CHAPTER 3

LITERATURE SURVEY AND RESEARCH METHODOLOGY

3.1 Introduction

Knowledge representation is the application of logic and ontology to the task of constructing computable models for some domain. This applies theories and techniques from three fields:

1. Logic provides the formal structure and rules of inference.
2. Ontology defines the kinds of things that exist in the application domain.
3. Computation supports the applications that distinguish knowledge representation from pure philosophy.

Knowledge can be represented in different forms, as mental images in one’s thoughts, as spoken or written words in some language, as graphical or other pictures, and as character strings. The representations we are concerned with in our study use psychological correlates namely, AMS and WAPIS, as ontologies.

A description of the methodology adopted by the researcher to carry out the present study has been presented in detail in this chapter. It includes the significance and scope of the study, the objectives framed, the research design, the sampling and statistical methods adopted, the tools of data collection, the definitions, research hypothesis, concept mapping, imaging techniques, and limitations.
3.2 History of Knowledge Representation (KR) Research

KR is concerned with expressivity and effective reasoning. The research on KR started in the early 1960's in the area of natural language understanding and the work on problem solving with 'procedural' and 'declarative' knowledge. Though much ad hoc formalisms were available at that time, no formal semantics were there to represent knowledge. So, the problems like how to assign meaning and how to say a computer 'understands' played a vital role in KR research. During the 70's and the 80's, semantics nets with structured node-link graphs were introduced for semantic representation of knowledge. But, they did not support interpretation and reasoning. After that, frames, production rules and predicate logic representations were developed. Subsequent to these techniques, a family of frame-like KR systems with a formal semantics played a role in KR. During the 1990's KR was rooted in the study of logics like temporal, context modal, default and nonmonotonic reasoning. Provisions were available on declarative representations and formal semantics. In the 2000's, KR research focused on web based systems that embed knowledge on web pages, new class of applications like electronic commerce, information retrieval on the web and object oriented modeling tools and ontologies. This study on KR used ontologies as a base. Ontological analysis clarifies the structure of knowledge. Given a domain, its ontology forms the heart of any system of knowledge representation for that domain. Without ontologies, or the conceptualizations that underlie knowledge, there cannot be a vocabulary for representing knowledge. Second, ontologies enable knowledge sharing.
3.3 Significance of the Study

The thesis entitled "A study of Knowledge Representation through Neuro and Psychological Correlates in the Brain of Homo Sapiens Using Artificial Intelligence" focuses on investigating the functioning and behavior of the brain of the homo sapiens in terms of knowledge representation through neuro and psychological correlates, in order to gain insight into the mentality of young adults – their approach to challenges, their intelligence and mutual strengths, their weaknesses, thereby increasing the scope for further studies, knowledge, and research in the areas of excellence namely, academic, vocational, social, skill achievement and the level of intelligence. It focuses also on the kinds of reasoning that can be done with that knowledge by developing a symbolic and spatial knowledge base using artificial intelligence.

The AMS focuses on analyzing the levels of academic and nonacademic achievement motivation among the post-graduate and under-graduate students, both women and men. The WAPIS focuses on the computation of IQ. With the help of comparative analysis, marked differences or otherwise can be brought to light among the students of computer science, fine arts, social work and medicine. A gender-based comparison can also be made on the relevant aspects. A thorough study of the levels of confidence, self-esteem, and futuristic outlook etc., of the young adults can be made. Future inference regarding academic performance, motivation and IQ can also be made. This study also discovers the factors that encourage or discourage the students, their satisfactions and disappointments, and their expectations from life etc.
3.4 Literature Survey

Early studies related to knowledge representation were reported by a number of researchers. Three experts in knowledge representation, Randall Davis, Howard Schrobe and Peter Szolovits, wrote a critical review and analysis of the state of the art in 1993. They summarized their conclusions in five basic principles about knowledge representation and their role in artificial intelligence.

