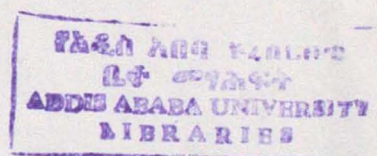


Addis Ababa University
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Department of Teacher Education and Curriculum Studies

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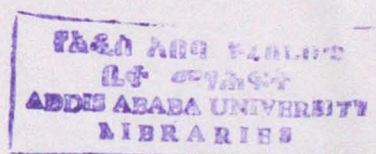


By
Dereje Andargie Kidane Mariam

June 2005

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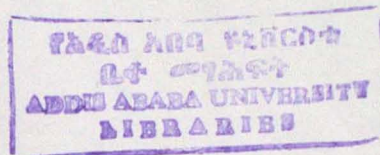
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**Dereje Andargie Kidane Mariam, Bed in Chemistry Alemaya
University 2003**

**A Thesis Submitted to the Graduate School of Addis Ababa University
College of Education, Department of Teacher Education and
Curriculum Studies, in Partial Fulfillment of the Requirements
for the Degree Masters of Art in Teacher Education and
Curriculum Studies**

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Abbreviations and Acronyms

CSTs	Chemistry Student Teacher
PBS	Problem Solving Behavior (Performance)
APSK	Easily Accessible and Problem Specific Knowledge Structure
TESO	Teacher Education System Overhaul
LTM	Long Term Memory
Me	Methyl
PSE	Perceived Self efficacy
PDT	Perceived Difficulty of task
ICDR	Institute for Curriculum Development and Research
UNESCO	United Nations Education Scientific and Cultural Organization
CI	Class Interval

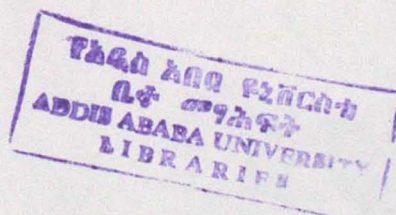
Abstract

This work was the starting point of my study, which aimed at disclosing components of problem solving ability of chemistry student teachers across some common and life rated areas of chemistry. Relevant and problem specific knowledge structure, problem solving behavior (Performances, Perceived self- efficacy beliefs, perceived attractiveness and perceived difficulty beliefs of chemistry were the variables of the study.

A descriptive case study method employed in the study. In the study thirty-nine randomly selected, fourth and third (Preparatory origin and freshman origin) year chemistry student teachers were involved.

The problem of study addressed using chemistry tasks, self-efficacy scales, interviews, discussions, information talks, and observations. The resulting data was analyzed qualitatively and quantitatively using mean, median, standard deviation, t-test, and one-way ANOVA. The study revealed that knowledge structure, perceived difficulty and perceived attractiveness beliefs towards chemistry, and problem solving behavior CSTS' were not the desired results.

Means comparison with reference to students' origin, revealed that there was a significant difference in all variables except self- efficacy beliefs. That is fourth year and third year freshman origin chemistry student teachers were significantly had better than third year preparatory origin counter parts. This study suggests that, the need for further investigation to understand why chemistry student teachers and particularly preparatory origin students' problem solving ability was severely hampered.



CHAPTER - ONE

1. Introduction

1.1 Background of the Study

One basic purpose of education is to enable students' to adapt themselves to life in society, which is full of problems. To be successful one must be adequately equipped with proper reasoning and reflecting power. Not only life in society, but also there are problems and puzzling situations, which are a normal feature of a learner,'s every day life in school, too. With this understanding, the Ethiopian government has designed new education and training policy in the course of producing problem-solving citizens at all levels of education. As can be read from the educational policy document (ETP, 1994: 4) one-emphasis area of education is "to strengthen the individual's and society's problem solving capacity, ability and culture starting from the basic education to all levels."

Concomitantly, teacher education system overhaul handbook, TESO (2003:38) states that, one of the objectives of teacher education is "to prepare teachers who can confidently promote active learning and the development of problem solving skills through a learner centered approach using a curriculum where content and methodologies are integrated." It is why this study is intended to tap with problem solving abilities of pre-service chemistry students, which may light on higher educations about to what extent successfully perform their share.

Problem solving is of ubiquitous importance whenever knowledge must flexibly use. Hence, problem solving plays a central role in all sciences and in most other fields. "There is an increasing need to teach improved problem-solving skills to students who must be adequately prepared to cope with a world characterized by growing complexity, rapid change, and vastly expanding knowledge" (Tuma and Reif, 1980:ix). They further stated that the present time is opportune for examining our current knowledge about problem solving and its relevance to practical education. Cyert in Tuma and Reif (1980:ix) also note that, in professional education, it is generally agreed that the objective is to train problem-solvers in particular field. As an individual faces a problem, he or she must be able to retrieve information to solve the problem and to know how to utilize the retrieved information effectively in order to solve the problem.

Pervin, (1984:445-448) argues that the world about us and within us is filled with many events and a vast array of information. Thus, living in this complex and changing world in which it is important to make decisions, how do we go about organizing information in order to make our lives reasonably stable and productive? Starting from birth we are bombarded with information concerning people and events in the world, how do we go about organizing this information?

Pervin, (1984:447) also says information is organized in to three in a way relevant to people in the world: organization of information relevant to situations and the organization of information relevant to events. In other words, implicitly it means that not only the amount (bulk) of information that makes one competent enough problem-solver, but meta-cognitive skills and beliefs towards problem situations also ingrained of problem-solving skills.

Problem-solving is fast becoming one of those expressions that mean all things to all people, (Bentley and Watt's, 1995:128). Problem solving as an educational activity is not new. There is a large and detailed body of research over many decades, exploring the characteristics of school problem-solving and problem solvers'. What is new is that, the type of the problem under consideration has changed, and tackling these new problems is becoming acceptable and respectable classroom practice. For instance, Desta (2001) and Solomon (2004), in their work of Masters Thesis indicated that, in the Ethiopian context, problem solving approach in schools is almost a null practice. They attributed the problem to many factors in addition to teachers' lack of proficiency in problem-solving process. Hence, they recommend the need for quality in-service and pre-service teacher training. However, the data used as a basis in their analysis to reach in conclusion about the competence of teachers was not adequate for some reasons. For one thing, both of them rushed in to conclusion on the basis of teachers' report about the concept represented by the word problem-solving (which is vague) not on the data that reflects their ability on solving problems; and also they were not subject specific and rather they generalized it to all disciplines. On the other hand, problem-solving ability has different cognitive components, which their data failed to reveal which component of problem-solving is suffered. On top of this, their study conducted on primary school teachers. Therefore, the present study has designed to assess the problem-solving ability of pre-service chemistry student teachers, and give a picture on the success or failures of the mission of the new education and training policy in teacher education institutes, particularly chemistry education.

1.2 Objectives of the Study

This study has the following objectives:

- Giving valid information about pre-service chemistry-student teachers' problem solving profiles,
- Comparing problem-solving profiles of chemistry-student teachers with reference to their year level
- Comparing problem-solving profiles of chemistry-student teachers with reference to their origin.

1.3 Statement of the Problem

Based on previous studies reviewed realization of the educational objective, that is problem solving remains to be the desire of Ethiopia at her schools. This attributed to many factors present in the school system. One of the factors was the issue of teacher's competence, which was the concern of this study.

Teacher education institutions are responsible for the provision of professional schoolteachers, who are skillful at solving problems in their area of profession. As TESO (2003:96) states that, the specific objective of secondary teacher education program is to:

"Develop students' skill, using appropriate methods for subject content; enable students to develop cooperative and student centered learning, and to use problem solving techniques in a number of different situations"

The researcher home department was chemistry education at Dilla College Teacher Education, Debub University. That is why I triggered to raise some questions to the performance of the college and specifically to chemistry department, such as: Is really teacher education programs producing the expected qualified teachers at least in his/her field of study? Do they lack problem solving ability for accomplishing their duty? What is the problem solving capability of chemistry students? And do chemistry department has successfully accomplished its part?

In line with this, the major purpose of this study was diagnosing and reflecting problem-solving ability of pre-service chemistry education students of Dilla College in Debub University. In the course of this study, the cognitive components of problem-solving process, namely: knowledge structure, cognitive functioning and beliefs of chemistry students would be assessed. Therefore, so as to reach the purpose of the study, the following guiding questions were formulated

1. What were the levels of problem solving ability of students in some selected and life related problems of chemistry?
2. What was the self-efficacy (perceived ability) level of chemistry student teachers' in solving chemistry Problems?
3. What were the levels of easily accessible and problem specific form of knowledge structure of chemistry student teacher?
4. What was chemistry student teachers' perceived attractiveness belief towards chemistry?
5. What was chemistry student teachers' perceived difficulty belief towards chemistry?
6. Was there a difference in solving chemical problem on the basis of student teachers origin and year level?
7. Was there a difference in problem specific and easily accessible form of knowledge structure based on students' origin and year level?
8. Was there a difference in chemistry student teachers' perceived self-efficacy based on year level and origin?

1.4 Significance of the Study

Enhancing problem-solving capabilities of students and employees has become a national issue. From the standpoint of the new education and training policy, it would be highly desirable to have a ways of teaching problem-solving process. The achievement of that objective is one of the reasons why working on problem-solving is important. Because of emphasis on problem-solving efforts to enhance the capability of students to solve problems need to reach most disciplines at all levels. It follows, therefore, that teachers need to be adept at using problem-solving strategies in their classrooms and laboratories to ensure the production of home problem-solvers.



In connection with this Solomon (2004), and Desta (2001), commented on the demand of well-trained teachers, who can use problem-solving strategies in their classrooms and laboratories and teach problem-solving skills. It was the researchers' opinion that, this study would contribute a lot to the program (secondary school teacher training) by assessing the status of pre-service higher education students' problem-solving ability and giving valid and reliable information. It might also serve as a springboard to other researchers for further study on issues related to what instructional strategies, and what curricular materials brought about them to their existing competence.

1.5 Limitation of the Study

I planed to use "think aloud" protocol and video recording while each of ten participants was working on the task to give thick description about the level of cognitive processing. Moreover, I was intended to observe students problem solving behavior while working on hands-on (laboratory work) chemistry tasks. However, I faced with complicated problems including financial, time constraints, and students' lack of familiarity to think aloud. Therefore, I tended to increase the number of participants from ten to thirty-nine and used only written tasks. The aspects of cognitive processing such as strategies methods reported in terms of words in their performance taken as principal data source. This might have a contribution to make the description shallow.

1.6 Delimitation of the Study

This study conducted on chemistry student teachers at Dilla College of Teacher Education in Debub University.

The study is delimited to Chemistry student teacher because teachers are critical in the course of developing children's problem- solving competence and to realize educational objectives of Ethiopia. For the sake of in-depth and manageable study, it delimited to third and fourth year chemistry student teachers problem solving ability of Dilla College Teacher- Education.

1.7 Operational Definition of Terms

The following terms defined to show how they are operating in this study.

1. **Knowledge structure:** is a network/ schema in which facts, concepts, principles, procedures, and conditions interlinked about the problems area.
2. **Self- efficacy beliefs:** refers to perceived ability of CSTs' or solvers' expectation of performance on a task / subject if he/she would be engaged to it.
3. **Perceived attractiveness beliefs:** is the belief (value) CSTs' hold about usefulness, impressiveness, and attitude about the task or the discipline.
4. **Perceived difficulty beliefs:** is the belief hold by CSTs' about the difficulty level of the task discipline with reference to their perceived ability (self- efficacy)
5. **Think aloud:** :refers to verbalizing , making speech out loud while thinking
6. **Life related problems:** refer to problems possibly that you can face in your every day life.
7. **Chemistry problems:** are problems that demands chemistry knowledge structure, chemistry specific self-efficacy beliefs to solve.

CHAPTER TWO

2. Review of the Related Literature

Problems solving is a broad and loosely defined concept. It covers from behavioral perspectives to the modern (cognitive) perspectives of problems solving. Different books and articles have been organized around its different aspects. In this review section, I will draw on some sources of information and attempt to provide an integrated view of problem solving by narrowing somewhat to the focus of attention.

The first part of this section tries to address how problems are distinguished from other aspects of the environment (its background), when these problems are sensed and how these problems are interrelated or differed from one another. Following this part immediately it examines concepts of problem solving and why problem solving is demanded to be an element of chemistry education.

Some problem solving approaches are reviewed in order of their historical development, and then some topics about models of problem - solving are introduced. Some selectivity is necessary in reviewing the large number of problems solving models in order to focus on cognitive components of problems solving models. Therefore some of the models considered in this review are: Glaser, Raghaven, and Boxter; schoenfeld; Smith's model, and Newell et al's model. Such models contribute not only practical information on problem solving, but also theoretical information on the nature of problem - solving ability and differences between successful and poor problem solvers.

In this section the summary of the models and cognitive components of problem solving in chemistry also has between given a due consideration. The cognitive components such as chemical knowledge structure, cognitive functioning and belief systems about self and task of successful and unsuccessful problem solvers are considered. At last but not least the ways how these components could be assessed are discussed.



2.1 Over view of what a Problem is

Commonly, when we think of problems what might come to our mind are mathematical, algorithmic problems of any discipline at different levels of institutions. Likewise, there are problems that we face in everyday life. Even some times, we may not sense problems despite of their existence and hence skip by considering the problems as part of our ordinary life. However, if we closely look at problems have some common distinguishing characteristics. Several scholars have tried to single out the common characteristics of a problem.

To mention some, Decorte (1990) in Bomers and Knubben (1993:428) define a problem as a situation that exists in every professional education when a student lacking sufficient domain specific knowledge, often does not know how to use general skills and underlying heuristics. Malim (1994:149) conceptualizes problems as parts of our day-to-day activities which have the elements: The original stimulus situation (for instance, that of having invited people to tea and having nothing to offer them); the goal situation: (to have a tasty tea when visitors come); and the existing rules: (nothing is to be used except what is in the cupboard). In short, it means that, problem situation has a stimulus that needs to be sensed, or the goal that one needs to achieve and principles to apply.

Krulik and Rudnick (1987: 3;and Engeld (1985) in Metasebia (2002:75)) define problem in a similar fashion by saying that problem is a situation, quantitative, or otherwise, that confronts an individual, group of individuals to resolve, and for which the individual sees no apparent or readily available means or path to obtain the solution. For them Problem is a situation that requires reflective thought and synthesis of previously learned knowledge to resolve.

In addition, Krulik and Rudnick (1987:3) believe that problem must perceived as such by a student regardless of the reason in order to be a problem by him or her. Thus, the problem should satisfy the following three criteria: (Ibid: 3).

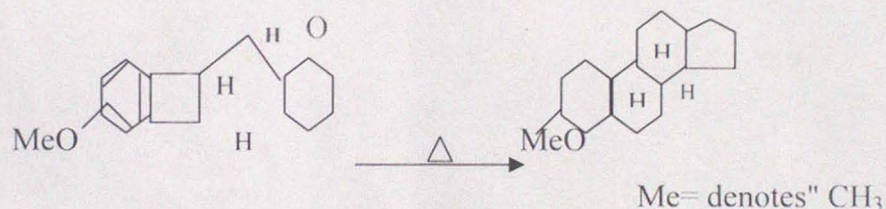
- i) Acceptance: An individual accepts the problem. There is a personal involvement, which may be due to any variety of reasons including internal motivation, external motivation, or simply desire to experience the enjoyment of solving a problem.
- ii) Blockage: The individual's initial attempt at solution is fruitless. His or her habitual responses and patterns of attack do not work.

iii) Exploration: the personal involvement makes the individual to explore new methods of attack. Similarly Beck (1992:436), claims that problem situation is an inherent part of being and the context that it situated, a motivated person to reach some goals, the goal state itself, and some barriers to reaching the goal. It is the barrier that Beck calls a problem. He clarified his idea by exemplification. Suppose one wants to a date to a movie, but he does not have money. The lack of many is the barrier, a problem that has to be solved before he can achieve his goal. If there is no barrier, there is no problem.

