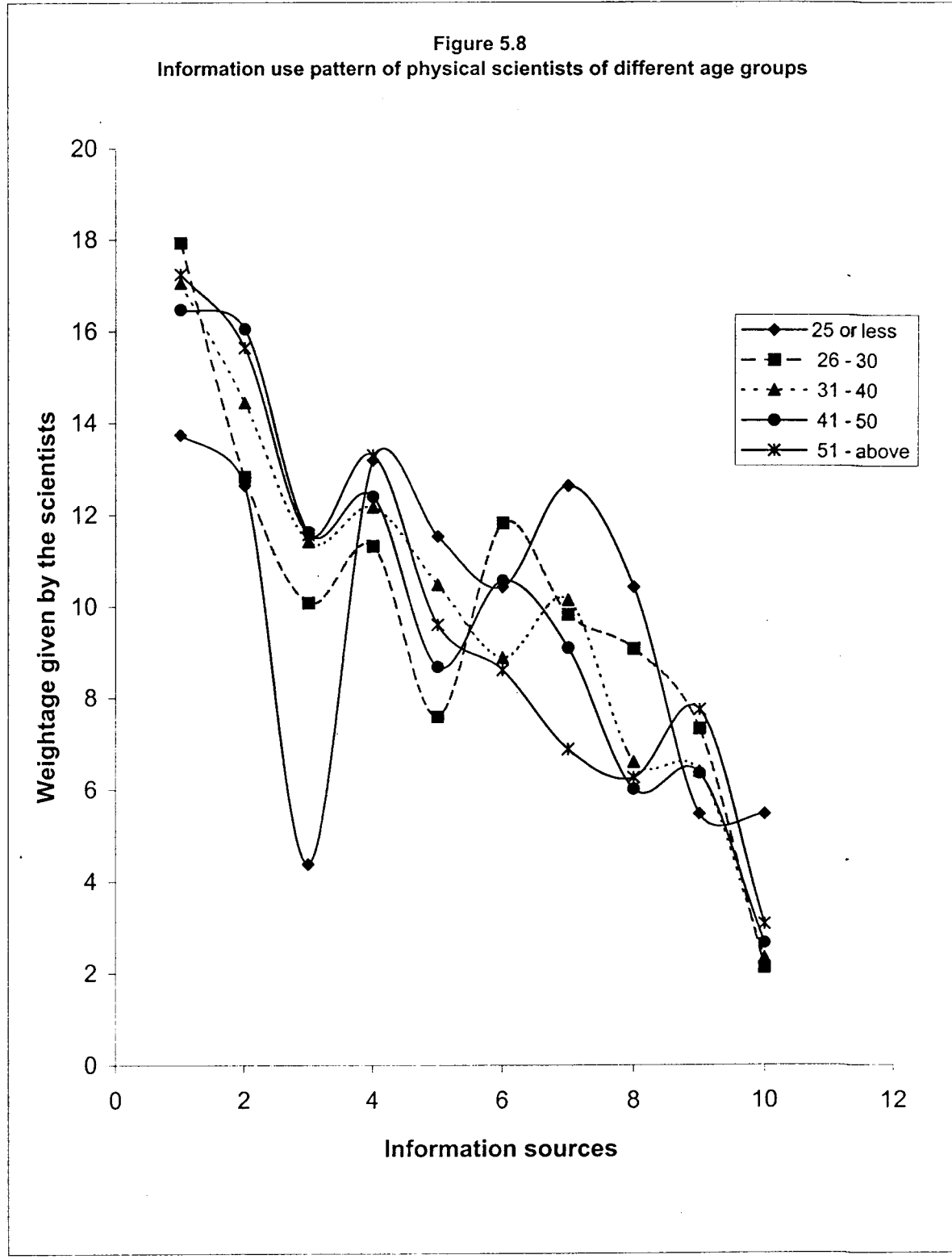


Figure 5.9
Information use pattern of scientists of different subjects

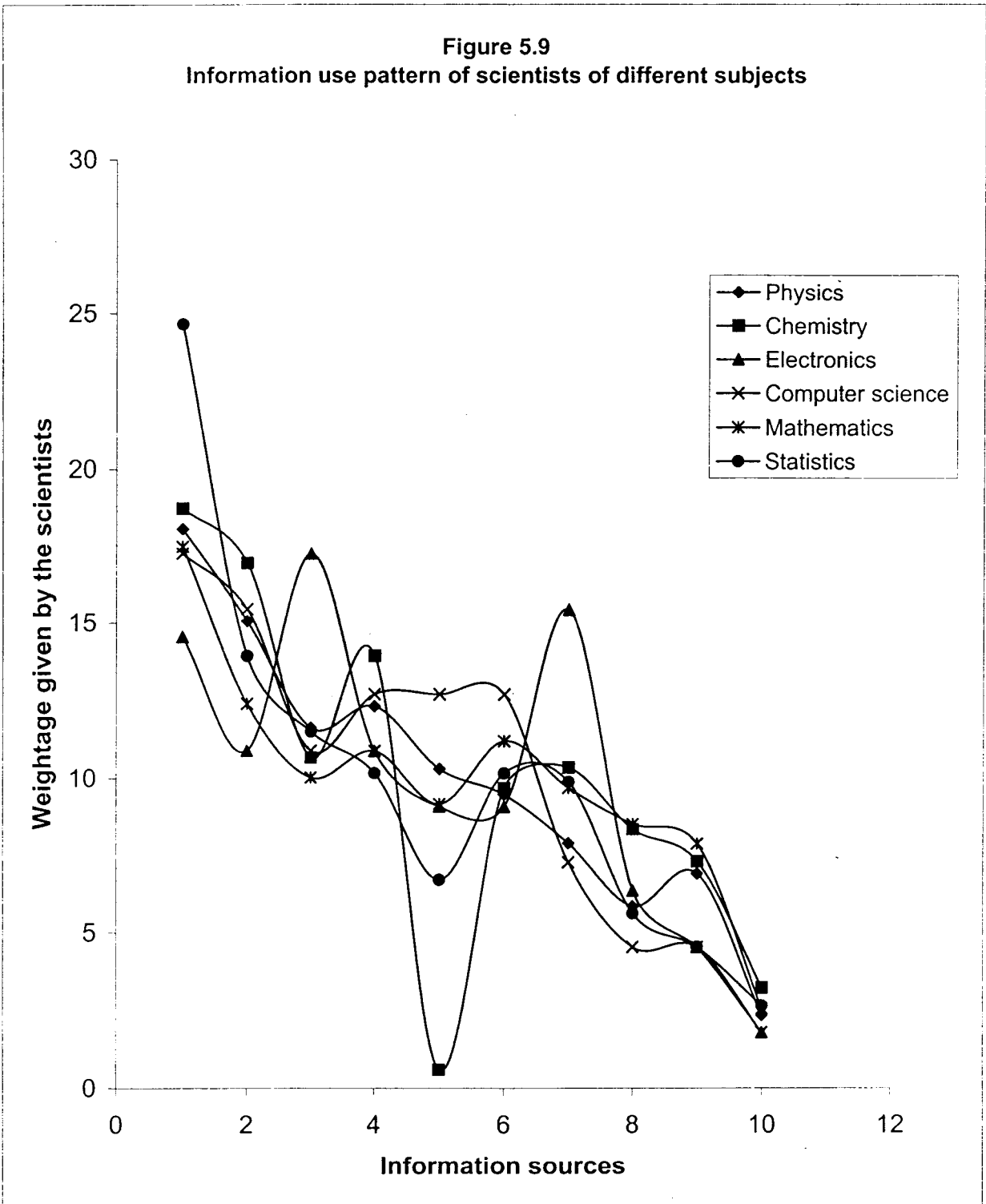


Figure 5.10
Information use pattern of scientists of different designations

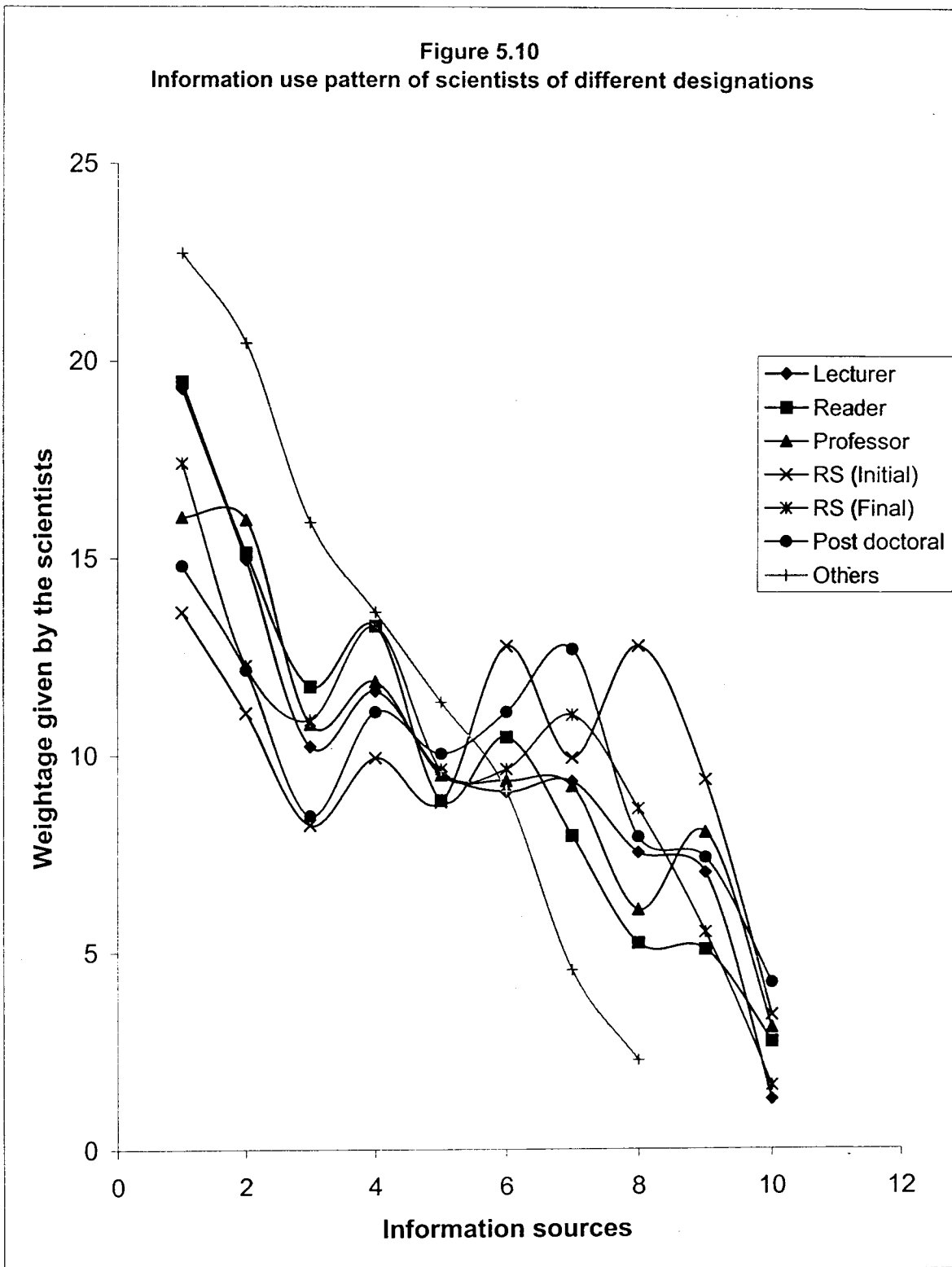
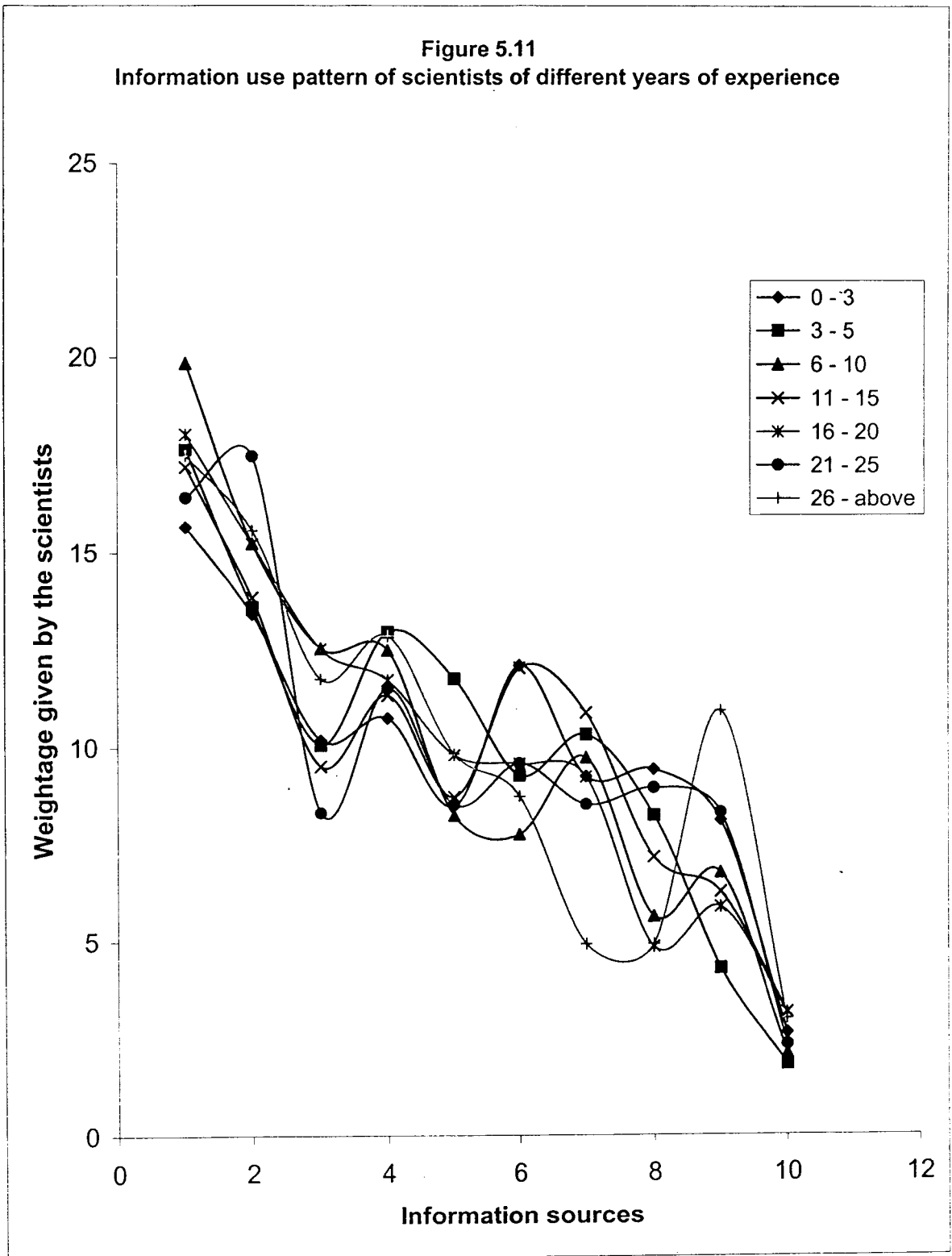


Figure 5.11
Information use pattern of scientists of different years of experience



5.1.9 Comparison of Scientific Productivity in terms of Research Papers and Ph.D. theses of different category of scientists

Some of the important variables discussed earlier have been integrated and on that basis a comparison has been made. The productivity in papers increases with the Ph.D. theses successfully completed, in all categories of scientists. But no fixed proportionality between the Ph.Ds produced and research papers published is observed. In physics doctoral theses productivity is 1.47 and paper productivity is 28.83. In chemistry the doctoral theses productivity is 3.82, but the paper productivity is only 27.5. In electronics doctoral theses productivity is 0.5, but paper productivity is 36.5, a high value. In mathematics doctoral theses productivity is 0.9, its paper productivity is 12 (Table 5.22).

In the table 5.23 experience, doctoral theses productivity and paper productivity are given. For the experiences 6 to 20 years, the doctoral theses productivity increases from 1 to 2.95, the paper productivity in between 22.81 and 24.74. The scientists first concentrate on the successful completion of the Ph.D. theses and hence the paper productivity is in stagnation. But after 20 years, the paper productivity steeply increases along with the increase in Ph.D. theses. In this stage the productivity is the combined activity of research students and the individual scientist.

a) age

Table 5.19

Productivity in doctoral theses and
Research papers of scientists of different age groups

Age years	Productivity of Scientists	
	Doctoral theses	Research papers
25 or less	0	1
26 – 30	0	9.56