1. *A knowledge representation is a surrogate.* Physical objects, events, and relationships, which cannot be stored directly in a computer, are represented by symbols that serve as surrogates for the external things. The symbols and the links between them form a model of the external system. By manipulating the internal surrogates, a computer program can simulate the external system or reason about it.

2. *A knowledge representation is a set of ontological commitments.* Ontology is the study of existence. For a database or knowledge base, ontology determines the categories of things that exist or may exist in an application domain. Those categories represent the ontological commitments of the designer or knowledge engineer.

3. *A knowledge representation is a fragmentary theory of intelligent reasoning.* To support reasoning about the things in a domain, a knowledge representation must also describe their behavior and interactions. The description constitutes a theory of the application domain. The theory may be stated in explicit axioms, or it might be compiled into executable programs.
4. *A knowledge representation is a medium for efficient computation.* Besides representing knowledge, an artificial intelligence system must encode knowledge in a form that can be processed efficiently on the available computing equipment. As Leibniz realized, some of the most interesting problems can be represented easily enough, but solving them may require an enormous amount of time and effort to compute. New developments in computer hardware and programming theory have had a major influence on the design and the use of knowledge representation languages.

5. *A knowledge representation is a medium of human expression.* A good knowledge representation language should facilitate communication between the knowledge engineers who understand AI and the domain experts who understand the application. Although the knowledge engineers may write the definitions and rules, the domain experts should be able to read them and verify whether they represent a realistic theory of the domain.

These five principles were used as a framework for discussing Educational Diagnosis through psychological testing by Merz, and William R in 1994. They studied how the brain and nervous system affect the thinking and behavior of school children. In 1996, John F. Sowa used these five principles for discussing the issues of knowledge representation and illustrating them in terms of the traffic light domain.

Of late, education experts have begun to use neurology to explain why some children have trouble acquiring language skills, learning to read, developing arithmetic reasoning skills, and so on. Using neurology in schools can help teachers serve children
with learning disabilities more effectively because a child who has neurologically related
disabilities does not benefit from the same teaching techniques that a student who learns
at a slower rate benefits from. Neurological assessment is a tool for evaluating how
much a child’s performance may be influenced by the unusual functions of the brain and
the nervous system. It helps school psychologists measure a child’s skills systematically
and determine the best learning environment for the child.

In 1980, Davis and Stephen researched on how students maintain a positive self-
image and attribute their academic setbacks and failures to a third person or factor,
namely the professor’s “toughness” in correction.

In a study carried out by Salovey and Rodin in 1980, it came to be known that a
superior performance by one’s best friend, sibling or spouse clearly has a greater impact
on one’s feeling about oneself and one’s need to achieve laurels and aspire greater
heights than before, than a superior performance by someone one knows only slightly.

A study done by Parsons et al. in 1978, Spener and Featherman again in 1978
and Tesser in 1985, shows that a factor that underlies achievement efforts is the positive
or negative value that someone places on success or failure.

Gehlert, Timberlake and Wagner in 1992, examined the relationship between
vocational identity and academic achievement among 1,290 college freshmen, using the
vocational identity scale. Results indicated no significant relationship between VI scores
and subsequent academic performance.

In 1993, Lamport and Mark researched on the informal interaction of college
students and faculty with regard to effect on students’ academic achievement, satisfaction...
with college, intellectual and personal development, persistence and attrition, and career and educational aspiration. Self-efficacy for academic milestones, in combination with other academic and support variables, was found to be the strongest predictor of college academic achievement. Outcome expectations, vocational interests and low levels of stress were in turn the strongest predictors of academic self-efficacy.

Rekha Singhal and Girishwar Misra in 1994, investigated the effects of perceived sense of self and perceived expectations of self on the preferences for achievement goals in individualistic, familial, and societal spheres, among Indian secondary school and college students. Expectations held by the significant others (e.g., parents, teachers, peers) and age level were the most powerful determinants of the perceived importance of achievement goals. Adolescents perceived achievement goals as relatively more important than did undergraduates. Gender, age and a sense of self evinced a joint influence on the preferences for certain achievement goals.