In summary, from all these concerning what a problem is, it is a situation, which have the following interdependent components:

(a) Stimuli (situation): which does a motivated organism sense. If the situation is not sensed by the indusial and he is not motivated, there might not be a problem. For instance, when a nine-grader chemistry student studying about hydrocarbons on a certain organic chemistry reference book comes across with the following problem:

Explain the following reaction



Here there is not a deriving force and motivating factor to tackle this problem. This is because a nine grader has not background information about this problem and does not have any relevance to the topic s/he is studying. Therefore, he may skip it by perceiving that it means nothing worth to him.

(b) Obstacle (Barriers). If the stimulus situation has apparently obvious path to follow to its solution, it would not be a problem, rather it would become a question or exercise. A problem situation has an obstacle that limits one not to pass readily to its solution.

(c) The goal state: If the problem has not a goal state, an individual will not be motivated to find a solution. Hence, it will not have a deriving power to motivate the problem solver. Thus, the problem should have a goal state to make the individual motivated and to achieve the goal by passing the obstacle. Moreover, it has to be clear that, there is not a problem situation that we call

intrinsically a problem or not a problem. It might be a problem to some individuals but not for others.

2.2 Types of Problems Based on Their Structured-ness

Problems can be classified as well-structured or ill-structured on the basis of their goal state, the approaches they use to solve, and the nature of their solution (Metasebia, 2002:74). Simon in Frederiksen(1984:336) and Good and Brophy in Metasebia (2002:75) distinguished between well-structured problems, such as puzzles or arithmetic word problems, and the fuzzy (ill-structured) problems that are frequently encountered in real life. Well-structured problems mainly require information contained in the problems statement and perhaps other information stored in long-term memory (LTM), including procedural knowledge such as knowledge of an algorithm; ill-structured problems require one to rely more extensively on resources of LTM or to go to external sources for additional information. Simon cited in Frederiksen (1984:366), defines ill-structured problems as those that

- (a) Are more complex and have less definite criteria for determining when the problem has solved.
- (b) Do not provide all the information necessary to solve the problem, and
- (c) Have no “legal move generator” for finding all the possibilities at each step. He believes that the processes the same for solving well-and ill structured problems. But, for ill-structured problems one’s conception of the problem offers gradually as new elements are evoked from LTM, or outsider sources, and a wide repertory of recognition processes are necessary to evaluate whether one is “getting warmer” as a result of each altered state.

Of course Simon does not place sharp distinction between well-and ill- structured problems. He noted that being simplified into a series of well- structured problems often solves ill structured problems. The problem is well structured in the small but ill structured in the large. Similarly well - structured problems often have aspects of ill-structured problems, Green (Frederiksen, 1984:366). The three categorization of Frederiksen can better reflect their differences.

One type of problems by Frederiksen, (1984:366-367), which most deserves the term “well-structured” consists of problems that are clearly formulated, for which an algorithm is known.

and for which criteria are available for testing the correctness of solutions. For instance: Calculate the morality of a 40gm NaCl in a two-liter solution can be considered from this category of problems. It is because the algorithm is already available and can lead to exact solution, which is 0.5 M. Another category, which labeled as "Structured problems", consists of problems that are similar to well-structured problems as just defined except that their problem-solving procedure or some crucial steps must be generated by the problem solver. For example, calculate the morality of 20% solution of sulfuric acid may fall under this category of problems. The third category contains problems that really deserve the term "ill-structured", problems in this category lack a clear formulation, a procedure that guarantees a correct solution and criteria for evaluating the solution. Most real-life, research, political, etc. problems might fall under this category.

In sum whether problems defined in whatever ways, or are from different areas (academic or real life problems); whether they are ill structured or not, they involve the same cognitive problem solving process which is the concern of this study.

2.3 The Dynamism of Conceptualization of Problem Solving

Having said different perspectives about the conceptualization a problem, it is important to discuss about the concept of problem solving.

In most of our schools there is a common conceptualization of problem-solving, as an activity of searching solutions to mathematical and algorithmic problems in Chemistry, Physics, Mathematics, and any other subjects. However, this study adopts the modern conceptualization of cognitivists, which characterizes it as one form of cognitive process. Problem-solving is a dynamic/or progressive psychological concept like that of learning theories. The dynamism of this concept is discussed following.

Behaviorists conceptualize problem- solving as a process of trial and error, when a problem situation presented until correct response obtained. It involves the physical manipulation of variables of problem situation. It denies the involvement of thought process. It merely involves the physical activity in controlling the variables when the stimuli are presented, just like what other animals do. Does really no thinking process during problem-solving?, Probably not. In relation to this, Dewey (1960:17) notes that,

the ability to think is highly important, and regarded as a distinguishing power that marks man off from the lower animals are. Our activity should not be merely impulsive and merely routine activity. Thinking enables us to direct our activities with foresight and to plan according to ends-in-view, or purpose which we are aware. Thinking process converts action that is merely appetitive, blind, and impulsive into intelligent action.

In reaction to behaviorists, the group of German psychologists called gestalts characterizes problem-solving as a sudden rearrangement of mental elements into a structure that provides a sudden and permanent solution to the problem. This sudden reorganization of mental elements when problem is presented into a mental structure that provides a solution is called "insight experience". It involves thinking of the problem and then rearrangement of mental elements. However, they deny the cognitive processing of problem-solving. This brings a challenge to their notion that problem-solving is an insight experience. Does really trial-and-error devoid from inside of mind during problem-solving? Are really solutions provided to a problem within a fraction of second like a "Flash of light"?

Cognitive psychologists come into place to react with the Gestalts Behaviorists idea towards problem-solving and conception in its contemporary paradigm. Now days most education systems incorporate cognitive objectives in their curricular materials to enhance the cognitive solving problem capacity of students. It is a complex cognitive interaction processes starting from the beginning (presentation of problem situation) to achievement of the desired goal (solution). Problem-solving involves a complex thinking process that includes obtaining sufficient information, understanding of the requirements of the task solution, generating hypothesis or solutions, implementing such solutions, and evaluating them, Smith in (Agran 1997:365). Court in Agran notes that students have difficulty in problem-solving because they are strategy deficient or have limited awareness of their own cognitive processes. For a student to achieve internalized representational (cognitive) thinking the students' cognitive structures (thinking skills) need change, not his or her behavior however the converse may not be true.

As Court argues clearly modifying what a student behavior will not produce a change in his or her thinking unless such instruction is implemented. Cognitions, not behaviors, need to be changed. Some authors such as Tylor, and Dionne, (2000:34); Surgue, (1994:16); Goldman, (1986:78); identify a critical interacting cognitive components of problem-solving performance. Heppner and Krauskopt, 1972; Schoenteld, 1983; Silver and Marshal, 1994; in Tylor, and Dionne, (2000:38) notice, in education context, as in life in general characterize problem solving process as interaction of factual knowledge, cognitive and meta-cognitive strategies, experiences, belief systems and social factors.

Goldman (1986:78) suggest that whether a cognizer actively seeks an answer to a given question depends on the relative strength of the desire for an answer, his beliefs about comparative ease or difficulty of finding an answer, and other cognitive sources such as how to operate, utilized your knowledge and other activities.

More generally at present time researchers attempt to look problem solving from different angles. To begin with, some say problem-solving is a thinking process ranging from initial state to the solution state. Others view it as the application of knowledge acquired to new situations. Still others perceive that, if a problem is an unknown worth solving, problem solving is "any goal directed sequence of cognitive operations," directed at finding that unknown (Anderson, 1990:221; 1985:198). Also others view it as one approach of teaching concepts. Although it has not a single and precise negotiated definition in one way the other modern psychologists and other scholars of the area agreed up on the idea that problem solving is a search for solutions to problematic situations which is the interest of this paper. Perhaps the difference of their views might lay on the typology of the process and the approaches they use.

Krulik and Rudnick (1987:4); Andrews, 1981 in Bomers and Knubben1987: 425) view problems solving as a process by which an individual uses previously acquired knowledge and skills, and understanding to satisfy the demands of unfamiliar situations. They further elaborate that a student must synthesize what he or she has learned, and apply it to the new and different situation. Furthermore, they assume problem-solving skill as a distinct body of knowledge that can be taught as such. For them knowledge (previously acquired), the ability to use that knowledge are important factors that problem solvers need to possess. In other words, the ability

to use concepts, principles and facts are an essential part of problem solving process. They also believe that both knowledge and the ability to use knowledge are teachable.

In a similar fashion, Anderson in Frederiksen (1984:366) claims that problem solving is any goal directed sequence of cognitive operations directed at finding the unknown. Those cognitive operations have two attributes. First, it requires mental representation of the problem and its context. That is human solvers construct a mental representation (or mental model) of the problem, known as problem space, Newell and Simon (Frederiksen 1984: 367). Although there is little agreement on the meaning of mental models or problem spaces, internal mental models (as opposed to social or team mental models) of problems are multimodal representations consisting images and metaphors of the system and executive strategic knowledge (Jonassen and Henning, 1999). Mental model consists of knowledge structure of the problem, knowledge of how to perform task, and any other problem solving activities, the environment of the problem and its constituent parts, and knowledge when and how to use procedures. The mental model of successful problem solvers integrates these different kinds of knowledge, and is the most critical of problem solving.

Secondly, successful problem solving requires that learners actively manipulate and test their mental models. Thinking is internalized activity especially when solving problems, so knowledge and activity are reciprocal and interdependent processes, (Ibid). We know what to do and we do what we know. Similarly successful chemistry problem solvers know that problem solving requires generating and trying out solutions in their minds (mental models or problem space) before trying out in the physical world. Soden, (1994:1) strengthen the idea by saying that: "It is through thinking more effectively that we become better problem solvers at work or our own personal lives."

On the other hand, Aggarwal (1998:245) argues that problem solving is an instructional technique or method where by the teachers and pupils attempt in a conscious, planned, and purposeful effort to arrive at some explanations or solutions to some educationally significant difficulty. Although, Aggarwal emphasizes his definition problem solving to classroom context,

he conceives that problem solving involves a various cognitive (conscious) activities and is beyond instructional method.

In Chemistry, problem solving and its networks are defined by Farzer and Casey in Kornhouser(1992:127). They define it as the result of application of knowledge and procedures to problem situations and they propose four stages, such as definition of the problem, selection of appropriate information, combining the separate piece of information; and evaluation of the solution. Kornhouser also argues that the best chances for success in a chemical problem solving rests on a combination of strong background knowledge in chemistry, a good knowledge of problem solving strategies and tactics, and on confidences. Therefore problem solvers need to possess well coordinated cognitive components of solving which means the three critical cognitive components of problem solving,namely: process knowledge structure, cognitive functioning and belief system towards the task, (Sugrue 1994:7).

2.4 Why Problems Solving Orientation in Chemistry Education

In dealing with the issue of problem solving orientation in chemistry education, we must first consider the large question why we teach chemistry? We all are living in a chemical world that rarely sense how they benefit or affect our life and our economy at large. For instance, new problems appear like those raised by green house gas production, hazardous chemicals such as nuclear waste accommodations, water pollutions, energy shortages are some of the growing macro scale problems of our nation and world at large, which they are waiting for creative mind for their solutions. In spite of the obvious relationships between chemistry and every day life, students of all level make little connection between chemistry that happens in the classroom and that happens outside of schools. An emphasis on development of problem solving in chemistry classroom can lessen the gap between the chemistry classroom and the outside world and thus set a positive mood in the classroom (Krulik , and Rudnick 1987:5). As studies show that in many chemistry classes, mostly students don't make any connections among the chemistry ideas being taught during a week lesson let alone after the completion of their schooling or university education. They perceive each topic as a separate entity, which is detached from the physical world it stands for. They do not know that their intellectual chemical knowledge is representation of the physical world. Intellectual knowledge is the symbolic; abstract representation of the

physical world, (Gagne, 1977:133). On top of this, problems can never be solved in vacuum, therefore schools should teach usable form of knowledge.

“Learning is problem solving”, (Soden, 1994:27). He further discusses that problem-solving skills are one form of thinking skills. Learning and study are also thinking skills. Learners have to use certain mental operation and procedures to store new information in a way, which enable them to retrieve it easily when it is required. People can become good learners in the same way as they became good problem solvers. Many of the mental operations, which are useful in problem solving, are also useful in learning. He further argues that when one confronts with a problem it is useful to search for one’s memory for a similar task and its solution. The same mental operation would be efficient when something new has to be learned. Therefore, learning and problems solving involve interdependent mental activities. Efficient problem solving depends on relevant information having been entered initially in the memory and then to its appropriate category. Soden, (1994:28) also claims that efficient learning depends on using many of the mental procedures, which used in problem solving to sort out incoming processes. Therefore, in teaching problem solving, you are also teaching people how to learn for them selves, so is problem solving orientation in chemistry education.

Kalbag, (1987:129), explains the importance of problem solving orientation in education in a different approach. That is problem solving converts information in to knowledge. Information can be stored in books, Libraries and in our memories, but information stored will be converted into knowledge when it is put into use. For instance, he says, when we are given a formula $E=mc^2$ (Where E= denotes energy, m=denotes mass, and C= denotes speed of light), one cannot expected to be able to use how strong he is in arithmetic. He has to choose the appropriate unit compatible to the formula. It is only after he has used that information could converted into knowledge. He further argues that it is always problem solving that always produce knowledge that is much more active and usable than information acquired in other ways.

Generally, problem-solving orientation in education has great contribution in learning usable form of knowledge, and developing self-learning and problems solving skills. Therefore, ~~X~~ problem-solving orientation in chemistry education should be a critical concern at all levels, not only to solve professional or life problems, but also to learn and convert information stored in memories in to usable knowledge structure. It might be due to this deriving philosophy of

problem solving that educational authorities seriously concerned about designing educational objectives in order to develop cognitive capacity and problem solving skills.

2.5 Historical Approaches of Problems Solving

As different psychologists and experts point out there are different approaches (ways) to be used as a means of solving problems. Among these some of them are discussed in following section. *cs*

2.5.1 The Behavioral Approach

The behavioral approach of problem solving was the dominant approach in early studies of American Behavioral psychology. It was with the work of Thorndike (1898) on the behavior of a cat in a box that brought into existence, (Phye and Andere, 1986: 172; Gilhooly, 1988:6; and Houston, 1986:46). From observation of the behavior of the cat in a box, he concluded that problems could be solved through a number of trial-and-error that is with no conscious planning, monitoring, and thinking of problem solving strategies. Then on wards he developed a trial-and-error learning model and used this model as a basis to problem solving in general. Houston (1986:347) relates this approach with "a blind flashing" trying out of different solutions until the stumble on the correct one. In general the behavioral views (models) of problems solving allows little room to thought and planning in problem solving which marked man off from other lower animals (Phye and Andre, 1986:172; Dewey, 1960: 17-18). For behaviorists in many situations, human do not think about before engaging in behavior, and their activities is very random, and is just doing impulsively.

Thorndike's and other behaviorists' argument had fallen under critics with the movement of a group of German psychologists called as gestalt's. The failure of Thorndike argument of trail-and-error approaches might arises from the fact that his experiment was conducted on animals to study the behavior of human being which might lead his generalization to suffer from external validity (generalization to being).