31 – 40	0.72	17.59
41 – 50	2.34	26.53
50 above	7.06	49.06

b) sex

Table 5.20

Productivity in doctoral theses and
Research papers of male and female scientists

Sex	Productivity of Scientists	
	Doctoral theses	Research papers
Male	2.41	26.23
Female	1.54	18.11

c) Designation

Table 5.21

Productivity in doctoral theses and
Research papers of scientists of different designation

Designation	Productivity	
	Doctoral theses	Research papers
Research scholar initial stage	0	0.83
Research Scholar final stage	0	9.375
Lecturers	0.1875	14.8125
Reader/Lecturers Sr.	1.51	23.62
Professors	6.31	47.04

d). Subjects

Table 5.22

Productivity in doctoral theses and
research papers of scientists of different subject fields

Subjects	Average productivity	
	Doctoral theses	Research papers
Physics	1.47	28.83
Chemistry	3.82	27.5
Electronics	0.5	36.5
Computer Sciences	2	20.5
Mathematics	0.9	12
Statistics	0.14	7.86

e) Experience

Table 5.23

Productivity in doctoral theses and
research papers of scientists of different experiences

Experience in years	Average productivity	
	Doctoral theses	Research papers
3 or less	0	2.8
3 – 5	0	13
6 – 10	1	22.81
11 – 5	1.67	24.28
16 – 20	2.95	24.74
21 – 25	6.2	40.1
26 or above	7	61.86

There is an increase in productivity with production in doctoral theses in all categories of scientists except in the case of some of the subjects. In Physics, Chemistry and electronics their difference can be observed. In the case of experience from the 6 to 20 years, the doctoral theses productivity increases from 1.67 to 2.95, the productivity in papers remain almost same (varies from 22.81 to 24.74) this indicates that a part of paper productivity is result of scientists own productivity in papers and a part of it is the research students guided by the scientists. After 20 years, own productivity decreases and increase observed is mostly due to the doctoral work of his research students. At this stage we can observe a correlation between doctoral theses produced and research papers published.