In 1995, Thompson, Davidson and Barber conducted two experiments and tested central assumptions of the self-worth theory of achievement motivation. Experiment 1 confirmed that self-worth protective students perform well following failure that allows a face-saving opportunity, but perform poorly following failure that does not allow face-saving. The results of Experiment 2 confirmed that the poor performance of self-worth protective students following failure is associated with a lesser tendency to assume personal responsibility for failure.

During 1995, Diane Christopher and Joan Gorham, investigated relationships among, and changes in, student-state motivation, teacher immediacy, and student-
perceived sources of motivation and de-motivation, across the course of a semester in college classes. Findings support a casual relationship between teacher immediacy and state motivation and also replicate a pattern in which students perceive motivation as a personally owned state and de-motivation as a teacher-owned problem.

In 1997, Margita Mesarosova studied the level and the structure of the motivation of students with varying levels of intellectual potential and school achievement. The results were significant to the assumptions made.

Brownlow, Gilbert and Reasinger in 1997, found that intrinsically driven students had dominant intuitive preferences, and they indicated both interest and skill in academics, creating and analyzing. In addition, students inherently interested in their college work exhibited greater commitment to their future careers than extrinsically motivated students. Students who were motivated by the rewards or compensation that could be accrued for their work (e.g., extrinsically motivated students) showed dominant sensing preferences, and expressed interest in organizing and analyzing. In addition, those with intuitive, feeling, and perceiving preferences revealed interest in creating.

In 1998, Lew, Allen, Papouchis and Ritzler examined the relationships among gender, acculturation, achievement orientation, and fear of academic success. The cultural values endorsed were significantly related to individual-oriented achievement. These findings suggest that persons with a bicultural identity tend to adopt a multifaceted achievement style. Society-oriented achievement was related to the high fear of academic success, whereas an individualistic orientation was buffered against such conflicts.
Wolters and Christopher in 1998, extended current models of self-regulated learning by addressing three research questions, namely: What strategies do students use to regulate their motivation? Is the use of these strategies dependent on contextual factors? How is motivational regulation related to other aspects of self-regulated learning and achievement? Findings provide evidence that students regulate their level of effort in academic tasks by using a variety of cognitive, vocational and motivational strategies.

In 1999, Bembenutty and Karabenick focused on Students' Academic Delay of Gratification (ADOG), which is their postponement of immediately available opportunities to satisfy impulses in favor of pursuing chosen important academic rewards, or goals that are temporally remote but ostensibly more valuable. Results support the hypothesized association between ADOG and students' self-regulated learning, which consisted of academic motivation and the use of cognitive, metacognitive, and resource management learning strategies.

McCabe, Blankstenin and Mills conclude from their study that interpersonal sensitivity was a significant predictor of academic performance for both males and females in 1999. However, in females, social problem solving was not related to academic performance. In males, negative problem-orientation and dysfunctional problem-solving styles were important aspects of problem solving related to academic performance.

In 2000, Daniel House examined the effect of student involvement on the development of academic self-concept. Results showed that the number of hours spent reading was related to the students' self-rating of writing ability. Conversely, reading
hours tended to be inversely related to self-rated mathematical ability. Participation in volunteer activities and student clubs was positively related to self-perceptions of drive to achieve. Overall, the study shows that student involvement is related to several types of academic self-concepts.

Kevin Cokley in 2001, examined whether the quality of interactions that students have with the faculty, influences students’ academic motivation and academic self-concept. Results show that significant differences existed between students in academic self-concept, intrinsic motivation, and extrinsic motivation. Students with more positive perceptions of faculty encouragement exhibited higher academic self-concept and academic motivation scores than did those having more negative perceptions of faculty encouragement.

3.5 Aim of the Study

The aim of the study is to investigate the functioning and behavior of the brain of the homo sapiens in terms of knowledge representation through neuro and psychological correlates in order to gain insight into the mentality of young adults – their approach to challenges, their intelligence, their mutual strengths and weaknesses, thereby increasing the scope for further performance in education, in research in the areas of educational and occupational achievement motivation by developing a symbolic and spatial knowledge base. This study also aims at finding out the association between the socio-demographic details of each student and their levels of achievement motivation and intelligence.