2.5.2 The Gestalt's Approach of Problems Solving

In reaction to the America Behavioral psychologists and German school of psychology Gestalt's emphasizes on the role of mental structure, organization in perception, and thinking, (Houston,

1986:347; Phye and Andre, 1986:173-4; and Gilhooly, 1988:6). With regard to problem solving approach, they claim that it is sudden an "Aha!" like "insight experience" which results from sudden rearrangement of mental elements to a structure that provide a solution to the problem. He was Kohler (1925) provided evidence to Gestalt's approach of problem solving from his study conducted on chimpanzees. From the study, he observed that behavior of Chimp did not seem to involve random trial -and-error behavior, but rather they emerges a sudden solution to the problems. He called this sudden rearrangement/restructuring of mental elements to provide solution to a problem as "insight experience". Based on this study he concluded that human problem solving also based on thinking about the situation and rearranging mental elements to reach the solution of a problem just like a "flash" of light. He believes that this "insight" experience carried out through a series of thinking and trial-and -error processes in the mind. Therefore, he gives especial emphasis to involvement of thinking for problem solving. What both Thorndike and Kohler committed was their conclusion on to human being based on study of animal behavior. With regard to the Behaviorists view of trial-and-error approaches of problem solving, Gestalt's argues that a number of trail-and-error might be done in the mind of the problem solver, and after a number of trail-and-error in mind that can be reached correct and permanent solution and then to engage physically in the solution (Houston, 1986:348).

2.5.3 The Stages of Problem Solving

Several authors have analyzed problem solving in several series of stages. For instance, modern theories of problem solving and concepts were drawn up on a step analysis of problem solving developed by Polya, (Houston, 1986:349; Reynolds and Flagg, 1983:223). According to Polya problem solving involves breaking of problems into sub goals up to which it can be directly solvable. The process involves:

- Understanding the problem which involves determining the goal, conclusions of the problem and the available data;
- Devise a plan to guide a solution of a problem;
- Carry out the plan; and
- Check back that involves relieving the solutions and correct the plan as necessary.

Research methods of problem solving can be taken as a typical example of this approach. Polya

felt that devise plan to guide a solution of the problem is critical which demands critical thinking, hence over all problem would be broken down into a set of secondary goals, or sub goals, in which each to be more easily solved than the original one. The sub goals even may further be broken down until it becomes a directly solvable task. Wallen (1926) in Phye and Andre (1986:174) argued in a similar fashion as just described above. This approach of problem solving paved a way to algorithmic ways of problem solving. Algorithmic method of problem solving is a procedure that, if correctly applied, will always result in success, (Houston, 1986:349).

Unfortunately, we may not break down all problems into sub-problems to devise an algorithm and if we do not have an algorithm, we need to search for another approach of problem solving which is heuristic approach that involves an educated guess how best to go to solution. You might need to guess which will be the best way to solve/handle the problem, (Houston, 1986:350).

2.5.4 The Piagetian Approach to Problem Solving

Cognitive information processing taken the leading place in schools curriculums and hence is problem-solving approach. Since the early 1960s, the dominant position in American psychology moves from Behavior to cognitive psychology, (Phye and Andre, 1986:175). Piaget and his followers developed a problem-solving approach focuses on mental logic that supports problem solving and how that logic develops. They make a relation between cognitive development and problem solution. The basis of their assumption is cognitive information processing model of problem solving which has got different components and analogically related to programmed computer; (Phye and Andre, 1986:175; and Houston, 1986:350) Problems solving consists of mental and behavioral activities that are involved in dealing with problems. Problem solving may involve thinking (cognition) components, emotional or motivational components, behavioral components (directed by cognitive components); a feeling of confidence in one's ability to solve the problem would respect an emotional component (Phye and Andre, 1986:175; Houston 198:350; Goldman, 1986:135; Cohen, 1991:166).

2.6 Some Models of Problem Solving

As Foshay, (2003:4) states that cognitive research done in the last 20 years has lead to a different models of problem solving. Today we know problem solving includes .a complex set of cognitive behavioral and attitudinal components. The four comprehensive models that assumed to make

stand out the cognitive components of problem solving are polya's; Glaser's, Raghavan's and Boxter's; Schoenfelds; and smith's models. (Sugrue 1994:4-7; Cohen 1991: 165)

Information processing methods are the basis for the development of these models on problem solving behavior to be analyzed and decomposed into a set of leveled stages (Cohen, 1991:166). Some of the models reviewed in the preceding sections. In its most general formulation solving a problem involves transforming an initial state to a goal state through a set of mental operations.

Mode 1: Glaser, Raghavan, and Boxter (1992)

This approach represents the latest version of a model that has been suggested and refined by Glaser, chi and their colleagues at different times, (Sugrue, 1994:4). The model primarily base it self on the results of novice and expert performance on knowledge rich tasks such as mathematics, physics, and chemistry. An important difference between experts and novices in any occupational area is that experts store their knowledge in large concept structures. (Maloney 1994:329; Gabel and Bunce, 1994:314; Soden, 1994:211). The larger structures and links between concepts can make them easily accessible where and when they are demanded. The Glaser's et al model cited in sugrue, (1994: 4) depicts five components of problem solving.

Structured, / Integrated Knowledge. Good problem solvers (what he call experts) use organized information rather than isolated facts. They store Coherent Chunks of information in memory that enables them to retrieve/access meaningful patterns and principles readily.

Effective Representation of a Problem. Problem solvers qualitatively assess the nature of problem and then construct a mental model or representation from which they can make inferences, add constraints to reduce the problem space. A major obstacle novice face when trying to solve problems (chemistry) is that of translating from the verbal statement of the problem to accurate and effective physical representation of the problem, (Maloney, 1994:340). For effective representation of the problem concepts of task environment and problem space are important. The Newell-simon theory of problem solving cited in Eylon and Linn, (1988:367) states that "the task environments is the structure of facts, concepts, and their interrelationships that make up the problems and the problem-space is the problem solvers mental representation of the task environment." Inaccurate and inadequate problem representation may make a problem difficult, or even impossible to solve it.

Proceduralize Knowledge. Good problem solvers know when to use and how to use what they know. In other words, they can make their knowledge bound to conditions of applicability and procedures for use.

Atomacity. In proficient performance component skills can rapidly and cooperatively executed, so that more processing is devoted to decision making with minimal inferences in the over all performance.

Self-Regulations. Good problem solvers have developed self- regulatory (monitoring) or executive skills, which they employ to monitor and control their cognitive processing, and performance in general.

Mode 2 Schoenfeld (1985: 1992)

McCormick and pressley (1997: 370), Sugrue, (1994:5) have developed a mathematical model of cognition that primarily supported by a series of empirical evidences on the effects of instruction on mathematics learning and performance. However, Schoenfeld shows, research from other fields also support and inform aspects of the model. His model of mathematical problem solving involves four components of information processing system, which detailed as follows.

A Knowledge Base (Resources) About Mathematical Concepts. The conception of mathematical thinking begins with mathematical concepts including both the declarative knowledge (“what”, or factual knowledge, understanding or propositional knowledge) and procedural knowledge (“how knowledge”, such as algorithmic and non-algorithmic procedures) required to mathematics (Houston, 1986:5; *ibid*). Of course the same is true about chemistry thinking.

Problem Solving Strategies. (Heuristics). Polya, (McCormik and Pressley, 1997) claims that problem solving strategies works only if the thinker is armed with a great deal of mathematical conceptual knowledge. Strategies and techniques are for making progress on unfamiliar or non-standard problems. Rules of thumb for effective problem solving includes; drawing figures, introducing suitable notations, exploiting related problems, reformulating related problems, working back ward and testing verification procedures (Sugrue, 1994:5). Heuristic approaches of problem solving are believed to be the most important approach. The term ‘Heuristics’ comes from Latin word *heurisco* that means ‘to find out’, (Gupta, 1991:33).

Monitoring And Control (Metacognition). According to Schoenfeld, cited in McCormick and Pressley, (1997); Sugrue, 1994: 5) metacognition is a global decision regarding self-regulated use of knowledge including selection of strategies, planning, monitoring and assessment, decision making, and conscious metacognitive acts. Students should know where and when to apply conceptual knowledge.

Motivation And Beliefs (Belief Systems). One's view of 'mathematical world' that is the set of (not necessarily conscious) determinants of an individual's behavior about self, about the environment, about the topic, and about mathematics in general. All these can arise from students experience as part of mathematical instruction, (Ibid).

Model 3 Smith 1991

As it is stated in Sugrue (1994:5), Smith's model of problem solving differentiates between external and internal factors that are thought to affect problem solving performance; and between good and expert problem solving. The distinction between good and expert problem solving reflects a concern that the conclusions of expert novice studies are based too heavily on the performance of experts for whom the 'problems' solved may not have been novel enough to elicit the kind of problem solving. Processes used by less than effort, yet successful problem solvers. Novices often successfully solve problems, but their solution processes are not same as those of experts. (Smith and Good, in Sugrue 1994:6; and Smith in Bonder and Domin, 2000:11). Smith suggests that expert problem solving is merely a subset of successful problem solving and that the goal of education in academic setting is to produce successful problem solvers, not experts as such. He also criticized the expert-novice dichotomy as unjustly equating expertise with success. Successful problem solvers often share more procedural characteristics that distinguish them from unsuccessful subjects than do experts when experts compared to novices, (Bonder and Domin, 2000:26). Therefore, on the basis of this view he develop a model of a characteristics of good problems solvers who are not highly experienced professionals. The internal factors included in smith's model are the most relevant cognitive components of problem solving and hence only this part of the model are presented here (Sugrue, 1994:6-7).

Affective. Good problem solving is enhanced by certain affective variables including: self-confidence, perseverance, enjoyment, positive self-talk, motivation, and beliefs and values, (Roberts, 1975:332; Vermeer, et al, 2000:308-309).

Experience The length of prior successful problem solving experiences (especially in the domain) of the problem enhances good problem solving

Domain Specific Knowledge. Good problem solving requires knowledge of the domain from which the problem drawn. These are three types of knowledge factual, conceptual or schematic and procedural. The problem solvers should have accurate (misconception free), adequate, organized, accessible, and integrated form of the aforementioned types of knowledge.

General Problem Solving Skill. Good problem solving can be improved by knowledge of general problem solving procedures such as field dependence, personality etc.

Generally, irrespective of degree of expertise, Smith proposes that good problem solvers tend to: adapt their knowledge and its organization to facilitate the solution of problems in the domain; apply their knowledge and skills; use forward resolving and domain specific expertise, use "weaker" problems procedures (means-end-analysis, trial-and-error, etc) on problem space "which incorporates a qualitative representation and description of the problem; plan (at least tacitly) the general strategy or approach to be taken (depending on the perceived complexity of the problem); break problems into parts and perform multistep procedures when necessary, keeping the results of previous steps in mind; employ relevant problem solving procedure/heuristics both domain specific and general; evaluate the solution and the solution procedure; and

abstract patterns in their own performance (identify powerful solution strategies), and identify critical similarities among the problems and useful problem types.

Mode 4 Newell et al (1958) Models of Problem Solving

Newell et al's model in Cohen (1991:166) underlies on the assumption of information processing model that considers problem solving involves multi-step mind operations in the course of transforming initial state of the problem to the goal state of the problem. The stages involve the process representation of the problem, selection of operators, implementation of the selected operators, and evaluation of the current state.

Representation of the Problem. Simon, Martin and Estyes in Bonder and Domin (2000:26) define problem representation synonymously with mental model construction about the problem. Simon uses the term representation in sense of 'internal representation' information that has been

encoded, modified and stored in the brain. Martin uses the term in a similar sense when he says that representation "Signify over imperfect conception of the world." Estey reminds us that a representation stands for but does not fully depict an item or event. At the representation stage, problem solver formulates the problem space that involves representing both the initial and goal states, understanding the instructions and constraints on the problem, retrieving relevant information from long term memory or collecting additional information about the task. The problem space is readily available with the problem, but must be constructed by the solver on the basis of his past experience, stored knowledge will affect the interpretation of the problem: so different problem solvers construct different problem spaces for the same problem.

The distinction between external and internal representation in problem solving as a component of his or her mind "External representation" are physical manifestations of this information. An external representation may be a sequence of words used to describe an internal representation. It might draw a list of information that captures particular elements of an internal representation. (Gabel and Bunce, 1994:316).

In general representation can be realized as a creation of cognitive structures to the problem to make ready for cognitive operation.

Selection of Operators. In this stage the solver selects operations that work in the constructed cognitive structure of transforming the initial state. Set of operations may be associated with the problem space, but they may have to be re-evaluated and/or new ones may have to be selected. When the problem space is small and highly constrained, it is easier to select the appropriate operator. When the problem space is large, the selection of operators requires heuristic search. A common heuristic for selection of operators is means-end analysis. The search system finds differences between the current state and the goal state and selects the operator that will reduce these differences. (Cohen, 1991: 166; 2001: 123; Chi, Glaser, and Rees, 1982:10-11).

Implementation of the Selected Operations. This stage results in a new current state that may or may not correspond with the goal state. In some problems the solution is reached in a single step, in others a series of operations is required.

When an evaluation of the current state of this is judged to correspond to the goal state, a solution is reached, the solving process terminates. If not, further transformation operations must be

selected and implemented. But these stages are not necessarily strictly sequential; and problem solver can back track and represent another problem space to start again.

2.7 Summaries and Implication of the Models

It is essential to note that the words that dichotomize problem solvers into expert-novice problem solver has fallen under critics by some researchers as noted in the above section. The present researcher also adopts this idea. In the worlds of problem solving, the terms novice and expert need to be exempted and should be used in distinguishing who is and/or who is not performing routines (exercises) with automation and/or in a controlled manner. However, problems are unfamiliar to the solvers. In the act of problem solving there are successful and unsuccessful problem solvers in which this study intends to consider. If we use the terms novice and experts in problem solving, we are suppressing creativity in problem solving and enhancing drill and practice is of what is already known by him self.

Generally, the model just described in above section contains many cognitive variables of problem solving. Sugrue (1994:7) identifies and categorizes the critical cognitive variables in to knowledge structure, cognitive functioning and belief systems towards the task. Rumelhart and Normans (1989) in Sugrue (1994:7) make distinctions between the variables that relate to the structure of knowledge in memory, and variables related to the cognitive functions and that operates on knowledge structure to assemble, control and monitor execution of a solution to meet the demands of unfamiliar task. McCombs, (1980); Mc Lead, (1985); Snow; (1989) cited in Sugrue, (1994: 7) point out that cognitive constructs of problem solving that relates motivation (beliefs) is necessary to account for differences in problems solving that results from perception or belief system about one self and the task.

The assumption of Sugrue (1994:8) about the critical cognitive components of problem solving is that the ability to solve problems in a particular domain/occupational area results from a complex interaction of the components. As Snow (1993) noted in Sugrue, (1994:8), errors in performance occurs when a persons "previously stored cognitive components and knowledge base are inadequate, or poorly applied, improvisational assembly and action control devices are weak because they are not geared to the specific task type at hand, or achievement motivation flag prematurely"

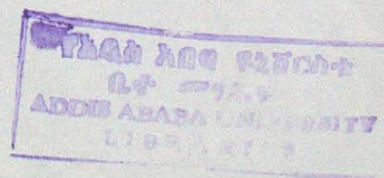
In conclusion, since it would be impossible to measure at time all the variables related to problem solving, the present researcher adopts Sugrue (1994) models of critical cognitive components of problem solving (knowledge structure, cognitive functioning and belief systems of the task) to asses the overall problems solving ability of the solver. Therefore, good chemical thinkers should be armed with well-structured chemistry knowledge. With no chemical knowledge, it is improbable to be a successful problem solver. The knowledge of how to work on a new situation flexibly with the available knowledge structure is also one of the critical cognitive constructs of problem solving. On top of this effective utilization of one's mental capacity, to persistently work with unfamiliar situation, has to develop positive self efficacy, and interest towards the problem situation, other wise if he/she has not good belief systems, might skip even may not sense a problem and not utilize his knowledge related to the problem. These three critical cognitive components of problem solving are discussed, in the following section in detail.