5.1.10 Use of Information Technologies

In the study 91.75% of scientists have the opinion that the application of IT will increase the productivity of scientists. However 5.16% scientists opined that IT would not increases the productivity. The rest 3.09% have no opinion recorded (Table: 5.24).

Table 5.24

Opinion on IT whether if increases productivity

	Number of Scientists	Percentage
Yes	89	91.75
No	5	5.16
No opinion	3	3.09

a) Use of computer facilities

In the table 5.25, the number of scientists productive and unproductive and their percentage of using the computer facilities are given. Total 68.04% of scientists make use of computer facilities out of 57.09% of unproductive scientists and 70.5% productive scientists make use of the facility.

Table 5.25

Scientists (productive and unproductive) in research papers

Place of use	Number of scientists making use of computer facilities					
	Productive		Unproductive		Total	
	No.	Percentage	No.	Percentage	No.	Percentage
Department	55	70.5	11	57.09	66	68.04
At home	10	12.82	1	5.26	11	11.34
Outside	1	1.28	0	0	1	1.03
Not used	12	15.38	7	36.84	19	19.59

68.04% Scientists are making use of computer facilities of the department, 11.34% make use of facility at their home 19.59% are not using at all. Among the unproductive scientists 36.84% are not making use of facility at all.

Table 5.26

Scientists (productive and unproductive) using computer facilities

Place of use	Number of scientists making use of computer facilities					
	Having Ph.D. production		Not having Ph.D. production		Total	
	No.	Percentage	No.	Percentage	No.	Percentage
Department	26	60.47	40	62.5	66	68.04
Home	10	23.26	1	1.85	11	11.34
Outside	1	2.32	0	0	1	1.03
Not used	6	13.95	13	24.07	19	19.59

Hence from the two tables 25 and 26, it is seen that only a few scientists have the facility of their own, most of them making use of facilities at their institution.

Hence more computer facilities shall be provided by the institution for the use of scientists.

b) Fields of IT use

Number of scientists using the modern technologies for the following purposes is tabulated in the table 5.27.

- 1) Preparation of papers
- 2) Conducting research work
- 3) Keeping abreast of developments in the subject field
- 4) Preparation for teaching.

Among the productive scientists 89.74% are using modern technology for preparation of papers, 75.4% are using for conducting research work, 53.85% are using for keeping abreast of latest

development of subject. 39.74% scientists use IT for the first three purposes (Table 5.27).

Table 5.27
Fields of use of IT

Fields of use	No. of Scientists using IT					
	Productive		Unproductive		Total	
	No.	%	No.	%	No.	%
Preparation of papers	70	89.74	9	47.37	79	81.44
Conducing Research work	59	75.64	10	52.63	69	71.13
Keeping abreast of least development in field	42	53.85	36.84	36.84	49	50.51
Preparation for teaching	-	-	-	-	28	39.44
For above first 3 purposes	31	39.74	26.32	26.32	36	37.11

c) Areas of use of computer facilities

Table 5.28
Use of Computer facilities

Areas of use	Number of Scientists using computers					
	Productive		Unproductive		Total	
	No.	Percentage	No.	Percentage	No.	Percentage
Information Search	61	78.21	12	63.16	73	75.26
Information Retrieval	43	55.13	6	31.58	49	50.52
New information generation	18	23.08	5	26.32	23	23.71
Data Analysis	48	61.54	5	26.32	53	54.64
E Mail	63	80.77	10	52.63	73	75.26
All the above purposes	12	15.38	2	10.53	6	6.19
Not used	4	5.13	2	10.53	6	6.19

c) Use of Networks

The Internet is used by 75.25% of scientists. 21.65% of scientists are not using any of the networks.

In the Table 5.29 the use of network facilities by scientists are tabulated. Internet facilities are provided by all the Universities. Hence most of scientists are making use of this facility.

Table 5.29
Use of Networks

Networks	Productive		Unproductive		Total	
	No.	Percentage	No.	Percentage	No.	Percentage
Ernet	14	17.95	4	21.05	18	18.56
Inflibnet	0	0	0	0	0	0
Nicnet	0	0	0	0	0	0
Internet	64	82.05	9	47.37	73	75.25
Not used	18	23.08	3	15.79	21	21.65

d) Extend of use

In table 5.30 the extend of use of the following technologies are tabulated.

1. Fax
2. Online
3. E-mail

Out of the above 39.18% of total scientists make regular use of the E-mail services, 8.25 scientists make use of online services and only

6.19% scientists make use of fax services regularly. The detailed extend of use, regular, occasional and rare are tabulated in table 5.30.

Table 5.30

Extend of use of Information Technology

Scientists		Regularly used		Occasionally used		Rarely used	
		No. Scientists	%	No. Scientists	%	No. Scientists	%
Productive	Fax	4	5.13	25	32.05	44	56.41
	Online	7	8.97	7	8.97	24	30.77
	Email	30	38.46	27	34.62	16	20.51
Unproductive	Fax	2	10.53	1	5.26	10	52.63
	Online	1	5.26	5	26.32	7	36.84
	Email	8	42.11	1	5.26	4	21.05
Total	Fax	6	6.19	26	26.80	54	55.67
	Online	8	8.25	12	12.37	31	31.96
	Email	38	39.18	28	28.67	20	20.12

f) Factors that prevent the use of IT

The scientists have been asked to mark their reasons for not to using or which prevent the use of modern technologies by giving preferences. By assigning arbitrary values for preferences 1-5, values 10, 8, 6, 4 and 2, the weightage in percentage for the reasons are as in the table 5.31.

Table 5.31

Factors that prevent the use of IT

Reasons	Weightage	Percentage
Lack of funds	357	32.63
Lack of facilities	347	31.72
Lack of time	155	14.17
Lack of training	148	13.53
Discrimination use.	87	7.95

The scientists find lack of funds and facilities are the main preventing factors to use the information technologies (64.35%). The lack of time has 14.17% and lack of training has 13.53% role in preventing the use of information technologies. Hence more facilities may be provided to the scientists for the effective utilization of modern technologies.

5.1.11 Self evaluation made by the scientists regarding their Scientific Productivity

Research: Only 12.37% of scientists are highly satisfied with their research work, 68.04% scientists are moderately satisfied.

Publication: 9.28% Scientists are highly satisfied 60.22% are moderately satisfied and 23.74% are not satisfied at all.

Advance level teaching: 21.33% scientists are highly satisfied, 50.33% are moderately satisfied 25.33% are not satisfied.

Academic achievements: 15.46% scientists are highly satisfied, 64.10% are moderately satisfied and 23.71% are not satisfied.

Table 5.32

Extend of Satisfaction of Research, Publication, Teaching and Academic achievements.

	Highly Satisfied		Moderately satisfied		Not satisfied	
	No. of Scientist	%	No. of Scientist	%	No. of scientist	%
Research	12	12.37	66	68.04	14	14.43
Publication	9	9.28	59	60.22	23	23.71
Advanced level teaching	16	21.33	40	50.33	19	25.33
Academic achievement	15	15.46	54	64.10	23	23.71

From above, Table 5.32, it is seen only a small minority of scientists are satisfied with their, research, publication teaching and academic achievements. Hence prime attention maybe given to the satisfaction of the scientists.

5.1.12 Factors of scientific productivity

From the data scientific productivity (in terms of published papers) and the various factors on which it depends are found out. They are the following

1. Sex
2. Age
3. Designation

4. Experience
5. Subjects
6. Ph.D. produced.
7. Information consumption time.
8. Use of conference proceedings
9. Use of primary journals
10. Use of abstracting / indexing journals
11. Use of review articles
12. Use of research reports
13. Use of books / monographs
14. Use of reprints / preprints
15. Use of consultation with others
16. Use of attending seminars / conferences
17. Use of membership in learned/ professional bodies.

The comparative contribution of each of the above variables is found out using the multiple correlation. The multiple correlation with all 17 variables is 0.7988254. Since this correlation is highly significant (near to 1) and highly different from the multiple correlations with other 16 variables by deleting one of the variables and thus all the 17 variables are highly contributive to the scientific productivity.

Among the above variables, the most effective are found as subjects and experience, and the least effective is membership in learned /professional bodies. Among the information sources, abstracting /

indexing journals and review articles are most effective. The variables with their significance in the decreasing order are given in Table 5.33. The last column gives the multiple correlation of all the variables except the particular variable in the second column.