As descriptive research studies are those which are concerned with describing the characteristics of a particular individual or group and diagnostic research studies
determine the frequency with which something occurs or its association with something else – the researcher has adopted these two research design techniques in this study.

3.6 Hypothesis

1. The respondents who have undergone the AMS test perceive a higher level of academic performance in the future than those who have not undergone the test.

2. The respondents who have undergone the WAPIS test perceive a higher level of academic performance in the future than those who have not undergone the test.

3. There will be a significant relationship between the socio-economic status of the individual and his level of achievement motivation.

4. There will also be an association between the individual’s socio-economic status and the level of intelligence.

5. There will be a significant difference in the levels of motivation and intelligence among the students of computer science, social work, fine arts and medicine.

6. With regard to the difference in the levels of achievement motivation and intelligence between the women and men students
   - Women students have a higher level of academic achievement motivation than men students

7. As the respondent’s parent’s qualification increases, the respondent’s academic performance also increases.

8. There is a significant difference between academic performance and the inferred or predicted performance.
3.7 Variables

**Independent Variables**

- Sex
- Father’s Educational Qualification
- Mother’s Educational Qualification
- Father’s Occupation
- Mother’s Occupation
- Class
- Religion
- Type of Family
- Nature of Place
- Caste
- Age
- College
- Ambition
- Extra Curricular Activities
- Average Percentage of Marks.

**Dependent Variables**

- Achievement Motivation Scale (AMS)
- Wechsler Adult Performance Intelligence Scale (WAPIS)
- Neuroimaging - Human Electroencephalography (EEG)
3.8 The Universe and Sampling

The Post-graduate and Under-graduate students of Kalai Kauvery College of Fine Arts, K.A.P. Viswanatham Medical College and Arts and Science Colleges form the population and universe of the study. The inclusive departments are:

- Computer Science
- Social Work
- Fine Arts
- Medicine

The Probability Sampling Technique (Simple Random Sampling Method) is more appropriate in this study, because every item of the universe has an equal chance of being included as a sample. In this case, 26 students each were taken from the disciplines of computer science, social work, fine arts and medicine. Among the 26 samples, 13 were male students and 13 female students.

3.9 Pilot Study

The purpose behind the pilot study was to find out the feasibility and suitability of the study and to formulate the problem more specifically. After having gone through many relevant literatures, periodicals, journals and scientific discussions with the research supervisor and other clinical psychologists, neurologists, psychiatrists and clinical social workers, the researcher carried out the pilot study in the Sowmanasya Hospital and the Institute for Psychiatry, Tiruchirapalli – 2.

A series of discussions with Dr. G. Gopala Krishnan (Director of Sowmanasya Hospital), Prof. T.K. Kadir Kaman (clinical psychologist), Dr. Geetha Raman
(neurologist), and Dr. Sundararajan (neurologist) were held and the researcher could realize the need for a study on knowledge representation through psychological correlates, as no such endeavor had been made so far. The tools, sample size, the mode of collecting the data, and conduct of tests were well discussed with the officials and permission were taken to undertake the study.

3.10 Tools of Data Collection

Structured Questionnaires were chosen by the researcher to be used as a primary tool for the data collection, since all the students have a sound educational background and are quite competent to answer the questions asked. Before finalizing the tools of data collection, the researcher had intensive discussions with the clinical psychologists, psychiatrists, neurologists and clinical social workers and gave orientation to all the students before they could fill up the questionnaires.

The initial component of the questionnaire covered the questions pertaining to the personal and socio-demographic characteristics of the respondent and the following tools were used for the present study:

- AMS
- WAPIS
- Neuroimaging – Electroencephalography.