2.8 Cognitive Components of Problem Solving Performance in Chemistry

Problem solving is more than direct retrieval of information from memory. There is a large body of research on problem solving in various disciplines. However, these different studies focus on different variables that might influence problem solving. It is some studies that examine the relative importance; interactions among such cognitive variables, which make difficult to piece together a definitive list of the cognitive factors. Sugrue, (1994: 3-4) has tried to categorize these cognitive variables revealed in different models of problem solving in to three critical cognitive components of problem solving, namely knowledge structure, cognitive functioning and beliefs systems towards the problem (task). In relation to this Heppner and Krauskapt, 1972; Schoengeld, 1983; Silver and Marshal, 1990; (Tylor and Dionne, 2000:413) Claim that in any educational context in life in general problem solving process is the interaction of factual knowledge, cognitive and meta cognitive strategies, experiences, belief systems and social factors. Comprehensive models of problem solving are just discussed in following section

2.8.1 Chemical knowledge Structures

Knowledge is one of our cognitive constructs that are necessary to consciously identify and solve problems. For instance chemistry problem solvers need to have chemistry knowledge. Many



psychologists and researchers working in problem solving area, claim that problems never be solved in vacuum. There should be background knowledge related to the problem at hand.

Many researchers in Taconis, Ferguson- Hessler and Brockkamp (2000:445-447); Soden (1994:41-2); Christine, McCormick and Pressley (1997:372), Gable and Bunce (1994:303-305); note that knowledge structure is a basic and unsubstituable components of problem solving that problem solver should posses to tackle problems in his professional area or life in general. McCormick and Presley (1997:8) assume that knowledge is a determinant of performance. He added that those who posses domain specific knowledge processes information efficiently than domain novices. Further more Taconis, Ferguson-Hessler, Brockkamp (2000:446) explains similarly in terms of Schema. Schema is a unit in human memory representing a functional package of knowledge and which are central to problem solving their content, and structur. Simon and Hayes (1976) in Gable and Bunce (1994:304) also remark that there is no substitute for having prerequisite knowledge if one to solve a problem. The studies made by Nurrenbern and Pickering (1987) and Sawrey (1990) in Gabel and Bunce (1994: 304) on college chemistry students by using conceptual knowledge base problems solving shows that conceptual understanding is necessary for problem solving. The studies reveal that problem solvers based on conceptual understanding performs twice than traditional (algorithmic) problem solvers For instance Gable and Bunce from their study on chemistry students' remark that in order to solve a chemistry problem in an acceptable manner, the problem solver must have both scientific and procedural knowledge. In sum, what all the studies show is that knowledge is a basic component of problem solving. Therefore, a successful problem solver should have well grounded knowledge structure.

2.8.1.1. Knowledge Structure of Successful Vs Unsuccessful Problem solvers

Many researchers such as Glaser (1984; 1990; 1992); Gorodetsky and Hoz (1980) cited in Gable and Bunce (1994:305) documented that successfully solve problems information should be structured in terms of concepts, principles, rules, conditions and procedures. For instance knowledge structure of good problem solvers is well integrated in a way if one of the nodes (concepts) of the structure is triggered the whole knowledge structure will be activated and the process of accommodation will come in to actions. Soden (1994:42), argues that knowledge be structured heirchically by imbedding specific knowledge in more generally applicable knowledge

so that it can be remembered more easily and applicable more flexibly in the process of problem solving. On the other way round, it means that if concepts are unrelated and scattered haphazardly problem solving process become hampered.

Gorodetsky and Hoz (1980) cited in Gable and Bunce (1994:305), from the result of their study on tenth grade chemistry students note that both successful and unsuccessful problem solvers used the concepts listed in their profiles analysis, however, the successful problems solvers made more connections for the two groups increased at higher level of the concept profile. In connection to this Glaser, (1984;1990;1992); and Marshal (1988; 1993) cited in Sugrue (1994:8), remarks that the structure of good problem solvers knowledge (sometimes called Schemas, or mental models, or knowledge) are connected, integrated, coherent or chunked. In contrast the knowledge of poor problem solvers is deemed to be fragmented, and unconnected. The more connected one's knowledge, the more the knowledge is activated when one pieced of the network is triggered by information presented by in a problem, Anderson, 1983; Gagne, Yekovich and Yekovich, 1993 cited in (Sugrue, 1994:8) . Furthermore, Chi et al (1983); Mestre, Dufresne Garace Hardiman, and Tougher (1992); Schultz and Lochhead, (1991);

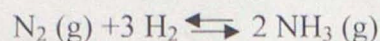
(Sugrue 1994:9) argue that the knowledge of good problem solver seems to be linked, organized around key principles, and related concepts which are linked to conditions and procedures for implementations.

The definition components of knowledge structure which are concepts, principles and rules is important for classifying instructional outcomes and is given by Merrill, (1983) cited in (Sugrue, 1994:9). Principle is defined as a rule, law, formula, or if then statement characterizes the relationship between two or more concepts. For example, the relationship between force and motion is defined by principles of Newton's law of motion.

Phye and Andre (1986; 254) also define rules or principles as statements that related concepts and tell how changes or alterations in one concept influence other concepts. They further argued that a person who knows a rule has an inferred capability that enables the individual to respond to the class of stimuli/situations with a class of performances.

Gagne (1977) in Phye and Andre (1986:264) viewed in a holistic manner that concepts, principles and skills have a set of critical features that give rise to their operations or identity situations to which they are applicable. Example: Explain the following chemical equilibrium.

- a) Why shifts to the left when reaction pressure is reduced (Lichatelier's principles).



- b) Why the chemical equilibrium shifts to the right when the pressure is increased?

- c) What will happen the equilibrium sate if some amount of NH_3 is removed and/or added?

Example 2: What happens to the Equilibrium state if you add more heat to the reaction system given below? $\text{A} + \text{B} \rightleftharpoons \text{AB} + (-) \text{H} \quad \Delta$

All these examples show how principles and concepts help as to relate to conditions and explain conditions. The concepts involve in the above reaction are equilibrium sate, reactants, products, shifts to the right, shifts to the left, Exothermic, and Endothermic reactions. Principle involved is Lichatelier's principles of chemical equilibrium

The causal relations between concepts are connected by principles. Therefore, understanding principles assume that of understanding concepts related by principles. A concept is a category of objects, events, people, or symbol, or ideas that share common defining attributes or properties and are identified by the same name, (Sugrue, 1994:9). For instance substance, salt, base, acid, energy, molecule are concepts which be expressed by same definitions. Understanding of concepts facilitates identification, or generation of examples of a concept.

For example, if one asked to

- (a) Give example of Salts,
(b) Classify the following compounds in their category.

NaCl , CaCO_3 , NaOH , NH_3 , MgO , LiOH , HCl , $\text{Mg}(\text{OH})_2$, BaCl_2 , NaHCO_3 , AlCl_3 , H_2SO_4 , CH_3COOH , $\text{CH}_3\text{CH}_2\text{OH}$, CH_3OCH_3 , CH_2O and CH_3OH ; he will apply his understanding of concepts salt, base, acid, alcohol, aldehyde and ether. Therefore, to facilitate problem solving, concepts and principles must be linked to conditions and procedures to facilitate their use in unfamiliar situations. A procedure is a set of steps that can be carried out to achieve some goal.

Conditions are aspects of the environment that indicate the existence of an instance of a concept; or that indicate the particular principle operating or might be applied; or that a particular procedure operating appropriately at unfamiliar situation (Sugrue, 1994:10). Therefore good problem solvers should be able to recognize situations where particular procedures can be performed to identify or generate an instance of a concept. They should also be able to assemble procedures based on a principle to engineer (shape) a desired outcome in a problem situation, (Simon and Simon in Maloney 1994:334).

Thro (1978) in Maloney, (1994:335) also notes that, problem solving ability of subjects vary directly with the establishment of related concepts in their cognitive structure. A knowledge structure is open to assessment. Diagnostic assessment of problem solving ability should involve identification of students who understand concepts, not the principles that links them; students who understand the concepts and principles but lack knowledge of procedures to apply them; and students who can perform procedures correctly but do not know when it is appropriate to apply them, (Sugrue, 1994:10). Therefore designing a task that let them to be manifested can assess these components of knowledge structure profiles.

2.8.1.2 Assessment of Knowledge Structure

As it is so far discussed in the earlier section, knowledge structure is one critical components of problem solving. When we are talking about knowledge structure, we are concerning about domain specific knowledge structure in which the elements; facts, concepts, and principles are interlinked (chunked) in away to structure knowledge in a usable forms of organization. In other words when we have a well-structured (chunked) prior knowledge the whole structure will be activated and then relevant information retrieved to works effectively on the problem situation. For example, a chemist who have well organized knowledge about Thermodynamics, comes across problem situations related to heat transfer, his knowledge structure about Thermodynamics will be activated by the given problem situation and then will retrieved the appropriate information about Thermodynamics principles. If the problems solver has not structured Thermodynamics knowledge, there may not be activation of knowledge structure to retrieve relevant information (data from his semantic memory), then ultimately might fail to solve the problem. Therefore, to understand one's knowledge structure and to judge his/her problems solving ability assessment need to be in place.

Assessment of knowledge structure involves the assessment of concepts, principles, and their interrelations, how concepts are linked to conditions and procedures. (Sugrue, 1994: 14). Knowledge of concepts can be assessed by asking students to generate examples to concepts, to define concepts, to describe related concepts, and discriminate questions/problems (Kean and Middlecamp, 1986:88); and as different authors cited in (Sugrue, 1994:14).

Principles in the knowledge structure of the solver can be assessed through categorization of problems into similar types based on knowledge that requires be using, and basing on problems that involve the same principle. Therefore students are asked to identify why a number of problems are similar, why did something during problem solving and accurate interpretation of problem solving, as many authors cited in (Sugrue, 1994: 14).

For assessing links among concepts with conditions, and procedure; and links among principles or rules with conditions and procedures for applying them is suggested by many scholars. (Sugrue 1994:14). For instance asking students to select or suggest a method for solving a problem; to debug a solution; to suggest the ordering of the procedures or steps in particular situation; giving particular set of conditions to think aloud as they attempt solution, or to explain why they use a particular strategy or procedures for identifying or generating instances of concepts are very important in chemistry and in the domain of science in general where many tasks involve testing substances, or objects in order to classify or identify their category. For example, to analyze an unknown substance in chemistry demands the knowledge of procedures. Tasks requiring knowledge of procedures that are linked to principles go beyond identification or generation of instances or object with particular defining properties. Tasks requiring knowledge of principles related procedures are that requires selection to application of procedures to modify some aspects of a situation that will result in a desired outcome (change in a related concepts).

2.8.2 Cognitive Functioning

The notion of cognitive functioning is central to the model of cognitive information processing that relates existing knowledge with the information presented in the persuasive message. It is the kind of cognitive process that support flexible adaptation of ones knowledge structure and it is referred in literature as metacognitions, (Phye and Andre, (1986); and Brown, Branstord, Ferrara, and Compion, (1990) in Sugrue, (1994); or higher order thinking processes, Baker, (1990); Kulnn, (1984) in (Sugrue, 1994:10). Flexibility in thinking refers to as lateral thinking, to mean

that students can learn to consider alternative points of view and to view and to deal with several sources of information simultaneously. Whether cognitive functions referred in different ways or not the essence that ultimately all wants to communicate is the same idea about flexible adaptation of one's knowledge structure when he/or she come a crosses new situation. Therefore, in this paper it may be used alternatively to say the same idea the metacognition is the knowledge and regulatory system that operates on cognitive knowledge structures.

Flavell (1979) cited in Phye and Andre (1986:206) defines metacognitive knowledge "that segment of your (a child's in adult's) stored world knowledge that has to do with people as cognitive creatures and with their diverse cognitive tasks, goals, actions, and experiences". In other words it means that it is knowledge of our stored knowledge about the world and that make us to have a thinking behavior before acting on it. Victor and Kellough (1997:168) gives an operational definition that metacognition is the ability to plan, monitor and evaluate one's own thinking.

Baker and Brown cited in Phye, a dn Ander (1986:120) distinguishes two types of metacognitions that is knowledge about cognition, and regulation of cognition knowledge about one's own cognitive resources (example, facts, concepts, principles or rules in Long-term memory and other sources), and knowledge about how compatible the demand of learning situations are with one's own resources.

For instance, do I have good knowledge structure about solutions to solve problems in this specific domain or not? Baker and Brown further argued that knowledge about cognition is relatively stable overtime, can be stated by the learner; may not be accurate; and is late developing and is so more complete in the older learner. When we are saying it is late developing, it means that the ability to think about and aware of one's own actions during problem solving, reading and writing can be developed by cooperative effort of teachers and students. It can be altered through instruction and is open to assessment. Therefore, education institutions should work to wards enriching students' knowledge about their cognition.

The second type of metacognition is regulation of cognition consists of the self-regulatory mechanisms used by active learners during on going attempt to solve problem (Brown, 1983: 634). The regulatory activities are thought to be relatively unstable; rarely stated; and relatively independent of the learners' age. The second type of metacognition is difficult to intervene

through instruction and assessment. According to Brown regulatory cognitive activities includes planning one's next move, checking the outcome of any strategies one might use, monitoring the effectiveness of any attempted actions, testing, revising, and evaluation one's strategies for learning. Although the two types of metacognitive strategies are distinguished conceptually, Brown argues they are closely interrelated and both should be considered to understand metacognition. From all these it can be said that metacognition includes knowledge (consciousness) about, and regulation of various cognitive process. It is a self-awareness and self-control of one's own cognitive activity.

Different scholars have isolated specific aspects of cognitive functioning that might be open to assessment. For instance Sugre (1994:17), planning problem solving approach, and monitoring progress, (Compione and Brown, 1990); planning, monitoring, selecting and connecting (Corno and Mandinach, 1993); planning, monitoring, and evaluating (Sternberg, 1985), and knowing when or what one knows, or does not know, predicting the correctness or outcome of one's performance, planning a head, efficiency and performance (Glaser, Lesgold, Lajoie, 1987). Although the scholars' forms of presentation are different their view of cognitive functioning revolves around planning, monitoring and evaluation of one cognitive performance.

2.8.2.1 Cognitive functioning of Good Problem Solvers

Good problems solvers spend a disproportionate amount of time in the initial planning phase of problem solving, and follow one solution path rather than trying out a number of solutions. Campione and Grown (1990); Gagne' et al, (1993); Glaser, (1992); Voss and Post, (1988); Larkin, McDermolt, Simon and Simon, (1990) cited in (Sugrue 1994:11).

Finegold, Mars and Ploya in Maloney (1994:329) remark some points concerning good problems solvers. To mention, good problem solvers translate the problems correctly and more exactly than do others. Good problem solvers plan their solution more fully and greater detail before carrying out than does poor solvers who tend to solve with out planning. Good solvers complete the solution to a problem in less time than poor solvers Good solvers relatively spend more time on translation than do poor solvers. Houston (1986:5) also notes/records that good problems solvers know what to ask themselves, and what to do with answers they receive as they think through the problem.