Table 5.33

Multiple correlation of the
variables excluding a particular variable

Sl. No.	Variables	Multiple correlation without particular variable
1	Subjects	0.5487018
2	Experience	0.5591568
3	Age	0.5643451
4	Abstracting / indexing journals	0.5665671
5	Review Articles	0.569345
6	Designation	0.5710185
7	Conference Proceedings	0.571622
8	Consultation with others	0.5832756
9	Books / Monographs	0.5833241
10	Sex	0.5836917
11	Ph.D. produced	0.5849892
12	Consumption time	0.5850849
13	Primary journals	0.5861187
14	Reprints / preprints	0.5861599
15	Research reports	0.589137
16	Attending Seminars / Conference	0.590067
17	Membership in learned bodies / professional	0.6618745

5.2 Summary of major findings of the study and its interpretation

1. Scientific productivity of male and female scientists: It is found that the average scientific information productivity in terms of research papers and doctoral theses of male scientists are more in number compared with female scientists. Hence special measures have to be taken for increasing the scientific information productivity of female scientists.
2. Scientific productivity and age difference: The scientific productivity of scientists can be categorized as a result of the dependent and independent work of the scientists. At the beginning of scientists' life immediately after acquiring the Masters level degrees, he starts his research work under a research guide, who is an expert. Hence to a very great extent the scientist depends on his research guide for his work. After acquiring the research degree of Ph.D or acquiring the skill of information consumption production, the scientist do his research work independently. This period is the critical or most important or most productive period of a scientist and it is found around the period of age 30-40 years, the lecturer to reader period and 6-10 years experience. After this period he enrolls research scholars and concentrate on guiding research besides doing research himself. In this stage he depends to a very great extent on the works carried out by the research scholars under his supervision.

But it is observed that only a few scientists could undertake independent research programmes other than what

has done at his doctorate level and most of scientists work on the conventional or extension what he has done at doctorate level. This happens due to the lack of expertise in information consumption–production and inability to explore innovative areas of research. Hence appropriate steps have to be taken for encouraging the Scientists in conducting innovative research programmes.

3. Scientific productivity and status: Scientists who do not produce Ph.D theses have more number of paper publications in the cadre as lecturers compared with those who produce Ph.D. theses. But senior scientists who do not produce Ph.D. theses have less number of paper publications compared with those who produced Ph.D. theses. For the Scientists having Ph.D's, the lecturer period is the most productive period and original independent research work is carried out. Hence an expert scientist carryout his independent research work and his publication activities in an effective manner on entry to profession as lecturer. Under the existing educational system, the scientists are not achieving the required expertise for attaining high scientific productivity.
4. Scientific productivity and experience: The study reveals that the productivity of a scientists is high when he is carrying out his independent work and later when he is supervising the maximum number of research scholars and thereafter. It is found that the outstanding contributions are made during the found that the outstanding contributions are made during the lectureship period or independent period. Therefore for the

societal point of view this period should be made most productive by devising or introducing new policies and measures.

5. Scientific productivity in different disciplines: In the fast developing disciplines and experimental areas the productivity is greater. Hence new developing areas for research shall be found out and the research funding agencies shall assist the scientists in new fast developing and experimental areas, which are of immediate, use to the society.
6. Relationship between productivity in terms of research papers and doctoral theses: The study reveals that the scientists with production of 3-5 Ph.D. theses have highest productivity. As a policy implication guiding research to the extend of at least 3-5 research scholars must be made as the integral part of the work of a university scientist along with senior post or further promotion or selection also must be linked with the successful guiding of doctoral research.
7. Scientific productivity and Information consumption

The scientists utilize maximum time for consumption when they are beginners due to lack of expertise in handling of information. After a certain period they acquire the expertise and information handling skill and the time of information consumption reduces to a critical minimum. Afterwards there is increase in scientific productivity with increase of information consumption. Hence special measures for making the scientists expert as early as possible and increasing the information consumption for increasing scientific productivity may be taken.

8. Use of Information Technology

The scientific productivity of a scientist is directly proportional to the information consumption. Information technology has a critical role in enhancing the information consumption, which leads to higher scientific productivity. Therefore information technology has a critical role in augmenting information productivity. The multiple correlation of the variables in the study reveals the high dependence of the variables such as personal characteristics, information consumption and use of various information sources on scientific productivity. The high dependence of information consumption and use of information sources over the scientific productivity indicates the importance of modern information technology techniques for high level information consumption . In the study it also reveals that most of the scientists do not have facility to make use of information consumption and production optimally. Hence urgent steps may be taken for making information technology available and to ensure their proper use.

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CHAPTER VI

VALIDATION OF INFORMATION CONSUMPTION PRODUCTION THEORY AND ROLE OF INFORMATION TECHNOLOGY

- 6.1 Restatement of the Theories
 - 6.1.1 Mathew's Theory of Information/Knowledge Consumption Production Correlation
 - 6.1.2 Mathews Stage Theory of Information Consumption Growth
- 6.2 Restatement of Major findings of the study
- 6.3 Implications of the two Theories on the Scientific Information Productivity of Physical Scientists
 - 6.3.1 Information Consumption Growth in Physical Scientists
 - 6.3.2 Theory of Information Consumption Production Correlation
- 6.4 Role of Information Technology in the Information Consumption Production
 - 6.4.1 Conduct of Research
 - 6.4.2 Use of Various Information Sources
 - 6.4.3 The Information Consumption Time

CHAPTER VI

VALIDATION OF INFORMATION CONSUMPTION PRODUCTION THEORY AND ROLE OF INFORMATION TECHNOLOGY

Information is broadly the recorded or communicated knowledge gained by human being through experience, observation, experiments and other means. It is the mankind's most valuable resource, which has been playing a crucial role in building human civilization and society in all spheres. In the post industrial society information becomes essential resource for planning and management of all other resources. Backwardness of a society or nation in the modern sense can be attributed by its inability to generate and handle including processing, storing, retrieving and disseminating scientific information and knowledge in the proper way.

The complex processes of scientific information or knowledge consumption and production could be methodologically studied only with the help of a set of sound theories. However no major attempt has so far been made to formulate correct theories and thereby to formulate strategies and policies in the practical context, except two theories formulated by Mathew as early as in 1985 that appeared in different languages, including Russian, Spanish, French etc. thanks to the interest

of the International Federation for Information and Documentation (FID), The Netherlands. These theories are known with the names of the author.

6.1 Restatement of the theories

As the theories are presented and elaborated in the chapter III of the present work, they are given below in a brief and abstract manner with further definition to explain the basic concepts.

Mathew named the two aspects of information consumption and production, rate and level, which denote the qualitative aspect and quantitative aspect respectively. The two theories are:

- 1) Mathew's theory of information/knowledge consumption production correlation
- 2) Mathew's stage theory of information growth

6.1.1 Mathew's theory of information/knowledge consumption production correlation

“There exists a direct correlation between high level information consumption and high level information production. Such kind of correlation may or may not exist in the case of low level information consumption.”

6.1.2 Mathew's stage theory of information consumption growth

The process of transformation from the low level information consumption to the high level information consumption takes place through various stages. The theory states that there are following four stages.

- i) Backward or low level information stage: The user or the society as a whole consumes and produces low level information at low rate too. Information has no value or important at this stage, even if they are available. Consumption of information is quite casual and not purposive. Information literacy is the dominant feature of this stage. Use of libraries, if any is for entertainment or for elementary information and material.
- ii) Pre-Condition to Take off stage: Consuming low level of information at a higher rate mainly from text books, class notes, popular materials or media; developing reading habits using libraries in a traditional sense, inculcating awareness of the value of information; feeling the need for advanced library services and simple information technology are the characteristic of pre-condition to take off stage or in brief, pre-take-off stage.
- iii) Critical or take off stage: Consuming fundamental and basic information in depth, increasing specialization in selected areas (s) familiarising with the state of art, attaining full mastery

information skill, greater dependence on highly advanced library services and information technology so as to get the latest development in the area of specialisation are some of the essential features of this stage. At this stage information is considered as an input or raw material. In other words, information is for application, for which the user acquires essential skill, including techniques of presenting or writing technical notes, reports, papers in standard style and format in an effective manner. This is a critical stage in the sense that only if one enters in this stage can survive at the high level information consumption.

- iv) **Advanced stage or stage of affluence in information consumption:** At this stage the user is noted with developing his information production capacity and to make assessment of the present trend of information growth and to visualise future trend too. The already attained high level information consumption, resulted in high level information production. The major activity of life has been reduced into high level information consumption and production, information technology has become the part and parcel of day to day life so as to minimise communication gap at international level.

6.2 Restatement of the major findings of the study

The investigator has studied the information consumption and production of various Physical Scientists, which includes Research

Scholars, Lecturers, Readers and Professors of the four Universities in Kerala. It is observed that there is increase in the productivity with increase of experience and status among the scientists who are productive in research papers (more than three papers) and doctoral theses (one or more)

The university physical scientists are classified into five categories according to their designation Research scholars initial stage, Research scholars final stage, Lecturers, Readers and Professors. The time spent for information consumption and the average productivity in terms of research papers and Ph.D. theses of each category are tabulated in Table 6.1.

Similarly, the university physical scientists classified according to their experience in seven groups and their average productivity with respect to research papers and Ph.D. theses are tabulated in Table 6.2.

Table 6.1

Information consumption and production of physical scientists

Category	Consumption time Hours per week	Average Productivity	
		Research papers	Doctoral theses
Research Scholars Initial	109.17	0.833	
Research scholars final	43.4	9.38	
Lecturers	29.67	14.81	0.188
Readers	33.78	23.62	1.517
Professors	37.3	47.038	6.308

It is observed that the research scholars-initial stage spent 109.17 hrs per week for the information use or consumption. At this stage the productivity is negligible. Research Scholars-final stage spent only 43.4 hrs per week, very less compared with the previous stage and the productivity increases to 9.38, lecturers spent only 29.67 hrs per week and their productivity in research papers 14.81. During this stage they starts guiding research scholars, some of them find successful by the end of this period. At the Reader stage the consumption time increases to 33.78 hrs per week along with the increase of productivity in research papers 23.62 and doctoral theses 1.517. At the stage of Professors, all the three quantities increase.