3.10.1 Achievement Motivation Scale (AMS)

The Achievement Motivation Scale was constructed and standardized by Dr. Shah Beena and published by the Agra Psychological Research Cell, Agra, based on forced-
choice technique. The following four factors of need are essential for Achievement Motivation Scale:

- Need for Academic Success
- Need for vocational Achievement
- Need for Social Achievement
- Need for Skill Achievement

The Achievement Motivation scale is a three point scale. Each statement is followed by three alternative responses. The alternatives are arranged in the order of one's inclination towards achievement in the areas, namely academic, vocational, social context and skills. Weightage 1, 2 and 3 are respectively awarded for alternatives (a), (b), and (c) of any statement [9]. The AMS test – re-test reliability co-efficient varied between 0.77 and 0.87, which infers that the test is highly reliable.

The validity of the scale was ascertained in a three-fold fashion.

E.g.

- **Content Validity**: The process of selecting the items through the judgment of experts confirms the content validity of the scale.

- **Item Validity**: The process through which the item-analysis has been carried out and the selection of items in the final test was made, adequately confirm its item validity.

- **Congruent Validity**: Pearson’s Coefficient of Correlation values between the subset scores and the total scores are high and significantly far beyond .01 levels of significance, and thus it confirms the validity of this AMS.
3.10.2 Wechsler Adult Performance Intelligence Scale (WAPIS)

The Indian Adaptation of WAPIS has been constructed by Prabha Ramalingaswamy, and published by Manasayan, Delhi. This test was obtained from Agra Psychological Research Cell, Agra. The test used here is an attempt to adapt Wechsler Adult Intelligence Scales to Indian conditions and set up norms for Indian population. The WAPIS consists of the following performance scales namely, Picture Completion, Digit Symbol, Block Design, Picture Arrangement and Object Assembly.

- **Picture Completion**: The missing part of an incompletely drawn picture must be discovered and named. This tests visual alertness and visual memory.

- **Digit Symbol**: A timed coding task in which numbers must be associated with marks for various shapes. This tests the speed of learning and writing.

- **Block Design**: Pictured designs must be copied with blocks. This tests the ability to perceive and analyze patterns.

- **Picture Arrangement**: A series of comic strip type pictures must be arranged in the right sequence to tell a story. This tests the understanding of social situations.

- **Object Assembly**: Puzzle pieces must be assembled to form a complete object such as a human profile or elephant. This tests the ability to deal with part-whole relationships.

The reliability of Picture Completion, Block Design, Picture Arrangement and Object Assembly was worked out by using the formula Cronbach’s Coefficient Alpha. Coefficient Alpha was used for finding out the reliability of the sub tests. The total test
and sub-test correlations have been worked out by using product-moment formula and correcting it for contamination by using the formula suggested by McNemar [10].

The validity of the scale was ascertained in a two-fold fashion.

- **Content Validity**: Construct validation consists of defining a measure in terms of numerous research findings. It is well established that age, education and socio-economic status affect the scores on intelligence test.

- **Factor Analysis**: Factor analysis using the principal component method was employed, followed by rotation, using the Varimax Method. The factor matrices show a common factor present in all sub-tests and in every group. This factor, while it can be termed as a 'general factor', is akin to Spearman's 'G' factor.

### 3.10.3 Neuroimaging - Human Electroencephalography (EEG)

The application of neuroimaging techniques has become increasingly prevalent as a method for characterizing the neural substrate of cognitive, vocational and emotional processing. Electro-encephalography is one of the neuroimaging techniques that read scalp electrical activity, generated by brain structures. The Electro-encephalogram (EEG) is defined as the electrical activity of an alternating type recorded from the scalp surface, after being picked up by metal electrodes and conductive media [11]. The EEG measured directly from the cortical surface is called electro cardiogram, while, when using depth probes, it is called electrogram. In this study, the researcher has referred only to EEG measured from the head surface. Thus the electroencephalographic reading is a completely non-invasive procedure that can be applied repeatedly to patients, normal adults, and children with virtually no risk or limitation. When brain cells (neurons) are
activated, local current flows are produced. EEG measures mostly the currents that flow during synaptic excitations of the dendrites of many pyramidal neurons in the cerebral cortex.