The study made by Sumfleth (1989) cited in Gable and Bunce (1994:305) on 16 years old students in German who had studied chemistry for two years. From analysis of an explanation test, achievement test and connectively test, he concluded that even though students had reasonable basic knowledge of chemical terms, they were unable to establish correlation between them and apply their knowledge in problem solving. What this study implicitly reveals is that having only reasonable basic knowledge structure does not make one good problem solver. Cognitive functions should also operate well on cognitive knowledge structures and should also use the knowledge structure flexibly to unfamiliar situations.

2.8.2.2 Components of Cognitive Functioning Open to assessment

Of course, there is not extensive research on the relative importance of the individual components of cognitive functioning that has been suggested. There are cognitive components of problem solving that have most often been singled out for assessment or training are planning and monitoring (Sugrue, 1984:11). These two components of cognitive functioning are included in the Sugrue's model and are can be targeted by assessment of problem solving. Planning in his model defined as thinking through what one will do before actually doing it, (Victor and Kellough 1997:170; and Sugrue, 1994:11). Monitoring is adapt ably defined in the assessment model as keeping track of a number of aspects of one's performance including time, the effects of one's efforts in relation to the goal and constraints of the problem, and adapting one's strategy if necessary.

The cognitive functioning is connecting that is linking incoming information to familiar information, or the creation of new links among the existing knowledge structure may be independent of the connectedness assessment, (Coorno and Mandinach, 1983; Clark and Black in 'press) in Sugrue, 1994:11).

2.8.2.3 Assessment of Cognitive Functioning

There are a number of approaches to assessing cognitive functions as many of researchers in problem solving and cognitive. For instance self assessment questionnaire, (Zimmermand and Martinez-pons, 1986; O'Neil et al (1992), and Pintrich and DeGroot, (1990) cited in (Sugrue 1994:11) provides data on the extent to which students perceive themselves to be engaging in a number of distinct metacognitive activities/functions. Furthermore, they added that "Think aloud

protocols" and Retrospective interviews using videotapes of performance are used to stimulate recall to assess cognitive functions.

Different authors cited in (Sugrue 1994: 13). indicate that think aloud method uses to assess students domain specific planning skills such as asking students to demonstrate how they planned to solve a particular problems, justify their plans, and recreate a plan based on a completely executed solution.. The relative proportion of time devoted to planning execution can also be used as measures of planning, Chi et al, (1993), (Sugrue 1994: 13). Monitoring can be assessed via think aloud methods. Observation of students' performance is also important to identify: the extent to which students look back over elements of the material presented, or elements of their solutions, comparison of solution speeds under different conditions, noticing of inadequate instructions and time allocations during performance, the extent to which students keep track of remaining and adjust their plans and strategies accordingly,(many author's cited in Sugrue 1994:12).

2.8.3 Beliefs about self and Task

Different researchers cited in Sugrue (1994:12) tell us that, although most empirical studies of problem solving have not measured affective variables, there is an increasing acknowledgement of the role of such variables in problem solving performance. Goldman (1986:80) also claims that whether a cognizer actively seeks an answer to a question depends on the relative strength of his/or her desires and his/or her beliefs about the comparative ease or difficulty of his/or her finding answer. For instance, if he/she thinks that of the task would be hard to him/her, and if he/she has a better use of his/her time and cognitive resources, he/she might skip the quest. Suppose, however, that he devotes at least some cognitive resources to the question: what specific activities of operations, will be utilized? This raises the more general question: What are the cognitive components of problem solving activity? Some theorists combine motivational variables with metacongitive variable in models of self regulated learning or cognitive engagement reflecting a complex interaction among these variables, Zimmerman, (1986); Carno and Mandinach, (1983) in (Sugrue, 1994:12).

2.8.3.1 Belief System of Successful Vs Un Successful Problem Solvers

Bandura (1982) cited in Sugrue (1994:45), Soodak, and Podell (1998:77) effort and persistence (i.e. sticking to a task until it is completed), Victor and Kellough (1997:170) in the face of difficulty are influenced by one's self-efficacy. Successful problem solvers should feel a sense of efficacy as thinker, like a feeling of "I can" and express a feeling of "I enjoy" Victor and Kellough (1997:171). Besides this Salomon and Leigh (1983) in Sugrue (1994:12) proposes that mental effort (or "mindfulness") is also influenced by one's perception of the demands of the difficulty of the task. If one feels that the task is difficult and has self-efficacy, he will engage in the task mindfully. The variables perceived self-efficacy and perceived demands of the task seems to operate independently of the extent one's task relevant base. The higher one's perception of one's ability and the higher the perceived difficulty of the task (within reasonable rang of difficulty), the more mental efforts one is likely to invest in cognitive processing during the task, Salomon and Gilberson, cited in Sugrue, 1994:12). On the other way round, when a problem solver perceived a task to be demanding relative to his/or her perceived self-efficacy, he/she might invest little sustained effort and consequently performs poorly. In a similar fashion Salomon and Leigh (1984:120) claims that the depth of processing, mindfulness, and the use of cognitive capacity, what they collectively call as the construct of amount of mental effort applied any task, problem, material depends on the perceived demands of the task relative to their perceived self efficacy in response to the task demand. They logically further argue that when the ability (knowledge structure and cognitive functioning) holds constant the amount of invested mental effort is a function of preconceptions of the relevant class of materials, the task, and their self efficacy, and is a good predictor of performance that is based on effortful processing.

According to Nisbett and Wilson, cited in Salomon and Leigh (1984:120) student perceived demand of task and perceived self-efficacy can be inferred from their self reports that reflect their implicit theories (explanations) concerning internal events, rather than the actual implementation of these theories and from their affective state while working. One's preconceptions of the task can/or cannot prescribe the mobilization of their stated abilities. That is intensive expenditure of effort can be achieved intensive mobilization of related abilities by a high efficacy feeling.

Bockaerts, (1987; 1981); Pintrich and DeGroot (1990), cited in Sugrue (1994:12) have pointed out that in addition to perceived self efficacy and perceived demands of a task, effort expenditure

is also influenced by the perceived attraction of the task, that promotes the higher cognitive engagement in the task.

Houston (1986:5) strengthens the idea by saying that "a good problem solver has a desire to solve problems. Problems interest him/her when they offer a challenge. They are not easily discouraged when incorrect, or a particular situation approach leads to a dead end. They go back and try new approaches again and again!! They refuse to quit!"

Cohen (1991: 167; 2001:128) added that good problem solvers are not afraid to guess. They will make an "educated guess" (i.e. a heuristic approaches) at solution, and then attempt to verify these guesses.

In sum, in order to generate a comprehensive profile of student's ability and willingness to solve problems in a particular domain, one might estimate the extent to which a student is likely to invest effort in the task that presents the domain. To that end perceived self-efficacy (PSE) perceived attractiveness of the task (PAT), perceived demands of the task aimed to be targeted in this study.

2.8.3.2 Assessment of Beliefs

Beliefs about one's competence and about the demands or attractiveness of a task are usually measured via questionnaire or interviews. Numerous interviews schedules and self-assessment questionnaire have developed to tap perceptions/attitudes/beliefs by different authors, (Sugrue, 1994:16). Sometimes students are with task scenarios and asked how they would respond in those situation most of the time, students are asked to rate how well a particular statement reflect their beliefs. For example, Feather in Sugrue (1994: 16) used the following item to measure student's belief about mathematics ability. "In general, how do you rate your ability to do well in mathematics?" students had to indicate their rating a 7-point scale ranging from very low on one end to very high on the other end. One of the Feather's items to measure subjective balance of mathematics was "How interested are you in mathematics?" students responded on 7-point scale ranging from not interested at all to very interested. Backaerts (1987,1991) cited in Sugrue (1994:) has developed instruments that asks students on a 5- point scale to items such as "How much do you like these kinds tasks?" to measure variables such as task attraction, perceived difficulty, and perceived competence.

Few methodologies for eliciting and scoring either open-ended responses to questions about beliefs or behavioral indicators of beliefs have been developed; Sugrue (1994:17). Snow, (1989,1990) cited in Sugrue (1994:17) describes an open - ended approach to eliciting beliefs that may be more valid than fixed format inventories chi et al (1982), in Sugrue (1994:17), also used an open-ended technique in which they asked students to indicate the aspects of the task that made them judge it as difficult.

CHAPTER - THREE

3. Research Design of the Study

3.1 Theoretical framework of the Design

As so far stated the major purpose of the study was to describe problem solving ability of Dilla College, Department of Chemistry education CSTs. In order to search a solution to this research problem I used mixed approaches (methods), namely: quantitative and qualitative research (problems solving) methods.

Problems related to behavioral variables could better be described through quantitative approach while, problems related to motivational, task, and environmental variables could better be described qualitatively through interview, discussion, and informal talks. Ames (1992:268) notes that a qualitative approach to a student motivation is concerned with how students think about themselves in relation to learning activities and to the process of learning it self. The belief systems therefore related to motivation such as perceived attractiveness and perceived difficulty beliefs of CSTs can better be assessed through qualitative methods. Blumenfeld (1992:279) also remarks that, intensive interviews with students about what salient elements of the dimension identified would be extremely useful to answer some of the questions about tasks, evaluation, authority raised above such as: What is meaningful task? What is reasonable effort? In other words the why of behavior can better be assessed through interview, discussion, and informal talks as contrasted with the 'how' and 'what' of behavior. It can be possible to observe what some body is doing and how he/she is doing but it might mislead to determine why he /she is doing. Jones in McClelland (1985:16) explains that, when one makes inferences from observing behavior about a person's intent he/she can arrive at a conclusion the intent that differs from what the person feels his/her intent was.

The inferences one make about interests from observing behavior can be wrong; for example, by looking a girl playing piano, he/ she can infer the girl wants to play piano, whereas the same acts could be consistent with her feeling that she is being compelled to practice. Therefore from this point of view to intensively describe why a certain level of problem solving behavior observed on a task qualitative ways of searching solution is preferred,(Ibid).

Performance of tasks, procedures, and resources used in performing tasks are observed and can quantitatively be measured. Self- efficacy (perceived ability) beliefs are expected behaviors to be observed on tasks, while performance is actual behavior observed on task. It is on the basis of this idea that I used quantitative approaches to answer self-efficacy; knowledge structure, and problem solving behaviors (performance) related questions.

3.2 Descriptions and Sampling of the Subjects

The subjects of the study were fourth and third year CSTs of Dilla College of teacher education. They were 122. As 2004/05 entry preparatory origin CSTs were new to the college and department they were supposed to be tensed, and feel instable and anxious. Therefore, so as to reduce an interference of extraneous variables and bias they were excluded from the study. Third year freshman origin referred to students of old curriculum (2002/03 entry). They were 46. Third year preparatory origin referred to students of new curriculum who stayed two years at preparatory school and two years at Dilla College (2003/04 entry). They were 34. During their pre-college education Preparatory origin students were supposed to learn introductory courses which were equivalent to freshman courses. Now, both third year preparatory origin and third year freshman origin are on the same year level and taking the same courses. Fourth year CSTs were 42. In order to reduce the chance that all subjects could be drawn from one-year level or origin I categorized these students in to three groups (strata), namely: third year preparatory origin (N= 34), third year freshman origin (N= 46), and fourth year (40) CSTs. I can assure you that students of each stratum were interested to be participant of the study. From these groups of students 32.5% (N = 39) were taken to participate in the study. The subjects were randomly selected from each stratum. That is 32.9% (N = 11) from third year preparatory origin, 30.43% (N = 14) from third year freshman origin, and 35% (N = 14) from fourth year CSTs. The total number of female students in both years' levels i.e. third and fourth was four, which were two from fourth year and two from third year. But only three of them were participated in the study.

For interview and discussion I purposely selected two students from each stratum. Their number was six, because the subjects' perspectives on the issues addressed became monotonous. Moreover, I also made informal observations, and talks with chemistry instructors and different groups of third and fourth year CSTs.

3.3 Descriptions of Instruments

The purpose of this study was to investigate Dilla College CSTs' problem solving ability. Besides, to see if there were differences on problem solving ability based on year level and students origin. Since, problem-solving behavior related to self- efficacy beliefs, knowledge structures, perceived difficulty beliefs, and perceived attractiveness beliefs of chemistry, corresponding to each variable four different instruments were designed.

3.3.1 Self - Efficacy Items: As a Means to Study Perceived Ability

An all - purpose measure of self- efficacy is too broad and is not a good method for determining self - efficacy in a discipline, or a particular situation.

Bandura (1997) in Diane (2003: 22) notes, that self- efficacy is domain specific so more accurate results are obtained when an instrument specific to the discipline is administered. Self-efficacy should not be too narrow or too broad, but specific to the subject. Taking these factors into account the instruments developed for this study was tailored to chemistry in order to be domain specific. The five-point scale (5=strongly agree to 1=strongly disagree) self -efficacy items used for this study. All were specific to chemistry (Appendix A). These items designed for chemistry parallel to Diane's self- efficacy items for anatomy and physiology by substituting the word chemistry to anatomy and physiology, and making small revision to the structure of the original items. To increase reliability of this instrument four (4, 7, 9, 14) of the fifteen items were negatively worded so that reliable information were tried to gather.

3.3.2 Chemistry Tasks (Problems)

Chemistry tasks are essential to infer problem solving ability. In connection to this Mayer in Fashay, (2003:4) remarks that problem solving is cognitive but is inferred from behavior, and its result in behavior that lead to solution. For instance, knowledge is stored in mind in several forms: words and pictures for - example. Further more, Leithwood et al, (1993:374) also discuss that, knowledge goes considerably beyond purely cognitive content implied by term. This implicitly tells us that knowledge structure and problem solving performance can be implied when the solver is working on tasks. In this study so as to measure accessible and problem specific knowledge structure and problem solving behavior, chemistry tasks were designed.

Chemistry tasks included one algorithmic and five conceptual problems (see Appendix A). The problems were constructed from some common and selected areas of chemistry. The area in which the tasks extracted was supposed to be learning by both third and fourth year CSTs. The topics where the tasks designed were sampled on the basis of the following criteria:

- a) The topics should be covered by previous instructions.
- b) The topics should be common in the sense that need to be mastery objectives to be acquired by every student of the year level considered in the study and
- c) The topics should be closely related to every-day life.

The problems expected to be parts of every day life. Tasks were open-ended. Each of the problems designed in such a way that not only to exhibit problem-solving behavior, but also to elicit propositional and procedural knowledge required in solving the problems.

Initially, I designed eleven problems: four algorithmic and seven conceptual problems. Two chemistry instructors, and two-second year chemistry masters students then revised these problems. Two analytical and inorganic chemistry instructors of Dilla College one from each, and two-second year masters students, one from environmental chemistry and one from analytical chemistry department of Addis Ababa University.

Lastly these problems were reduced in to six and administered The following criteria were met for chemistry problems should be:

- a) Stated in clear and simple languages
- b) Authentic and practically important and application problems
- c) Appealing to all the three group of students
- d) Solvable using a variety of solution strategies; and
- e) The difficulty of the problems measured in terms of the number of principles required to solve.

Chemistry tasks were integrated with instructions that demand students to set goals before engaging in solution process, to write the conditions (givens), constraints in solving and then to write every step that the solver used to solve each problem.

Task Analysis

Task analysis is one of the important steps of problem solving investigations.