Table 6.2

Information consumption and
Productivity of Scientists with respect to experience

Experience years		Information consumptive time	Average productivity	
			Research papers	Doctoral theses
1	3 or less	107.14	2.8	0
2	3-5	48.15	13	0
3	6-10	24	22.81	1
4	1-5	36.31	24.28	1.67
5	16-20	35.74	24.74	2.95
6	21-25	44.34	40.1	6.2
7	26 & above	24.29	61.86	7

The scientists of experience 3 or less years spent maximum time of 107.14 hrs per week for the information consumption. But the average productivity is seen only 2.8. Scientists of experience 3-5 years the consumption time reduces to 48.15 hrs per week and the productivity in research paper increases to 13. Scientist 6-10 years experience spent minimum time for information consumption of 24 hrs per week and their productivity in research papers is 22.81 and productivity in doctoral theses is 1. Scientists of experience 21-25 years spent 44.34 hrs per week for information, consumption and their productivity in research papers is 40.1 and productivity in doctoral theses is 6.2. Scientists of experiences of 26 years and above spent only 24.29 hrs per week. Their productivity is 61.86 far greater than the previous group.

The validity of the theory of information consumption production of Mathew (1985) has been tested with the observations of the present study.

6.3 Implication of the two theories on the scientific information productivity of physical scientists

6.3.1 Information Consumption Growth in Physical Scientists

It is seen that the research scholars-initial, who are the beginners in research, enroll as a research scholar and spent maximum time for information use. They spent 109.17 hrs per week (Table 6.1). In this stage low level information consumption takes place. The researcher has to

spend maximum time on the information use and consumption because of the lack of information handling skill. In order to carry on the research topic, he needs certain basic knowledge and hence more time is spent to acquire the basic knowledge. Hence as seen no new information is generated at this stage though more time is spent for the acquiring of information. The same case is with scientists of experience 3 or less years, who spent 107.14 hrs per week and nominal productivity in research papers of 2.8. The productivity observed at this stage is not of the research scholar, but it is research out put of the research supervisor, who publishes the results of his research work with research scholar as second author, to motivate and train him for publishing of research papers.

The research scholars-initial stage and 3 or less experience stage in the case of university scientists coincides with the first two stages in Mathew's theory. The research scholar acquired the general knowledge at the post graduate level require more of general information some what specific with the research topic to carryout his research. Hence the research scholar needs advanced special library services in the Universities, most of the departments are having a specialised library for this purpose Hence he spent most of the time in the reading of various literatures in his topic as well as in peripheral to subject. Hence the research scholar having no skill in generation of new information, exhibits negligible productivity.

On entering the next stage research scholar-final stage, the time spent for consumption reduces to 43.4, and scientist of experience 3-5 years, spent 48.15 hours per week, which is far less compared with the previous stage. In this stage he needs high level information and more specific information and starts analysing the consumed information. He uses the acquired information for conclusions with the help of his research guide. These conclusions or new ideas derived from the consumed information are coming out as new informations termed as information production. In this stage user acquires the techniques of presenting or writing technical notes, reports, papers in standard style and format in an effective manner. Once this skill is acquired the researcher needs high level informations. Thus at the end of his stage he completes the doctoral thesis with the publication of some research papers. Hence the productivity of research papers 9.38 for research scholars-final stage and 13 for scientists 3-5 years experience is observed. This stage is equivalent to the third stage, Critical or Take off stage in Mathew's theory. By the end of the stage he acquires skill of information handling and he can independently carry out the process of information consumption production. Thus he enters the *last* stage in Mathew's theory, the advanced stage.

After successful completion of doctoral research work, one enters in the profession as scientists in the University with designation as Lecturer. Hence he has acquired the necessary skill in handling of

information known as information consumption and production. He attains high-level information consumption, which result in high level information production. With the saturation of information consumption he is spending only least time for consumption on current developments in the field for more productivity in research papers (Table 6.1). He spent 29.67 hrs per week for consumption of information for the average production of 14.81 research papers. During this period some productivity in Ph.D. theses are also observed. During this period research scholars are registered under his guidance and some of them will be completed at the end of this stage. This stage can be called as the advanced stage in Mathew's theory. Hence we can observe the high level information consumption for high level information production.

After attaining saturation or near saturation point of high level information consumption, what a scientist could do is to make himself aware of the latest trends for that he could attain with limited or less information consumption time. In most cases top scientists make use of the information consumption of their junior scientists or research scholars to keep themselves abreast of the latest development, that too with a limited time. This period corresponds to 6-10 years experience stage. Here also minimum time is spent for information consumption (24 hours per week for the average production of 22.81 research papers and doctoral theses productivity 1).

In the scientists of 11-15 years and 16-20 years experience, though the consumption time increases to 36.31 and 35.74 hrs per week, no considerable increase in paper productivity is observed, instead an increase in the productivity of Ph.D. theses is observed (from 1.67 and to 2.95). This indicates that during this period University teachers concentrate on the completion of Ph.D. theses of already existing research scholars and guiding more number of research scholars. The professors show an increase in the consumption time with a steep increase in productivity of papers as well as productivity of Ph.D. theses. Here the more the number of successful Ph.D. theses, the more papers published. The productivity of experienced teachers of 26 and above years irrespective of the publication drop phenomenon a steep increase in publication of research papers observed. This is due to the completion of more number of Ph.D. theses and publication drop due to burn out phenomenon in case of the scientists are not actually observed.

Hence the first stage in the ICP starts from the post graduate level, then Research scholar-Initial stage, Research scholar final stage, lecturer stage which is the advance stage, are the equivalent stages in Mathew's stage theory. By entering the lecturer stage, normally the University scientists develop skill of information consumption production and become experts in ICP.

6.3.2 Theory of information consumption production correlation

In the Table 6.1, it is seen that the time spent for information consumption and information production are not uniform at different stages. At the beginning stage of scientists, the time spent is more for information consumption and the productivity is least. While going up on the higher stage the time spent for information consumption decreases, where as that the productivity increases. Then reaches at a stage when, time spent for the consumption becomes minimum and there is considerable productivity. From this stage onwards, the time spent for consumption of information increases with increase of productivity.

The research scholars at the initial stage consume information for 109.17 hrs per week with average productivity if 0.8333 research papers. At this stage low level information consumption takes place. The research scholars final stage spent 43.4 hrs per week and have average productivity of 9.38 research papers. The lecturers spend the least time for consumption, 29,.67 hrs per week but have average productivity of 14.81 research papers. Then readers spent 33.78 hours per week for information consumption and their productivity in papers rises to 23.62. The professors spent 37.3 hrs per week for information consumption for the productivity of 47.03 research papers. In the case of productivity of Ph.D. theses, lectures have average productivity of 0.188, readers have 1.57 professors have 6.308. (Table 6.1)

In the table 6.2 the information consumption time and productivity of the scientists are tabulated. Scientists of 6-10 years experience spent the least time of 24 hrs per week and their average productivity 22.81 in research papers and 1 in doctoral theses. The scientists of 11-15 years, and 16-20 years experience spent more time 36.31 hours per week and 35.74 hours per week for the productivity of 24.28 and 24.74 respectively in research papers and 1.67 and 2.95 respectively in Ph.D. theses. Here the proportionate increase is not seen in average productivity of research papers because of the guiding of more number of research students and not completed the theses. Scientists with 21-25 years experiences utilises 44.34 hours per week for information consumption and their average productivity is 40.1 in research papers and 6.2 in Ph.D. theses.

The time spent for information consumption by scientists in the cadre of lecturers and of experiences 6-10 years is minimum and have considerable productivity in research papers. From this stage onwards we can observe an increase in time spent for information consumption corresponds to an increase in average production in research papers and Ph.D. theses. Hence we can say that in the scientists in the cadre of lecturers and of experience 6-10 years onwards there exists a direct correlation between the information consumption time and scientific productivity.

But at the Research Scholar- initial stage and final stage low level information consumption takes place, with more consumption time, but

the information production is less. Hence there is no relation exists between the low level consumption and production.

From the findings of the present study of scientific productivity and information consumption of physical scientists of Universities in Kerala, the Mathew's theory of information consumption production correlation is found to be valid in the case of physical scientists of Universities in Kerala.

6.4 Role of Information Technology in the Information Consumption production

The norm of science dictates that science is public knowledge and therefore scientific findings must be communicated to the community of scientists. Hence scientific papers and scholarly journals have always been the prime channel of science communication.

In 1962 Fritz Machlup indicated that the United States was the major player in the production of information. Price observed modern science has been growing exponentially in size and complexity. Hence the term "big science" has been coined to refer to this significant growth. Price pointed out that a research publication was a characteristic of a modern nation and proportional to the national's economic size as measured by its gross domestic product. Hence, productivity of science and technology information determines the nation's overall development. The scientific productivity of the nation's will be increased for the overall

development of the nation, hence the nations give prime importance to the conduct of research.