**Brain waves classification**

For obtaining the basic brain patterns of individuals, they are instructed to close their eyes and relax. Brain patterns form wave shapes that are commonly sinusoidal. Usually, they are measured from peak to peak and normally range from 0.5 to 100 µV in amplitude, which is about 100 times lower than ECG signals. Power spectrum from the raw EEG signal is derived by means of the Fourier Transform. In power spectrum, the contributions of sine waves with different frequencies are visible. Although the spectrum is continuous, ranging from 0 Hz up to one half of sampling frequency, the brain state of the individual may make certain frequencies more dominant. Brain waves have been categorized into four basic groups (refer figure 3.1):

Alpha learning graduates are capable of controlling their brainwaves in 4 major frequencies:

- **Delta** = 1-3 Hertz (cycles per second)
  Deep physical relaxation, pain control & stress release.

- **Theta** = 4-8 Hertz (cycles per second)
  Memory, both memorization and recall and IQ growth.
Figure 3.1. Brain Wave Samples with Dominant Frequencies Belonging to Beta, Alpha, Theta, and Delta Bands.

**Alpha** = 9-13 Hertz (cycles per second)

Learning, reading and listening.

**Beta** = 14-30 Hertz (cycles per second)

Decision making, logic and problem solving.

Using the appropriate wave frequency for each part of learning, i.e., listening versus memorizing, is the key to accelerated learning and increased retention. Once an individual has "learned" the appropriate frequencies they can use them at will whenever a particular function is needed. Extensive use of computerized optical-acoustical brainwave
training equipment and electroencephalograph analysis enables each person to track their daily progress during the course.

Applications

The greatest advantage of EEG is speed. Complex patterns of neural activity can be recorded occurring within fractions of a second, after a stimulus has been administered. EEG provides less spatial resolution compared to Magnetic Resonance Imaging and Positron Emission Tomography. Thus, for better allocation within the brain, EEG images are often combined with MRI scans. EEG can determine the relative strengths and positions of electrical activity in different brain regions. According to R. Bickford, research and clinical applications of the EEG in humans and animals are used to:

- monitor cognitive engagement (alpha rhythm)
- produce biofeedback situations, alpha, etc.

As the EEG procedure is non-invasive and painless, it is being widely used to study the brain organization of cognitive processes such as perception, memory, attention, language, and emotion in normal adults and children. For this purpose, the most useful application of EEG recording is the ERP (Event Related Potential) technique.

EEG Biofeedback

The so-called mind machines or brain machines are devices for induction of different mind states (e.g. relaxation, top performance) by the entrainment of the brain waves into desired frequency bands by repetitive visual and audio stimuli. For making the training more effective, biofeedback methods were involved. Originally, changes in
finger skin resistance or temperature were monitored. EEG biofeedback or neurofeedback uses the EEG signal for the feedback input. It is suggested that this learning procedure may help a subject to modify his or her brainwave activity. One of the methods involved in neurofeedback training is the so-called frequency following response. Changes in the functioning of the brain in the desired way, e.g. increase in alpha activity, generates appropriate visual, audio, or tactile response. Thus, a person can be aware of the right direction of the training.

3.11 Pre-Testing

The researcher administered 15 questionnaires to under-graduate or post-graduate students from different departments, which were not included in the total number of samples taken. Individually the questionnaire was discussed along with the respondents in terms of the technical terms used and the rationale behind using these tools of data collection. The researcher had gone for a few additions and deletions pertaining to the personal data. After the final approval of the psychiatrists, clinical psychologists and neurologists, the researcher ascertained the utility of the ‘questionnaire method’ for the respondents. The relevance of the socio-demographic details questionnaire, the two scales and the EEG was checked, thereby ensuring that the questions were conveyed to the respondents without disturbing their actual meaning.