To this point Robert, et. al (1982:237-8) note that most investigation of problem solving and reasoning begins with task analysis. Task analysis is not a formal and standard set of procedures; the type of analysis will vary depending on the theoretical framework of the researcher as well as the extent and sophistication of available research and theory. However, outcome of this analysis is explicit statement of all cognitive activity that occurs from initial presentation and final solution of a problem.

Therefore, in view of this idea, in order to examine status of cognitive components of problem solving ability such as, problem solving behavior (Performance), and APSK of chemistry student teachers on the tasks I developed scoring criteria (see Appendix C) from the theoretical framework discussed in Chapter 2.

Using scoring models, scoring of the results of the problems made. Score of each problem could range from 0 to 4. Summing up the score of each problem made the total scores. Therefore, the total PBS, and APSK could range from 0 to 24.

Based on scoring model explanations used (see Appendix, C) the ranges of scores were classed in to three nominal scales. The nominal (categorical) scales for PBS were: Poor problem solvers (ranges of scores below or equal to 6), Moderate solvers (range of scores greater than 6, and less than or equal to 18), and Successful solvers (ranges of scores greater than 18). The nominal scales used for APSK level were: No APSK or fragmented ASPK with specific misconceptions (range of scores below or equal to 6), Partial and fragmented APSK (ranges of scores greater than 6 or less than or equal to 18), And active and well-integrated APSK (ranges of scores greater than 18).

3.4 Procedure of Data Collection and Analysis

The results derived from the analysis of quantitative and qualitative data. The qualitative data collected through interview on an individual basis and discussion on a group basis. Moreover, I also made informal talk with instructors and students, and informal observations from

expressions written by students on walls of chemistry department that reflect their perceived beliefs towards chemistry.

The quantitative data collected through self- efficacy scale and chemistry tasks on an individual basis from each of 39 participants. In the first round, distributing self- efficacy scales and collected data about self- efficacy beliefs. On the second round, using the chemistry task data was collected about ASPK and PBS. In addition to the instructions provided in print form, verbal instructions were given to as how to work on each problem).

The data gathered from both self- efficacy scales and chemistry tasks were scored so as to make them convenient for statistical treatment. The tasks were subjected to task analysis, so that numerical data produced. For scoring the data obtained from chemistry tasks about APSK and PBS, scoring criteria developed from the literature was used,(Robert,et.al,1982:238). Data obtained on the variables were summarized using descriptive statistics: mean, median, and standard deviations. Inferential statistic: two - sample independent t- test, one- way ANOVA (F- test) were made to see if there were a statistical significance difference observed among the four groups of the subjects of the study on the variables Self- efficacy beliefs, APSK, and PBS.

CHAPTER-FOUR

4. Data Presentation and Analysis

This chapter presents the results of this study. First, it describes the samples' demographics and then it details the survey responses. The results of this study organized in two forms quantitative and qualitative. The quantitative aspects of the data of this study used descriptive (such as mean, median, and standard deviations), and inferential (such as two- sample independent t-test, Tukey-test one- way ANOVA) statistical analysis.

4.1 Quantitative Components of the Study

The quantitative aspect of problem solving variables namely: level of perceived self- efficacy, easily accessible and problem specific knowledge structure (APSK), and performance (problem solving behavior observed) on chemistry tasks were treated using descriptive and inferential statistics. The descriptive part of the study summarizes the data observed on the variables by using mean, median and standard deviations. The inferential part of statistical analysis was applied to see whether or not significant statistical differences were observed in relation to student's origin (freshman origin, preparatory origin), and the year level. The inferential statistical tools used for this purpose were two-sample independent t-test, and analysis of variance, i.e. Tukey test and one- way ANOVA

4.1.1 Statistical Description and Analysis of Data

Thirty-nine chemistry student teachers (CSTs) were asked to take part in the study. All of them willingly participated in the study. Out of the 39 subjects six students were participated in group discussion and interview. The subjects include 36 males and 3 females. 25 of the samples were third year (11 preparatory origin, 14 freshman origin), and the rest 14 were fourth year CSTs. The demographic descriptions of the samples are summarized in table below.

Table 1. Description of the Sample (N= 39)

Sample characteristics		Frequency (N)	Percent (%)
Gender	a. Female	3	7.70%
	b. Male	36	92.30%
Year level and origin	a. Third year fresh man origin	14	35.90
	b. Third year preparatory origin	11	28.20
	c. Fourth year	14	35.90
Tasks are from chemistry topics we have already learnt	a. Yes	36	92.30
	b. No	3	7.70

As it can be seen from the table, 3 of the 39 students replied, as they did not learn the topics. This implies that the knowledge component of problem solving was suffered in some group of students.

4.1.1.1 Problem Solving

Chemistry task were designed from different area (contents) of general chemistry.(see Appendix A). The tasks were chemistry problems that could elicit problem-solving behavior of students within respective areas of chemistry. Each of the problems was practical in the sense that one could experience in his/her daily life. Each of the problems was open- ended which could subject to content analysis to produce numerical data at the interval scale of measurement. Therefore, task analysis was made on these tasks

As it is discussed in the methodology section, scoring was made using scoring criteria drawn from literatures such as Sugrue, (1994); Robert et. al, (1982). Scores greater than three were classified as score of successful solvers, Scores greater than one were classified as moderate solvers, and scores less than or equal to one were classified as score for poor solvers. . Means and standard deviations of each item are summarized in table below.

Table 2 Means and standard deviations of performance scores on each problem

Item	Mean (x)	SD (standard deviation)
1	0.82	1.45
2	2.23	1.54
3	1.97	1.18
4	1.08	1.64
5	2.77	0.96
6	1.31	1.17

As it can be seen from the table, students performed (scored) to every of the items less than scores expected of successful solver

1. What were the levels of problem solving ability of students in some selected and life related problems of chemistry?

Using a scoring model (criteria) derived from literatures; total score to every student was calculated by summing score of each problem. Scores could range from 0 to 24. Scores greater than 18 were classified to show performance of successful problem solvers, scores greater than six were classified to indicate moderately successful problem solver and scores less than or equal to 6 were classified to show performance of poor solvers.

The data that shows the level of CSTs' problem solving behavior is summarized in table below

Table 3. Group frequency distribution for fourth and third year CSTs scores on chemistry problems

Scores	f(N)	Percent	Mean	Mode	Standard deviation
18-24	4	10.26	10.5	10	4.92
12-17	10	25.64			
6-11	19	48.72			
0-5	6	15.38			
Total	39	100			

CI=5

The table depicts that; the mean total, mode, and standard deviation of CSTs' performance scores were 10.5, 10, and 4.92, respectively. This shows that, Dilla College CSTs' problem solving behavior was well below the expected level (18) of successful solvers' performance. A close look at on the data gathered from CSTs about their problem solving behavior on the basis of their level and origin showed some variations (differences). In the forth-coming paragraphs these differences are presented in detail.

Fourth year chemistry student teachers found moderately successful solvers. Their performance scores on some sample chemistry tasks are summarized in table below.

Table 4 Group frequency distributions of fourth year CSTs score on chemistry problems

Scores	f(N)	Percent	Mean	Standard deviation
18-24	3	21.43	12.07	4.05
12-17	2	14.29		
6-11	9	64.29		
0-5	-	-		
Total	14	100		

CI=5

The table depicts that means and standard deviations of the performance scores of fourth year chemistry student teachers were 12.07, and 4.05 respectively. This indicates that they were not successful solvers. When the mean score obtained in table 4 compared with the total mean scores obtained in table3, it seems that problem solving behavior of fourth year CSTs' were better than third year CSTs'. However, this information was not self-sufficient to judge that, problem solving behavior of fourth year CSTs was better than third year CSTs. Therefore, a further analysis was required on the basis of year level and origin.

The performance data obtained form third year CSTs showed, that they had fallen in the category of moderately successful solvers. The data is summarized in table below:

Table 5 Group frequency distributions for third year CSTs score on chemistry problems

Scores	f(N)	Percent	Mean	Standard deviation
18-20	3	12	9.52	5.25
15-17	1	4		
12-14	5	20		
9-11	4	16		
6-8	6	24		
3-5	4	16		
0-2	2	8		
Total	25	100		

CI=3

Table 5 shows that mean total and standard deviation of third year CSTs' performance were 9.52 and 5.25 respectively. However, it shows that within the range of moderately successful solvers, third year CSTs performed below their fourth year counter parts.

On the other hand a close look at on performance score data of third year students with respect to their origin showed a great difference. The data obtained from third year freshman origin showed that they were in the range of moderate successful solvers. The data is summarized in table below.

Table 6 Group frequency distribution for third year freshman origin CSTs, score distribution on chemistry problems.

Scores	F (N)	Percent%	Mean	Standard deviation
18-20	3	21.43	12.78	4.19
15-17	1	7.14		
12-14	5	35.71		
9-11	3	21.43		
6-8	2	14.29		
Total	14	100		

CI=3

The table depicts that mean total score and standard deviation of third year freshmen origin students' performance were 12.78 and 4.19, respectively, which was in the range of moderately successful solvers,. This reflects that problem-solving behavior of freshman origin CSTs' was better than the total mean of third year CSTs. But it did not vividly show the reason that, mean performance difference within third year (preparatory origin and freshman origin) CSTs.

Another look at on the problem solving score obtained from both third year preparatory origin and third year freshman origin CSTs explicitly revealed that, third year preparatory origin CSTs level of performance was lower than third year freshmen origin. The data is summarized in table below.

Table 7 Group frequency distributions for third year preparatory origin CSTs score on chemistry problems.

Scores	f(N)	Percent %	Mean	Standard deviation
9-11	1	9.10	5.36	3.07
6-8	4	36.36		
3-5	4	36.36		
0-2	2	18.18		
Total	11	100		

CI=3

As it is presented in table 7, the mean total and standard deviation of third year preparatory origin CSTs' performance were 5.36, and 3.07, respectively. It means that third year preparatory origin CSTs performed in the expected range (below or equal to 6) of poor problem solvers. Their performances mean was also well below fourth year and third year freshman origin counter parts.

Generally it was found that CSTs were not successful problem solvers. Specifically third year preparatory origin CSTs, were found poor solvers, whereas third year freshman origin and fourth year CSTs were found moderately successful solvers.

4.1.1.2 Self Efficacy

Survey self-rating statements 1 to 15 were likert items reported on 5- pointed scale (1= strongly disagree to 5= strongly Agree). These items measured self- efficacy levels of CSTs, and included statements such as. I am confident I can do well in chemistry, and I don't think I will get a good grade in chemistry. All statements were positively worded except for items 4, 7,9, and 14, which were negatively worded to increase instrument reliability. Liker items produced reliable data at the ordinal scale of measurement. As it had already discussed the research design section, each of the negatively worded items scoring were made by reversing the weights to be strongly agree=1; to strongly disagree=5. For instance a student strongly disagree with the negatively worded items score 5, and 1 for who strongly disagreed.

The means and standard deviations for each items is summarized in table below.

Table 8 Means and Standard Deviations of CSTs rating for each self- efficacy items

Item number	Mean (x)	Standard deviation (SD)
1	4.23	0.93
2	3.80	0.98
3	4.26	0.71
4	4.51	0.84
5	4.33	0.73
6	4.85	0.36
7	3.66	1.16
8	3.31	0.76
9	3.85	0.95
10	3.97	0.80
11	4.03	0.77
12	3.98	1.01
13	4.23	1.02
14	4.38	0.92
15	4.10	0.67

As it can be seen from the table, students agreed or strongly agreed most with positively, worded items; and strongly disagreed or disagreed with negatively worded items.

2. What was the self-efficacy (perceived ability) level of CSTs in solving chemistry Problems?

After reversing the numerical values for negatively worded statements (4, 7, 9 and 14), total self- efficacy score were calculated by summing the scores for all likert items. Scores could range from 15 to 75. Scores greater than 60 were classified as high self- efficacy, scores greater than 30 were categorized as moderate self- efficacy, and scores less than or equal to 30 were classified under low- self - efficacy. The data about self- efficacy beliefs of CSTs is summarized in table below.

Table 9 Grouped frequency distributions of both third and fourth year CSTs scores on self-efficacy scale.

Scores	f(N)	Percent	Mean	Media	Standard deviation
70-74	4	10.26	60.05	60	8.18
65-69	11	28.21			
60-64	5	12.82			
55-59	8	20.51			
50-54	8	20.51			
45-49	1	2.56			
40-44	1	2.56			
35-39	1	2.56			
Total	39	100			

CI=5

As it can be seen from table 9, the mean total and standard deviation of CSTs' self-efficacy belief were 60.05 (just above the moderate self- efficacy level), and 8.18 respectively. The median was 60. This shows that chemistry student teachers had high self-efficacy beliefs. Such a crude presentation of the self-efficacy belief data might provide deceiving information. Therefore, the data on self- efficacy beliefs was analyzed in detail on the basis of students' year level and origin.

The self- report of fourth year CSTs about their self- efficacy belief showed that they were in the range of moderate self- efficacy level. The data about their self- efficacy belief is summarized in table below:

Table.10 Grouped frequency distribution of fourth year CSTs scores on self-efficacy

Scores	f(N)	Percent	Mean	Median	Standard deviation
72-77	1	7.14	59.29	57.5	7.19
66-71	4	28.97			
60-65	-	-			
54-59	6	42.86			
48-53	2	14.23			
42-47	1	7.14			
Total	14	100			

CI=5

The table depicts that the mean, median, and standard deviations were 59.29, 57.5, and 7.19, respectively. It means that fourth year CSTs reported themselves as they were in the range of moderate self- efficacy beliefs, just below high self-efficacy belief range.

On the other hand, the self-report data obtained from third year CSTs revealed that, they were in the range of high self- efficacy beliefs, just above the boundary of moderate self- efficacy belief range. This data is summarized in table below.

Table 11 Grouped frequency distribution of third year CSTs scores on self-efficacy scale

Scores	f(N)	Percent	Mean	Median	Standard deviation
70-74	3	12	60.4	62	8.66
65-69	7	28			
60-64	5	20			
55-59	3	12			
50-54	5	20			
45-49	-	-			
40-44	1	4			
35-39	1	4			
Total	25	100			

CI=5

Table 11 depicts that mean, median, and standard deviation of third year CSTs' self- efficacy belief scores were, 60.48, 62, and 8.66, respectively. It means that third year CSTs had high-perceived ability beliefs and their self-efficacy belief was higher than their fourth year counter parts. However, this did not provide a clear picture whether or not there would be a significant self-efficacy belief difference with reference to students' origin.

Third year freshman origin chemistry student teachers self- report data on self- efficacy beliefs is summarized in table below.

Table 12 Grouped frequency distributions of third year freshman origin CSTs scores on self-efficacy scale

Scores	f(N)	Percent	Mean	Median	Standard deviation
70-74	2	14.29	63.36	65	6.82
65-69	4	28.97			
60-64	4	28.97			
55-59	2	14.29			
50-54	1	7.14			
45-49	1	7.14			
Total	14	100			

CI=5

As it can be read from the table mean, median, and standard deviation of third year freshman origin CSTs found 63.36, 65, and 6.82, respectively. It means that third year freshman origin CSTs had high and better self- efficacy belief than fourth and third year preparatory origin CSTs.

The self- report data of third year preparatory origin chemistry student teachers about their self- efficacy belief is summarized in table below.