6.4.1 The conduct of research

The research is an information management process in which four steps are involved, data collection and analysis, communication and collaboration among researchers and or communication of research findings information storage and retrieval and dissemination. Hence in this process of research, proper application and utilization of information technologies has the following advantages.

1. Increase the use of computation in support of data collection and analysis.
2. Increase the amount of informatics that can be collected and analysed.
3. Possibilities of creation of new families of instruments in which computer control and data processing are central to data collection.
4. Automated operation of instruments and automated collection of data often at remote locations without the researcher having to be present.
5. Increased availabilities of software packages for standard operations such as engineering design, data storage and retrieval, statistical analysis and computation of mathematical function.
6. Increased and more rapid information sharing

7. Possibility of new type of collaborative arrangement among researchers, increasingly independent of geographical location and local time schedules.
8. Communication of information at remote.

The scientific productivity of scientists has been found to be dependent on various factors. Among these factors sex, age, designation, experiences, subjects are personal characteristics of a scientist and they are constants with respect to a scientist. The variable Ph.D. produced is a factor of productivity and it is the net result of the remaining variables. Hence we will discuss the remaining variables and their characteristics in the scientific productivity.

The variables and multiple correlation excluding a particular variable is given in the table 6.3. Since the multiple correlation coefficient 'R' considering all the variables is 0.7988, which indicates that the variables in the table are highly significant for the scientific productivity of scientists. These variables can be classified in to two groups. One is the time spent for information consumption and other is the use of information sources.

Table 6.3

Multiple correlation of variables

Variables	Multiple correlation without this variable
Information Consumption Time	0.5850849
Abstracting / Indexing journals	0.5665671
Review articles	0.5693451
Conference proceedings	0.571622
Consultation with others	0.5832756
Book / Monographs	0.5833241
Primary journals	0.5861187
Reprints / Preprints	0.5861899
Research reports	0.589137
Attending seminars / Conferences	0.590067
Membership in learned / Professional bodies	0.6618745

6.4.2 Use of various information sources

The task of collecting, recording and making available all informations on the intellectual activities of man have itself becomes a complex process calling for specialised skills and knowledge. The increase in the volume of printed matter and recorded information has become bewilderingly large and varied the continuous and proliferation of information at a tremendous rate is now described as a phenomenon of

information explosion. Scientific knowledge has extended to such a degree of magnitude that its size dwarfs all other areas of knowledge.

There is a vast growth of books and periodicals. This growth of books and periodicals not only made problems for stacking, cataloguing, budgeting, etc and also for locating informations. Due to rise in periodicals, as a bibliographic control, the abstracting and indexing journals emerged. It is estimated that there are about 2,000,000 journals in all fields of science and technology altogether in 1980's. Growth of scientific organisations, made scientists to attend the international conferences, which increased \widehat{c} fold from 1950 to 1970 and the number of scientists and technologists increased much. Due to increase of publications, no effective bibliographic control is possible. In order to tackle the above said problem with case of information sources, considering its significance in the scientific productivity of teachers, the application and proper utilisation of new information technologies has become a necessity now a days.

6.4.3 The information consumption time

It is observed that the information time of scientist has a high significance in the scientific productivity in the sense that optimal consumption time so as to attain optimal productivity. Hence the scientific productivity of scientists can be increased either by increasing the consumption time of scientists or increase of rate of consumption. Since most of the highly productive scientists are utilizing the maximum

available time for the information consumption and production, there is no more time to spare for the purpose. Hence only alternative is to increase the rate of consumption. This is possible only by the application of information technologies.

In the two theories formulated by Mathew (1985) he has elaborated the strategic role of information technology both in information consumption and information production processes. The study validated this basic proposition that of the theories that information technology has very important role in information consumption production processes. The study conducted in USA (Clement, 1990) also validated the basic proposition.

CHAPTER VII

SUMMARY, CONCLUSIONS AND POLICY IMPLICATIONS

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CHAPTER VII

SUMMARY, CONCLUSION AND POLICY IMPLICATIONS

7.1 Resume of the study

The present study represents an attempt to assess the scientific information productivity of physical scientists in the Universities in Kerala, to find out the factors that affect the scientific information productivity and to examine the role of Information Technology in augmenting the scientific productivity of the physical scientists. This study also attempts to test the validity of the two theories of knowledge formulated by Mathew, (i) Theory of Information Consumption-Production Correlation and (ii) The Stage Theory of Information Consumption Growth. The study has been undertaken by considering the fact that the scientific and technological information productivity is the basis of a nation's overall development and the universities have an important role to play in creating highly productive scientists. The study has special implications in formulating national strategies and policies in higher education science and technology and the applications of new information technologies in this realm of higher education, scientific learning and research.

10. Conference proceedings
11. Review articles
12. Research reports
13. Books and Monographs
14. Reprints / preprints
15. Consultation with others
16. Attending seminars / conferences
17. Membership in learned / professional bodies

7.1.3 Major objectives of the study

1. To assess the level of scientific productivity of physical scientists measured in terms of published works including new inventions and guiding doctoral research works as information production in the Universities in Kerala.

2. To explore the various factors that affects the information productivity of physical scientists in the Universities under study.

3. To examine whether there exists a direct correlation between information productivity of physical scientists and use of library and information resources and services termed as information consumption so as to test the validity of the generalised theory of information/knowledge consumption production correlation.

4. To identify the various stages of information consumption growth for information production, among the scientists, so as to test the validity of the stage theory of information/knowledge consumption growth.

5. To examine the role of information technology in augmenting the scientific information consumption and information production.

6. To suggest the ways and means for increasing the efficiency of Physical scientists with regard to use of library and information resources, and thereby information consumption and production.

7.1.4 Major Hypotheses:

The study tested the following hypotheses:

- 1) There exist differences with regard to information consumption and information production for different categories of physical scientists in the Universities of Kerala.
- 2) There exist similarities in the pattern of information use among the different category of physical scientists.
- 3) The proper application of information technology could augment the information consumption production processes of the physical scientists in the Universities in Kerala considerably.

7.1.5 Procedure: The study has been conducted in the four Universities in Kerala among physical scientists covering University teachers and research scholars having published research works. Data for the study has been collected through administering questionnaires and conducting interviews directly by the investigator. Data regarding the scientific productivity and information use by the scientists were analysed to draw important conclusions.

7.2 Important Findings

The important findings of the present study are presented below in the order of objectives.

7.2.1 Level of scientific productivity of physical scientists

The average scientific productivity of physical scientists in terms of the research papers published and Ph. D theses supervised in the various subjects are given in Table 7.1.

Table 7.1

Research paper productivity and Ph. D. theses
productivity of Physical scientists in different subjects

Subjects	Research Paper Productivity	Ph. D Theses Supervised
Electronics	36.5	0.5
Physics	28.83	1.47
Chemistry	27.5	3.82
Computer science	20.5	2
Mathematics	12	0.9
Statistics	7.86	0.14

The average productivity in terms of published research papers is greater in Electronics. This may be because of the fast development of Electronics now a days followed by Physics, Chemistry, Computer Science, Mathematics and Statistics. Mathematics and statistics are

abstract or concrete subjects and the publication output is less, and hence scientists in that subjects in the Universities in Kerala have low productivity.

In the case of doctoral theses productivity Chemistry has the highest productivity followed by Computer Science, Physics, Mathematics, Electronics and Statistics. Hence the average productivity is varied from subject to subject.

7.2.2 Factors that affect the information productivity of scientists

The factors that affect the scientific productivity may be grouped in to four categories, personal characteristics, information consumption time, and use of information sources and application of IT.

1. **Personal characteristics:** The scientific productivity depends on the sex, age, designation experience, doctoral theses successfully guided and subject/ research field of the scientist.
2. **Information consumption time:** Information consumption of a scientist cannot be measured directly since it is a mental activity. Hence for measuring the information consumption time spent by the scientist for information consumption is taken. It is found that the information consumption time is significant in the scientific productivity of scientists.
3. **Use of information sources:** The scientific productivity depends on the use of various information sources. Among the various

information sources, the most significant is the abstracting / indexing journals, followed by review articles, conference proceedings, consultation with others, books / monographs, primary journals, reprints/preprints, research reports, attending seminars/conference and membership in learned/professional bodies.

7.2.3 Correlation between information productivity and information consumption

There exists a direct correlation between high level information consumption and information production. This findings of the study validates the theory of Information Consumption and Production Correlation of Mathew (1985).

7.2.4 Stages of information consumption growth: The study established the fact that the scientists acquire the expertise in information consumption and production in the final stage, after passing through different stages. The scientists take 10 to 15 years to reach the stage of affluence or expert stage from novice. This validates the stage theory of information consumption growth (Mathew, 1985).

7.2.5 Role of Information Technology in Information consumption Production: In the study it is found that the consumption time and the use of various information sources are highly significant in the

scientific productivity of the physical scientists. Also it is found that at the stage of affluence or expertise among the stages in the information consumption growth, the information consumption time is directly correlated to the information production. Hence at this stage, if the consumption time is increased, the more productivity can be achieved. But good scientists may spend maximum time for the information consumption. Hence the consumption time cannot be increased instead, the rate of consumption can be increased by the application of information technologies, and thus the quantity of consumption can be increased, with in the fixed consumption time and thus productivity can be increased.

Information technologies can also increase the use of various information sources saving much time in the search and locating of information. The use of abstracting or indexing sources, which is found most significant among the information source for productivity, can be effectively and easily searched and accessible through the present networks and on line databases.