3.12 Source of Data

The source of data collection has been primary. The researcher collected information directly from the respondents using the socio-demographic questionnaire, the two clinical tests, AMS and WAPIS, and the Imaging Technique Human
Electroencephalography. The investigator was in a position to complete the two tests for 104 respondents within a spell of 18 months. But the EEG took more time, as the neurologists had to conduct the tests and interpret the results. Also the test itself took one hour per sample.

3.13 Statistical Methods Used

The data collected were carefully analyzed and processed. To analyze the data, the statistical tools namely, mean, median, standard deviation, test of association (Chi-square test), one way analysis of variance (f-test), students t-test, and Karl Pearson's coefficient of correlation were made use of. The one-way analysis of variance was used to find out the significant difference between three groups. The test of association (Chi-square) was used to find out the association between two variables. Karl Pearson's coefficient of correlation test was used to find out the relationship between independent variables (age, caste, father's qualification, occupation, mother's qualification, occupation, nature of place, type of family, religion, sex, class, ambition, college etc.,) and dependent variables (dimensions of AMS, WAPIS, and Neuro Imaging).

3.14 Concept Mapping

Concept maps are tools for organizing and representing knowledge. The fundamental idea as promulgated by David Ausubel – an expert in learning psychology, is that, learning takes place by the assimilation of new concepts and propositions into existing concepts and propositional frameworks held by the learner. Concept maps include concepts and relationships between concepts or propositions, indicated by a
connecting line between two concepts. Words on a line specify the relationship between the two concepts.

A concept can be perceived as regularity in events or objects, or records of events or objects designated by a label. The label for most concepts is a word, although sometimes symbols such as + or % are employed. Propositions are statements about some object or event in the environment, either naturally occurring or constructed. Propositions contain two or more concepts connected with other words to form a meaningful statement. Sometimes these are called semantic units, or units of meaning.

Concept maps are represented in a hierarchical fashion with the most inclusive, most general concepts at the top of the map and the more specific, less general concepts arranged hierarchically below. The hierarchical structure for a particular domain of knowledge also depends on the context in which that knowledge is being applied or considered. Therefore, it is best to construct concept maps with reference to some particular situation or event that represents the need to organize knowledge in the form of a concept map. The relationships between concepts in different domains of the concept map are represented using cross links. Cross-links help one to visualize easily how certain domains of knowledge represented on the map are related to each other. In general, cross-links often represent creative leaps on the part of the knowledge mapper, especially when new knowledge is being mapped. The three important features of a concept map that facilitates creative thinking are:

1. The hierarchical structure
2. The ability to search for and characterize cross-links
3. Specific examples of events or objects that help to clarify the meaning of a given concept.

3.15 Limitations of the Study

1. Due to non-proportion in the ratio between the students of post-graduates and under-graduates in the medicine, computer science, social work, and fine arts disciplines, a primary comparison could not be made between the two.

2. The researcher had to procure two research scales and, due to some complications, the scales reached the researcher considerably late. This period of waiting produced sufficient anxiety for the researcher.

3. The data collection process way delayed way beyond schedule due to barriers like examinations, and seminars which prevented the respondents from co-operating with the researcher.

4. The duration of time allotted to the researcher everyday was very minimum (2 to 4 pm) in the Kalaikaviri College of Fine Arts, which was felt as a major constraint.

5. Many respondents were reluctant to perform the tests because the WAPIS test took 1 hour and 35 minutes for completion. However, the researcher took longer time to complete the tests.

6. The students of fine arts were busy with various other programs during the time of performing tests and hence the responses might have got biased a little.
7. As the AMS and WAPIS tests were performed twice with the time gap of 6 months, it was time-consuming for the searching of the same set of students of disciplines namely medicine, social work and fine arts and computer science.

8. As the Neuro Imaging tests were performed in the neuropsychological lab in the National Institute of Mental Health and Neuro Sciences (NIMHANS), Bangalore, many of the respondents hesitated to go to Bangalore for the tests. However, the researcher motivated them to take up the tests according to their convenience.