Table 13 Grouped frequency distributions of third year preparatory origin CSTs scores on self-efficacy scale

Scores	f(N)	Percent	Mean	Median	Standard deviation
66-71	2	18.19	56.18	58	9.16
60-65	3	21.43			
54-59	1	9.10			
48-53	3	21.43			
42-47	1	9.10			
36-41	1	9.10			
Total	11	100			

CI=5

Table 13 depicts that mean, median, and standard deviation were, 56.18, 58, and 9.16, respectively. This means that third year preparatory origin CSTs reported themselves as they were in the range of moderate self-efficacy belief. When a comparison was made

between the mean and median of third year freshman origin, third year preparatory origin and fourth year CSTs, third year preparatory origin self- efficacy beliefs was found at the bottom.

Generally, it was found that (perceived ability) self- efficacy beliefs held by CSTs were found around the boundary of moderate and high self- efficacy belief ranges. Specifically third year freshman origin CSTs reported themselves as they were in the high self- efficacy range, whereas fourth year and third year preparatory origin CSTs reported themselves as they had self- efficacy belief slightly lower than high self - efficacy belief.

4.1.1.3. Problem Specific and Easily Accessible form of Knowledge Structure (PSK) for Solving Chemistry Problems

Accessible and relevant knowledge of CSTs to solve each of chemistry tasks (problems),(see appendix==) was scored by using scoring criteria (grid),(see appendix ==) on a 4- point scale from no accessible knowledge structure, or knowledge with specific misconception = 0, to well-integrated accessible knowledge structure= 5. The Tasks such as: you are living in rural area where there is no electricity and refrigerator, but you want to supply a coca-cola below the surrounding temperature. .How can you cool this soft drink? Suggest method and explain every of your step(s) were chemistry problems designed with accompanied instructions in such a way that can elicit accessible and relevant knowledge structures of CSTs to solve each of the problems. Scoring of APSK produced a numerical data on an interval scale. The data is summarized in table below.

Table 14. Means and standard deviations of CSTs scores on each problem.

Item	X	SD
1	2.15	1.25
2	2.74	0.98
3	2.64	1.27
4	1.74	1.39
5	3.31	0.82
6	2.63	1.29

As it can be seen from the table CSTs had partial accessible and problem specific knowledge structure but with specific misconceptions for problem 4(, (X= 1.74, SD= 1.39). They also had partial knowledge structure specific to the problems 1(X= 2.15, SD- 1.25), 2 (X= 2.74, SD =

0.98), 3 ($X = 2.64$, $SD = 1.27$), S ($X = 3.31$, $SD = 0.82$), and 6 ($X = 2.36$, $SD = 1.29$). Moreover, students had relatively well-structured and accessible knowledge structure to solve problem 5.

3. What were the Levels of Easily Accessible and Problem Specific form of Knowledge Structure of CSTs?

As it is discussed in the methodology section, after marking to each of the problems, the total mean score of CSTs calculated by summing scores of each problem. The total sum of scores should range from 0 to 24. Scores greater than 18 were classified as well-integrated and accessible knowledge structure, scores greater than 6 were classified as partial and integrated knowledge structure, and scores less than or equal to 6 were categorized as knowledge with misconceptions and fragmented components, or with no accessible and relevant knowledge structure to solve the problems.

The APSK of the would-be chemistry teachers' score ranged from 6 to 23. The APSK data gathered from chemistry student teachers of (both fourth and third) is summarized in table below.

Table 15. Grouped frequency distribution (fourth and third years) scores of CSTs on APSK.

Scores	f(N)	Percent	Mean	Standard deviation
21-23	4	10.26	14.4	3.99
18-20	6	15.38		
15-17	7	17.95		
12-14	12	30.77		
9-11	9	23.08		
6-8	1	2.25		
Total	39	100		

CI=3

As table 15 depicts mean, and standard deviation were, 14.14, and 3.99, respectively. It means that chemistry student teaches did not possess adequate APSK that helps them to successfully solve the problems. However, data collected about knowledge structure of

the three groups (fourth year, third year freshman origin, and third year preparatory origin) CSTs reflected difference in their level of APSK possession.

To begin with, the data collected from fourth year chemistry student teachers is summarized in table below.

Table. 16 Grouped frequency distribution of fourth year CSTs scores on accessible and problem specific knowledge structure

Scores	F (N)	Percent	Mean	Standard deviation
21-23	3	21.43	15.19	4.19
18-20	2	14.29		
15-17	2	14.29		
12-14	6	42.86		
9-11	1	7.14		
Total	14	100		

CI=3

As it can be seen from the table the total mean score and standard deviation of fourth year chemistry student teachers APSK were found 15.19 and 4.19 respectively. When it is considered with reference to the expected level of APSK demanded to solve, they possessed knowledge, which would not enable them to successfully solve chemical problems.

Similarly from an APSK data gathered of third year chemistry student teachers, it was found that their knowledge structure was fallen in the range of moderate APSK level. The APSK data is summarized in table below.

Tables. 17 Grouped frequency distributions of third year CSTs scores on APSK

Scores	f(N)	Percent	Mean	Standard deviation
21-23	1	4	13.68	3.66
18-20	4	16		
15-17	5	20		
12-14	6	24		
9-11	8	32		
6-8	1	4		
Total	25	100		

CI=3



Table 17, depicts that mean, and standard deviation of third year CSTs' APSK were 13.68, and 3.66, respectively. It means that their APSK level was not adequate to enable them to successfully solve chemistry problems. Although fourth and third year chemistry student teachers' APSK level were fallen in one (moderate APSK) range, table 16 and 17, revealed that fourth year students possessed the required knowledge better than their third year counter parts.

On the other hand the data from third year freshman origin chemistry student teachers showed that the APSK of third year freshman origin chemistry student teachers were better than third year preparatory origin and fourth year counter parts.

The data collected from third year freshman origin chemistry student teachers is summarized in table below.

Table 18. Grouped frequency distributions of third year fresh man origin CSTs scores on APSK

Scores	f(N)	Percent	Mean	Standard deviation
21-23	1	7.14	16.12	2.49
18-20	4	28.57		
15-17	5	35.71		
12-14	4	28		
Total	14	100		

CI=3

As it can be seen from table 18, mean and standard deviation of third year freshman origin chemistry student teachers were 16.12, and 2.49, respectively.

The means presented in tables 18, and 16 reveal that third year freshman origin chemistry student teachers' had better APSK than their fourth year counter parts. In the same fashion freshman origin APSK was better than preparatory origin chemistry student teachers.

The APSK data obtained from third year preparatory origin CSTs is summarized in table below.

Table 19. Grouped frequency distribution of third year preparatory origin CSTs scores on APSK

Scores	f(N)	Percent	Mean	Standard deviation
12-14	2	18.18	10.36	2.25
9-11	8	72.73		
6-8	1	9.10		
Total	11	100		

CI=3

The table depicts that means and standard deviations of the data were 10.36, and 2.25, respectively. It means that preparatory origin chemistry student teachers were in the range of moderate APSK level. When this is considered with reference to other groups (third year freshman origin, and fourth year), third year preparatory origin CSTs took the least position.

Generally it was found that the APSK possessed by chemistry student teachers could not be adequate to successfully solve chemistry problems. Specifically with reference to year level and origin, it was found that third year freshman origin chemistry student teachers had better APSK level over third year preparatory origin, and fourth year CSTs, whereas third year preparatory origin CSTs were least in the groups.

4.1.2 Statistical Comparisons of Data on the Basis of Year level and Origin

4. Was there a difference in solving chemical problem on the basis of student teachers origin and year level?

A one- way ANOVA variance analysis was used to examine if there were a significant difference between the means of fourth year, third year freshman origin, and third year preparatory origin chemistry student teachers (CSTs) at $\alpha = 0.05$ level. The mean problem solving score was 12.07 for fourth year, 12.79 for third year freshman origin, and 5.36 for third year preparatory origin CSTs. Their standard deviations were 4.05, 4.19, and 3.07 respectively. At $\alpha = 0.05$ level one-way variance analysis revealed that the population means were significantly different than the test difference (0), ($F= 13.36$, $P= 4.57$). To determine where the spot (s) of the population means

As it can be seen in table 2, even though sample means of fourth year CSTs was higher than the mean of third year CSTs their population means were not significantly different than the test difference (0), ($t= 1.57, P= 0.125$).

5. Was there a Difference in Problem Specific and Easily Accessible form of knowledge Structure based on Students Origin and Year Level?

A one- way ANOVA used to compare the population means of accessible and problem specific knowledge structure (APSK) of fourth year, third year freshman origin, and third year preparatory origin CSTs. The mean was 15.79 for fourth year, 10.45 for third year preparatory origin, and 16.12 for third year freshman origin. Their standard deviations were 4.35, 2.25, and 2.49, respectively. At $\alpha = 0.05$ level, a one- way ANOVA showed that the population are significantly different than the test difference (0), ($F= 11.64, p= 1.26$).

Tukey-test was used determined to the point where means of population parameters significantly different ($\alpha = 0.05$). The means comparison using a Tukey test can be found in table 22, ($\alpha = 0.05$).

Table 22. Third year preparatory origin, third year freshman origin and fourth year CSTs usable and problem specific knowledge means comparison, ($\alpha = 0.05$)

Years and Origins of CSTs	Mean	Difference Between Means	Simultaneous Confidence Intervals		Significant at 0.05
			Lower limit	Upper limit	
4 th year	15.79				
3 rd year preparatory origin	10.45	5.33	2.14	8.52	Yes
3 rd year freshman origin	16.21	-0.429	-3.42	2.56	No
3 rd year preparatory origin	10.45	-	-	-	-
3 rd year freshman origin	16.21	-5.76	-8.95	-2.57	Yes

From the table, means comparison-using Tukey test indicated that a significant difference observed between the population means of fourth year and third year preparatory origin, and population means of third year preparatory origin and third year freshman origin CSTs.

Nevertheless, there was not a significant difference between the means of fourth year and third year freshman origin CSTs irrespective of the differences between their sample means.

An independent two-sample test used to compare the population means of APSK of third and fourth year CSTs. Their sample means and standard deviations were 13.68, 3.74; and 15.79, 4.35, respectively. The result of t - test is presented in table below.

Table 23. Two sample independent t-test and summary statistics for fourth and third year CSTs on APSK.

CSTs year level	N	Mean	SD	SE	t	p
Third year	25	13.68	3.74	0.75	-1.59	0.120
Fourth year	14	15.79	4.35	1.16		

Difference of means: - 2.11

At $\alpha = 0.05$ level, third and fourth year CSTs was not significantly different from the test difference (0), ($t = -1.59$, $P = 0.120$). It means that students' APSK required to solve the problems, was not significantly affected by year level

6. Was there a Significant Difference in CSTs Perceived Self-Efficacy based on Year Level and Origin?

In a similar fashion to what has been done for problem solving scores and APSK, a one- way ANOVA was used to examine if there would be a significant difference among the population means of third year preparatory origin, third year freshman origin, and fourth year CSTs; Perceived self- efficacy. The sample means and standard deviations of third year preparatory origin, third year freshman origin, and fourth year CSTs were 56.18, 9.16; 63.36, 6.82; and 59.5, 7.70. A one - way ANOVA analysis of variance revealed that there was not a significant difference among the population means than the test difference (0), ($F = 2.61$, $P = 0.0873$, $\alpha = 0.05$).

A means comparison was made at $\alpha = 0.05$ to further check this result. A Tukey test showed that there was not any significant difference between any of the population means than the test difference.

Table. 24 Third year preparatory origin, third year freshman origin and fourth year CSTs' means of self-efficacy belief result of Tukey test at $\alpha = 0.05$ level.

CSTs Years level and Origin	Mean	Difference Between Means	Simultaneous Confidence Intervals		Significant at 0.05
			Lower level	Upper level	
4 th year	59.5				
3 rd year preparatory origin	56.18	3.32	-4.41	11.0	No
3 rd year freshman origin	63.36	-3.86	-11.1	3.39	No
3 rd year preparatory origin	56.18	-	-	-	-
3 rd year freshman origin	63.36	-7.18	-14.9	0.552	No

Furthermore two Sample independent t- test was made at $\alpha = 0.05$ level to compare the population means of perceived self- efficacy scores only on the basis of year level. The sample mean was 60.2 for third year and 59.2 for fourth year CSTs. Their standard deviations were 8.57, and 7.70, respectively. The t- test result on the means of perceived self- efficacy of third year and fourth year students summarized in Table below.

Table 25. Two sample independent t- test results on third and fourth year CSTs' perceived self- efficacy.

CSTs Year level	N	Mean	SD	SE	t	P- value
Third year	25	60.2	8.57	1.71	0.253	0.801
Fourth year	14	59.5	7.70	2.06		

Difference of means: 0.7

As it can be read from table 25, although the mean of third year CSTs seems higher than mean of fourth year CSTs, t- Test confirms that, the difference was not reach at significant level at $\alpha = 0.05$ level, ($t= 0.253$, $P = 0.801$). This means that there was not a significant difference in their perceived self-efficacy belief.

4.2 Qualitative Components of the Study

Chemistry is a practical science that all we experience in our every day activities. It is a version of the real (physical) world. Just like other sciences chemistry can be explained at molar and molecular level. Molecular aspects of chemistry are the description of the molar behavior of matter. In a similar fashion a molar level phenomena of behavior (i.e. problem solving behavior) can also be explained at molecular level (i.e. internal derives, forces, motives, beliefs description of the solver), (Feldman, 1966:76). This section is the report on how these internal derive (beliefs) such as perceived attractiveness, (values), difficulty of chemistry, and the implications I drew from it. In the first week of March 2004, I purposely selected six key informants from fourth year, third year preparatory origin, and third year freshman origin chemistry student teachers, two from each. I decided not to take extra to these subjects, because I found redundancy of words of selected subjects to explain their belief towards chemistry. During that time, I had begun to interview and made discussion on student's beliefs and personal views about the attractiveness and difficulty of chemistry. I hoped to use those beliefs and views while analyzing the interview and discussion protocol. On the first Monday of March, I hold an appointment to decide a convenient date of interview and group discussion. They were required to stay 45 minutes to 1 hour with me at student lounge. The discussion was on perceived attractiveness and perceived difficulty of chemistry. The discussion was open-ended. In the first discussion round, I briefed them about the goal of the discussion and to keep me informed about their beliefs and views on chemistry. I asked them to write notes if there would be a different perspectives and beliefs than their personal views so that it could substantiate the data.

4.2.1 Analyzing the Data: Emerging themes

During each interview and discussion session, I took notes on chemistry student teacher reflections and beliefs about chemistry. My and students' notes helped me to analyze the data in two stages. In the first stage, I read the protocols to see whether any common themes were emerging in the entries. After reading the text (protocol) carefully, I was able to glean a number of themes of interest to my study, which can be place in two categories: the first category related to perceived attractiveness of chemistry, and the second related to perceived difficulty of chemistry

4.2.1.1 Perceived Attractiveness of Chemistry

From the themes in the first category, I discovered that students' did not have a positive attitude to chemistry. I would like to discuss the most frequently mentioned themes, presented in table 26.

Table 26 Themes related to perceived attractiveness of chemistry by CSTs

Theme
Chemistry has not practical value
Chemistry education has not motivating component
Grading system in chemistry department is discouraging.

Many chemistry student teachers in this group showed their dislike to chemistry tasks and chemistry in general. They seemed to join the department not by their will. In several entries mentioned that chemistry does not have an intrinsic value to learn.

Here is an entry reflected by Mengesha (these names are pseudonyms), who was fourth year CST. His deep concern for his attitude and interest to learn chemistry to stay up-to-date are especially noteworthy;

I do not like chemistry materials, problem. I do not want to study chemistry. The university enforced me to join chemistry department. Once I joined the department, I have some immediate reasons to pursue. First I want to graduate and then look for other alternatives; I do not want to fail in exams; I want to gain good grades. I was not interested to join this department, because I believed that there would be no chance other than teaching chemistry. If it is for the sake of teaching, why I suffer for four years? It is because any body can teach chemistry by reading textbook. You know that, in our schools there is not laboratory facility. You cannot do anything more than talking like what historians do. If that is so what makes chemistry interesting and different from other social sciences. March.10, 2004/05.