7.2.6 Ways and means to increase the scientific information productivity.

Universities have to play a major role in imparting the skill of information handling to the younger or future scientists through well planned and structured programmes during his postgraduate studies and

doctoral research programmes. The following suggestions may be made to augment the scientific information consumption production process.

1. Seminar method of teaching/learning by faculty and students may be conducted as the part of curricular programmes.
2. Instead of the existing practice of learning by heart without understanding, emphasis must be given on understanding, grasping the knowledge and their application at the post graduate level.
3. Students must be encouraged in asking questions even in questioning the well known ideas or theories in practice.
4. Training in the application of various information technologies in learning and teaching programmes may be introduced as a part of course and curricula.
5. Due recognition and rewards must be given to highly productive scientists in the universities. In prescribing the minimum standards for placement or selection the prediction formula of scientific information productivity formulated in the present study may be followed instead of limiting 2 or 3 publications.
6. The scientific productivity being highly dependent on the information consumption time and use of information sources, more information consumption and easy use and access of information are possible by the application of information

technology or increasing the potentiality of the present information technology facilities in the institutions.

7.3 Tenability of the Hypotheses

The analysis of data throws adequate light on the tenability of the different hypotheses set for the study. The hypotheses of the study were:

- 1) There exist differences with regard to information consumption and information production for different categories of physical scientists in the Universities of Kerala.
- 2) There exist similarities in the pattern of information use among the different category of physical scientists.
- 3) The proper application of information technology could augment the information consumption production processes of the physical scientists in the Universities in Kerala considerably.

7.3.1 Tenability of first Hypothesis

The information consumption time and information productivity of physical scientists vary with respect to their sex, age, experience, designation and areas of speciality etc.

It is found that the research scholars and newly appointed physical scientists in universities spent a lot of time for scientific information consumption than others. So also is the case with experts. But there is much differences in information productivity. Infact developing subjects

like Electronics, scientific information productivity of scientists is greater than compared with abstract and traditional subjects like Mathematics and Statistics.

7.3.2 Tenability of second hypothesis

The second hypothesis is the similarity with regard to information use pattern of scientists. The scientists as a whole mostly depend on the primary journals for their information consumption. Then comes the abstracting/indexing journals, third is review articles. However for the physical scientists of Universities in Kerala the membership in professional or learned societies is given the priority as a source of information use. There exists a similarity in the pattern of use of information sources for all scientists irrespective for their sex, age, designation and subjects. However, the highly productive group depends on abstracting/indexing journals highly than even the primary journals.

In the case of information technologies for the information consumption production most of the scientists are using the available information technologies, computers, e-mail, internet, etc. for their information search and consumption.

7.3.3 Tenability of third hypotheses

The third hypotheses is concerned with the role of information technology in augmenting the scientific information productivity. Over 91 percent of the scientists considered that application of information technologies will increase their scientific information productivity, 68 percent of the scientists are making use of computer facilities available in the teaching departments, 71 percent scientists are making use of computers for conducting research work and 81 percent are using for preparation of papers over 75 percent scientists are making use of Internet facilities, about 68 percent making use of e-mail services. The majority of physical scientists (64.35%) think that present information technology facilities are insufficient and they could not make use of the latest technologies because of the absence of facilities or lack of funds. It is observed that though most of teaching departments in the universities in Kerala have the advanced technologies, they are insufficient in meeting the requirement of the physical scientists.

7.4 Policy Implications of the Study

The study reveals the weakness as well as the potentialities of Universities in Kerala especially with regard to physical science. Physical sciences are very weak and underdeveloped in the University system of Kerala, eventhough they have to play a strategic role in the industrial and scientific development of the society. The scientific information productivity of physical scientists at university level is low.

The education and training facilities for the future physical scientists are unsatisfactory. In Kerala there is not a single national level higher educational institution in the field of physical sciences. The courses offered in the research programmes undertaken are basically traditional. Unless urgent steps or measures have undertaken Kerala will be lagging behind in most of the other states in South India in the field of physical sciences as well as industrial development. In formulating the alternate strategies and policies for the sake of convenience and precision, three level approach namely, university level, state level and national level could be adopted even though it may involve some sort of overlapping.

7.4.1 University level Strategy

1. Research paper productivity of the University Physical Scientists have dependence on the doctoral theses successfully guided paper publications are dependent on the number of research scholars under the scientist's supervision. The productivity in research papers increases on the increase of age and experience in the case of University Scientists. But actually, the productivity of scientists falls at the certain age called the burnout phenomenon, which is not observed in the University Scientists. By making use of ideas and intelligence of young research supervisor who attained the burn out stage, the number of research publication increases as the age and expertise increases in the University Scientists.

Now a days the criteria of selection and posting of research scholars are changed and the research supervisors have no freedom in the selection of research scholars. Some relaxation and freedom is allotted in the selection and appointment of research scholars who qualify the UGC/CSIR examination for the award of the JRF and for the Part Time Research scholars. The research supervisor cannot appoint the research scholars of his choice. Also the Universities are not filling the vacancies of research scholars in time.

Hence the lesser the number of research scholars under the research guide, the lesser will be the over all productivity in that specific area. Even after the enrolment of the research students, due to the administrative red tapes, the supervising teacher or the student have to spend much time to clear all those problems and get sanction for the purchase of equipment's, chemicals, getting fellowships and for other allowances.

2. Most of the scientists are hesitating to take major projects. The infrastructure facilities and number of research scholars can be increased by undertaking major projects. The unwillingness of University Scientists towards the major projects are because of the administrative difficulties they have to face due to impractical rules and delay in release of funds by the University. Hence the University authorities should take attention to simplify the rules and allotting more freedom and powers to the supervising scientists or investigators of the projects

for getting sanction for various actions and for release of funds under the projects.

3. It is observed that the function of applications of information technologies is two fold. The application of information technologies will make the scientists easier and earlier to attain the advanced stage or expert stage in the information consumption growth and it also catalyses the increase of productivity by increasing the rate of information consumption since the high level information consumption is directly correlated to the high level information production.

University should include the application of information technologies in the courses and curricula at the postgraduate level. Though application of information technologies are introduced at the school level by the Government of Kerala, Universities have not taken IT as a paper at the post graduate courses. Hence to attain expertise in information consumption by developing information handling skill, application of information technologies will be taken as an integral part of the postgraduate courses and the skill in application of information technologies will be tested for awarding degrees. A separate minimum marks will be fixed for IT skills for theory and practical. In the selection and appointment of a research student and University Scientists and for the higher placement and promotion, a certain minimum IT skill should be insisted. The IT skill of the University Scientists will be updated

periodically in accordance with fast new development in information technologies especially in the field of physical sciences.

7.4.2 State level Strategy

The scientists working in well established laboratories have high productivity. The infrastructure facilities and latest developments of information technologies have great dependence on the productivity of scientists. Scientists on getting positions in developed countries become highly productive. A scientist working in newly developed subject area should not get the sufficient infrastructure facilities in his laboratories and the University could not assist with sufficient funds because of current financial problems. The state government should take measures for specialising and concentrating by each University in a particular specialised area so that the research and infrastructure facilities can be provided at one centre instead of being spreaded in many places. Hence the state government should take measures for pooling of scientists in a specialised area into a single centre with all necessary facilities at state level and for the purpose of pooling of existing scientists working in various centers with insufficient infrastructure facilities, the interuniversity transfer of scientists also may be considered.

7.4.3 National level strategy

1. The team research among the University scientists will be encouraged. A team of scientists can contribute more compared to individual in productivity. Nowadays most of the advanced research work is in interdisciplinary area and a single scientist cannot carry out the research. While allotting projects for effective result, the team of scientist's proposals will be considered instead of single scientists. Hence Government of India should give directions to the financial agencies such as UGC, DST, DAE for giving preference to proposals from team of scientists for research projects.
2. The present criteria for appointment or promotion and placement will not insist on the maintaining of scientist's productivity. A scientists having six research papers or three research papers and a doctoral thesis will get promotion to higher position. Most of the University scientists are having this minimum number of research papers, on appointment and can get promotion and placement even without further productivity. In the point of view of increasing productivity of University scientists, present criteria of fixed number of publications will be revised and it will be fixed according to the facilities of the institutions and age and experience of scientists. For the purpose prediction formula for the scientific productivity of University scientists developed in the present study will be used for fixing the

number of publication required for the entry into profession and for the placement and promotion at each stage.

7.5 Suggestions for further research

The study of scientific information consumption and production of scientists is a very complex process and multi disciplinary since the theories of information and knowledge are dealt in Philosophy, Psychology, Computer Science, besides Library and Information Science. Because of these complexity no previous attempts has been made to conduct research in the present area. Hence this is a pioneering attempt to study the scientific information consumption and production of physical scientists in the universities in Kerala by the investigator and dealt the topic in a general and basic manner and tried to open a gateway for research in depth. The areas of further research as located by the present study are given below.

1. A comprehensive study of scientific information consumption and production of scientists in other universities in different parts of India to be conducted and integrated to the present study so as to get a generalised view.
2. In order to assess the national scientific information productivity of scientists workingⁱⁿ various institutions under Universities and others may be conducted. The scientific productivity can be assessed on the basis of prediction formula developed in the present study.

3. Similar studies on the information/knowledge consumption/production of other (Social science) scientists in the universities in Kerala and in Indian to be conducted to assess productivity and find factors of productivity and test the validity of knowledge theories of Mathew (1985) so as to get a more generalised view.
4. Special studies can be conducted for assessing the role of information technology in informatising society and thereby redesigning IT application.
5. A detailed and specific study on the role of information technology in augmenting scientific information productivity of India can be conducted.
6. A comprehensive study on the present introduction and application of information technology whether it is appropriate for the informatisation of society for the development of Indian to be conducted.

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APPENDIX

APPENDIX
DEPARTMENT OF LIBRARY AND INFORMATION SCIENCE
CALICUT UNIVERSITY
KERALA 673 635

Dr. Raju. M. Mathew
Reader
www.mathewrm.com
(Research Supervisor)

Soman. K.N
Research Scholar

Dear Sir/Madam,

We are conducting a research study on the topic “A study of Scientific Productivity and Information Use Pattern of Scientists in the context of New Information Technology with special reference to Universities in Kerala”.

The enclosed questionnaire is intended to study the Scientific Productivity and Information Use pattern of Scientists in the new environment of application of information technology in Universities of Kerala. Questions are designed so that the answers may be just mark the correct answer in the appropriate box (es) or simply in one or few words. Kindly co-operate us in completing the present study by filling the questionnaire and returning the same.

Sincerely Your's

Dr. Raju M. Mathew

Soman K.N

QUESTIONNAIRE FOR SCIENTISTS OF UNIVERSITIES IN KERALA

Please record your answer to the following questions by entering the code number or tick mark (☐) corresponding to your choice in the box on the right of each question.

Part I-Respondent Identification

- | | | |
|----------------------------------|----|---|
| 1. Name: | | 2 |
| 2. Sex | | <input style="width: 80px; height: 20px;" type="text"/> |
| Male | 1 | |
| Female | 2 | <input style="width: 80px; height: 20px;" type="text"/> 3 |
| 3. What is your age group ? | | |
| 25 or less | 1 | |
| 26-30 | 2 | |
| 31-40 | 3 | |
| 41-50 | 4 | |
| 50 or above | 5 | |
| 4. Name of faculty or department | | <input style="width: 80px; height: 20px;" type="text"/> 4 |
| Physics | 1 | |
| Chemistry | 2 | |
| Electronics | 3 | |
| Computer Science | 4 | |
| Mathematics | 5 | |
| Statistics | 6 | |
| 5. Designation | | <input style="width: 80px; height: 20px;" type="text"/> 5 |
| Lecturer | 1 | |
| Reader/Lecturer | 2 | |
| Sr./Lecturer Sl. | 3 | |
| Professor | 4 | |
| Research Scholar Initial | 5 | |
| Stage | 6 | |
| Research Scholar Final | 7 | |
| Stage | 8 | |
| Post Doctoral | 9 | |
| Others | 10 | |

6. Qualification [use tick mark (✓)]

M. Sc.

M. Tech.

M. Phil.

Ph. D.

	6
	7
	8
	9

7. Experience in teaching / Research (University Level):

3 years of less 1

3-5 years 2

6-10 years 3

11-15 years 4

16-20 years 5

21-25 years 6

26 years or above 7

	10
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Part II (A)
Information Use

1. What are the information sources you use ? Please rank the following items on the order of importance (if the first preference is primary journals then put 1 in box 11).

Information Source Preference

- | | | |
|---|----|---------|
| Primary Journals | 1 | First |
| Abstracting / Indexing journals | 2 | Second |
| Conference Proceedings | 3 | Third |
| Review articles | 4 | Forth |
| Research reports | 5 | Fifth |
| Books / Monograph | 6 | Sixth |
| Reprints / Pre-prints | 7 | Seventh |
| Consultation with others | 8 | Eighth |
| Attending Seminars / Conferences | 9 | Nineth |
| Membership in learned bodies / Professional organisations | 10 | Tenth |

	11
	12
	13
	14
	15
	16
	17
	18
	19
	20

Organisation

2. How much time do you spend for the following purposes in a week.

	Hours
A Information Search / Retrieval	<input type="text"/> 21
B Reading	<input type="text"/> 22
C Teaching	<input type="text"/> 23
D Research	<input type="text"/> 24

3. How much time is spent for the use of the following Information sources in a week

A Journal Articles / Papers	<input type="text"/> 24 a
B Patents	<input type="text"/> 24 b
C Research reports	<input type="text"/> 24 c
D Short Communication	<input type="text"/> 24 d
E Reviews	<input type="text"/> 24 e

Part II(B) Scientific Productivity

1. Please note the number of your published works, including conferences / seminar papers.

	National	International
Research papers	<input type="text"/> 25	<input type="text"/> 26
Research Monographs	<input type="text"/> 27	<input type="text"/> 28
Conference papers	<input type="text"/> 29	<input type="text"/> 30
Text books	<input type="text"/> 31	<input type="text"/> 32
General books	<input type="text"/> 33	<input type="text"/> 34
Popular articles / reviews	<input type="text"/> 35	<input type="text"/> 36
Referee / expert / consultancy services	<input type="text"/> 37	<input type="text"/> 38
Academic awards	<input type="text"/> 39	<input type="text"/> 40

2. Please note the number of doctoral theses (Ph.D.) guided by you. 41

3. Please note the number of your publications included in the International Abstracting journals / services 42

4. Please note the total number of citations made about your publications in other works 43
5. Please list the number of conferences to which you have been invited
 National 44
 International 45
6. Please note the number of learned Societies / professional association in which you are a member / affiliate
 National 46
 International 47
7. Please note the number of major and minor sponsored research projects you have undertaken.
- | | National | International |
|----------------|-------------------------|-------------------------|
| Minor projects | <input type="text"/> 48 | <input type="text"/> 49 |
| Major projects | <input type="text"/> 50 | <input type="text"/> 51 |

Part II (C)
Use of Modern Information Technologies

1. Do you make use of computer facilities (Tick Mark)
- | | | |
|---------------------------------|----------------------|----|
| At home | <input type="text"/> | 52 |
| In the department / Institution | <input type="text"/> | 53 |
| Out side | <input type="text"/> | 54 |
2. For what purposes are you using computers and communication technologies (Tick Mark)
- | | | |
|--|----------------------|----|
| Preparation papers | <input type="text"/> | 55 |
| Preparation for teaching | <input type="text"/> | 56 |
| Conducting research work | <input type="text"/> | 57 |
| Keeping abreast of latest development in the field | <input type="text"/> | 58 |
| Recreation / entertainment | <input type="text"/> | 59 |
3. Types of soft wares available (Tick Mark)
- | | | |
|---------------------------------|----------------------|----|
| A. Commercially purchased | <input type="text"/> | 60 |
| B. Developed by yourself | <input type="text"/> | 61 |
| C. Developed by the Institution | <input type="text"/> | 62 |

4. Do you make use of computer facilities for (Tick Mark)

- | | | |
|-------------------------------|--------------------------|----|
| A. Information Search | <input type="checkbox"/> | 63 |
| B. Information retrieval | <input type="checkbox"/> | 64 |
| C. New Information generation | <input type="checkbox"/> | 65 |
| D. Data Analysis | <input type="checkbox"/> | 66 |
| E. E-mail | <input type="checkbox"/> | 67 |

5. What are the networking facilities you are using

- | | | |
|---------------------|--------------------------|----|
| A. ERNET | <input type="checkbox"/> | 68 |
| B. INFLIBNET | <input type="checkbox"/> | 69 |
| C. NICNET | <input type="checkbox"/> | 70 |
| D. INTERNET | <input type="checkbox"/> | 71 |
| E. Others (specify) | <input type="checkbox"/> | 72 |

6. Extend of use of Information technology

Regularly used 1

Occasionally used 2

Rarely used 0

A. FAX

B. Online services

C. E - Mail

<input type="checkbox"/>	73
<input type="checkbox"/>	74
<input type="checkbox"/>	75

7. How much quantity of Information sources you are through modern Information technologies (Computer and Communication technologies) in a week

A. No of journals

B. No. of papers / articles

C. No. of patents

D. No. of Short communication

E. No. of research reports

F. No. of reviews

<input type="checkbox"/>	76
<input type="checkbox"/>	77
<input type="checkbox"/>	78
<input type="checkbox"/>	79
<input type="checkbox"/>	80
<input type="checkbox"/>	81

8. Do you think that modern information technologies (Computer and communication technologies) increase the scientific productivity of teachers / Scientists and research scholars ?

Yes 1

No 0

<input type="checkbox"/>	82
--------------------------	----

9. What are the factors that prevent to use the advanced Information technology
(Please rank the following in the order of importance)

A. Lack of funds	1	First		83
B. Lack of facilities	2	Second		84
C. Lack of time	3	Third		85
D. Lack of training	4	Fourth		86
E. Disinclination to use it	5	Fifth		87

10. To what extent are you satisfied with your scientific productivity in terms of the following. Mark

Highly satisfied	1		
Moderately satisfied	2		
Not satisfied	0		
A. Research			88
B. Publication			89
C. Advanced Level Teaching			90
D. Academic achievements			91

11. Suggest ways and means for increasing the scientific productivity of the teachers / scientists and research scholars.