One chemistry student teacher who is Gebre beliefs that there exists a departure between the chemistry what he has learnt in class and he is experiencing outside school. He surprised on the expression that chemistry is a practical science. He also comments on this expression and others his views and beliefs on chemistry:

Chemistry has not a significant practical value to my life and to our society as well, except making chemistry students busy. It might be practical science to those of developed nations like Europe and Americas. Because they have every facility to modify, control and use chemical reactions and chemical substances. But in case of developing nations like Ethiopia, and particularly to my every day life chemistry has not any benefit to obtain we are learning chemical facts, histories, and theories which have not any relation to our daily life, but which have direct impact to the daily life of Europeans and the Americans. March 12, 2004/05.

Gebre, had not believed that, he could benefit from learning chemistry. He highly devalued practical importance and contribution of chemistry to every day life. He also reached in naive generalization that chemistry is to Europeans and Americans, not to Ethiopians.

Within the context of chemistry, department students obtained their satisfaction from acquiring grades. These promoted primarily, a sense of adequacy, achievement and motivation to mindfully study chemistry and work on chemical problems. The main source of satisfaction to students was the grades rewarded for their effort. Two extracts below illustrates how students gain satisfaction from acquiring good grades:

...You know that success is important for motivation .As you become more successful, studying will become more pleasurable and satisfying... I very dislike chemistry department. Working on chemistry assignments and chemistry problems would be interesting if it were graded, just like other departments. I am working day- and -night with chemistry, but I often get grades less than my effort and performance. I usually felt anger in my chemistry grades I do not know the reason. Hiwot, March14, 2004/05.

When one turns to dissatisfaction, some quite striking differences found between students and chemistry teachers. CSTs, once again were concerned about examinations, and grades. They were more inclined to express a sense of injustice to when low grades were awarded. Interestingly there was a third year preparatory origin CSTs, who was Girum bitterly, reflects his views on grading systems in chemistry department:

A low grades almost in all chemistry courses, and I know students of other department, almost who did not work, and yet gained distinctions. I cannot believe that the system is fair. I think the examiners think that, I will mark the first one tough, so they will really work on the next. After all what is new to the department of chemistry? Nothing! As to me, there is nothing motivates you to work hard in this department. Rather there are teachers who make you disinterested in the department. March 19, 2004/05.

In sum, from CSTs' views I learned that chemistry was not appealing to them. CSTs were not interested to teach chemistry in their future career.

4.2.1.2 Perceived Difficulty of Chemistry

In this stage, I found that all students were trying to respond to my comments, and writing substantial entries. All the six were reflective and deep concerned participants regarding to their beliefs about difficulty of chemistry. The most common frequently emerging themes related to CSTs' perceived difficulty of chemistry are summarized in table below.

Table 27. Themes on difficulty of chemistry as perceived by chemistry student teachers

Theme
Chemistry is hard not impossible
Chemistry is one of the most challenging subject

Most of chemistry student teachers believed that chemistry is difficult subject matter. They seemed to explained its difficulty by comparing it with other subjects, students dropout and avoidance tendency to join chemistry department. In several entries they mentioned that, chemistry is a challenging subject.

Here is an entry as perceived by Maaza.

Chemistry is one of the most challenging subjects. Many first year chemistry student teachers want to leave the department and join another department. Failure in chemistry has little to do with how bright students are. It has to do with the fact that chemistry is hard. It takes time to understand chemistry, and students who have not right chemistry background can get in trouble. Many students want to withdraw and leave the department. The situation is high for female students. For instance, last year there were about fifteen female students, but only three of them promoted to third year. Some of the rest students readmitted and some dismissed for good. March 7, 2004/05.

In addition, other students believed that, students from freshman origin and students from preparatory origin had different chemistry background knowledge. They reflected the impact of student's origin to exist in the department. Girum underlined the fact that freshman origin had better chemical background knowledge than preparatory origin CSTs.

His critics of the merging of preparatory and freshman origin students were:

Freshman origin students arrive in the campus early than preparatory origin students. Therefore, they had better opportunity to adapt the university atmosphere. They can learn better by university instructors than latecomer's students (preparatory origins). Freshman origin students had better chemistry background knowledge for subsequent learning than preparatory origin students. Although we had learnt general chemistry and introductory courses of other subjects in schools, the situation was very different and cannot equated to introductory courses offered by university instructors. The pace of instructors is fast and students from preparatory origin often fail behind the classroom situation. Freshman courses offered in universities can fill those gaps and brings students up to the expected level of their department courses. March 20,2004/05.

I come to understand that it is important to have not only good instruction and curriculum organization, but also a good support structure for the transition as students navigate changes in their schooling. It is also important for students to come to learn general chemistry courses in universities than in schools. In relation to this idea Maaza responded that:

One of my greatest challenges has been adjusting with few female students and male chemistry students. It was sometimes isolating, in fact gradually, I feel, and it made me stronger to see that I could make it. I developed more confidence in my abilities over the courses of my education, since I joined this department. March 10,2004/05.

To sum up, considering the themes that emerged in this study, I saw that students teachers desired to study and work on chemistry problems were closely related to practical value, and grading systems of the department, and fates of the future career of the graduates of chemistry department. Seeing that these are essential made me aware of a particular missing component from our chemical education system. I learned from this study that undergraduate chemistry student teachers lack appropriate motivation, reward to their work, and sensitization to the value and practical importance of chemistry. They also believed that, it is difficult to successfully understand and solve chemical problems within the available time limit and context of Ethiopia's chemical education system.

CHAPTER - FIVE

5. Discussions

This chapter presents the discussion of the results of the study. The discussion of the study organized into three sections to make life easy for both the writer and readers. The first part of this section discusses on CSTs perceived attractiveness and difficulty beliefs of chemistry task. The second and third part of this section focuses on perceived self- efficacy beliefs and as accessible and problem specific knowledge structure and problems solving behavior of CSTs.

5.1. Perceived Attractiveness and Difficulty of Chemistry Tasks

There are some negative aspects of this finding. Students were able to state specific aspects of their perception on the usefulness (attractiveness) and difficulty level of chemistry. They attributed the source of their perception to the grading systems practical values of chemistry to their every day life, enforcement to join the department, and difficulty of chemistry compared to other subjects, which demands extra time and effort with no special benefit. This set of beliefs about chemistry tasks appeared to negatively influence CSTs in their own problem solving ability and chemistry learning.

By viewing that chemistry is a difficult subject, and has not practical importance, it limited not only their problem solving ability, but also their creativity and engagement in solving chemical problems. If CSTs internalized that chemistry could be solved how long it take, and belief that solving problems had practical value to life. It would say that the initial introduction to problem solving was through their positive beliefs of chemistry tasks, and then it would make sense to students persistently engage in problem solving process.

Students should be encouraged to explore some problems as extended projects that can be worked on for hours, days or longer, (Higgins, 1993:11). However, chemistry student teachers under investigation lack quality of persistent engagement, and heard when they were complaining working with chemistry takes time.

Authors such as, Salomon and Leigh in Sugrue (1994:12); Doyle (1983, 1985) in Ames (1992:273), and Higgins (1993:12) remark that one's perception of the difficulty of task, the usefulness or relevance of task are some essential aspects of problem solving. Solomon and

Leigh in Sugrue, (1994:12) note that, the depth of processing, mindfulness, and the use of cognitive capacity, collectively called as the amount of invested mental effort to any task, or problem, or material depend on the perceived demands of task relative to their perceived ability in response to the task demand (difficulty level). For instance, if a solver perceived that the task is too easy, or too difficult to work, he/she will not engaged in problem solving process. When one considers the task is too easy every body can perform it. It so has not special motivating reward to continue to the next. When the solver as too difficult perceives the task, then every body could failed to perform and hence discourage to continue. Therefore, both successful and unsuccessful problem solvers might skip the task when they perceived, it is too difficult or easy.

Different researchers consider this set of belief systems as a furculum to problem solving. The enduring belief (values) about desirability of some actions are standard for guiding one's actions and thoughts, for influencing the actions and thoughts of others, and for morally judging one self and others, (Liethwood et. al, 1993:372). When conceptualized in this way these belief systems (value) have a pervasive role in problem solving. Values shape one's view of the current and desired goal state and figure centrally in the choice of actions to reduce the perceived gap. The values (belief systems) situated in both working and long-term memory, Hambric and Brandon in (Leithwood et al, 1993: 373-374). Values situated in working memory acts as perceptual screening. When speaking of perceptual screening, it means that decision about perceived difficulty and attractiveness of chemistry made by values situated in the working memory. Hambric and Brandon further elaborate that values in the working memory allows the solver to "see what he wants to see "and" hear what he wants to hear" ,P. 374. In general, the degree to which solvers actively sense, and seek answer to a given question depends on the relative strength of the desire for an answer as compared to other competing desires. Otherwise, having a problem will not necessarily motivate to try to find solutions. Hence, the desire of solving problem highly rests on solvers belief about the value and difficulty of the task. The present study reveals that belief component of problem solving is really suffered from Dilla College CSTs.

Values situated in long-term memory have a direct effect on the solvers thoughts about what actions to take a behavior channeling. Moreover as NCTM documented in Higgins (1993:11) perseverance in solving is important as students need to realize that some problems just take time to solve, and will better prepare them to solve problems they are likely to encounter in their daily

life. Therefore, belief towards solving chemical problems requires substantial investment of time need to be holding by solvers.

Task difficulty beliefs of successful problem solvers are different from these two extremes. Successful problem solvers perceived tasks as challenging that requires reasonable effort within the perceived ability of solver. This belief can motivate students to accomplish the task. Generally, perception of task difficulty level that poorly matched to students perceived abilities and skill levels affect, appropriately tasks and sustained student motivation to engage in cognitively complex tasks to over time (Ames, 1992:273). However, the qualitative parts of this study revealed that this was one of the missing components in Dilla College chemistry education students.

Further more, in connection to this researchers found out that success and failure in achievement has a significant role on student's motivation to engage in solving problems. For instance, Pintrich (2003:672); Ames (1992:264) note that content material and tasks, activities meaningful and interesting, relevant and useful to students, task rewards, and evaluations structures that promote mastery of learning, understanding course and lesson content, effort, progress, and self improvement standards and less reliance on social comparison or norm referenced standards. They further argue that mastery goals increase the amount of time children spend on learning tasks and their persistence in the face of difficulty but the quality of their engagement in learning. On the contrary, the present study pointed out that CSTs believe that chemistry is a challenging subject and does not have a practical value to their live. Active engagement is characterized by the application of effective learning and problem solving strategies, students' use of these strategies in turn depend on a belief that leads to success and failure can be remedied by a change in strategy, (Ames, 1992:264). When it viewed based on the above arguments, evaluation system of Dilla College of chemistry education was not serving as extrinsic incentive to students. It degraded student's motivation to invest their mental effort to work hard in chemistry. Chemistry student teachers believe that, to whatever degree they worked hard, there was not fair grading system. This unfair grading system made chemistry teachers to graduate with low cumulative grade point average (CGPA) compared to other department.

5.2 Easily Accessible and Problem Specific Knowledge Structure (APSK) Versus Problem Solving Performance on Chemistry tasks (PBS)

The results of the variables APSK and problem solving performance (PBS) inventory indicated that there were statistically significant difference between fourth year and third year preparatory origin CSTs, and third year freshman origin and third year preparatory origin CSTs on both of the variables. Their F-values and P-values were: $F=11.64$, $P=1.26$; and $F=13.32$, $P= 4.57$, respectively. Although a significant difference was observed among these three groups of CSTs, this difference was not observed between fourth year and third year, third year freshman origin and fourth year CSTs on these variables (i.e. PBS and PSK). The calculated t- and p- values in the course of comparison between third and fourth year CSTs on the variable PBS were 1.57 and 0.124, respectively where as their t- and p- value on a variable APSK in the same order were -5.99 and 4.18.

The results of the inventory indicated that CSTs' APSK used in solving chemical tasks was not active and well integrated. The APSK inventory gave them a place to be in a moderate level of knowledge structure to be successful in chemical problem solving processes. It also indicated that CSTs were not successful in solving chemistry tasks. Hence, such a problem solving behavior might observed on chemistry tasks because of the fact that they had no active and well-integrated knowledge structure. On top of this their belief systems on chemistry and chemistry tasks, as it has already discussed well in the previous sections might influence their problem solving behavior on the tasks. When students' posses moderate APSK level, lacks appropriate belief on task difficulty, and value or attractiveness of chemistry, problem, solving process can be hampered. In other words, lack of active- and well-integrated knowledge structure, and appropriate belief systems implies some cognitive components of problem solving suffered a lot.

When speaking of knowledge structure, it is to say about procedural and propositional knowledge of chemistry, (Houston, 1986:5). As many literatures document successful problem solvers need to possess those critical cognitive components of problem solving namely; Knowledge structure, and belief systems (perceived self-efficacy level, perceived difficulty of task and perceived value or attractiveness of chemistry) about self and chemistry. For instance, it is improbable to solve problems with out the possession of active and relevant knowledge structure. Authors such as, Taconis, Ferguson-Hessler and Brockkamp (2000:445-447) note knowledge as the basic and unsubstituable components of problem solving. Snow in Sugrue (1994:8) strengthen this idea by

stating that not only lack of knowledge, but also when a person's previously stored cognitive components and knowledge base are inadequate and poorly applied, improvisational assembly and action control devices are weak because they are not geared to specific task at hand and achievement motivation prematurely leads to error occurrence in performance.

It is known that everybody has a bulk of information that he/she has acquired since from birth. However, this infinite set of information may not help us to solve chemical problems, unless it is well chunked and relevant to the task. Good problem solvers use organized information rather than isolated facts, (Sugrue, 1994:4). Different authors in Gabel and Bunce (1994:305) document that, successfully solve problems, information's should be structured in terms of concepts, principles, rules, conditions and procedures.

This study showed that chemistry student teachers (CSTs) of Dilla College of Education lack accessible problem specific chemistry knowledge structure. This condition even gets worse when one considers the case of third year preparatory origin CSTs. It might be due to this reason that this group of students found poor problem solver. Gorodetsk and Hoz (1987) cited in Gabel and Bunce (1994:305) note that both successful and unsuccessful problem solvers used concepts listed in their profiles analysis. However, successful problem solvers made more connections for the two groups measured at high level of the concept profile. Why we say that information needs to be structured and accessible? It is because large knowledge structures, and links between concepts can make them easily accessible where and when they demanded. However, this study revealed that, chemistry student teachers' APSK was not active, misconception free well chunked, effectively and efficiently utilize in solving chemical problems.

Learning involves acquiring knowledge. Chemistry teacher education assumed to teach CSTs, so that they can acquire knowledge. This knowledge is expected to empower CSTs in solving chemical problems. However, Dilla College of chemistry education considered its mission of empowering seems failed.

This might be due to various reasons. For instance, as the study indicated, CSTs had not possess appreciable level of APSK to proceed to the next in the course sequences of the department. This might also made them lack prior knowledge for every of the topic forth coming. As already pointed in the previous section, the other reason for CSTs did not possess APSK and successful PBS might be lack of appropriate motivation, perceived difficulty beliefs, and perceived values

(attractiveness) of chemistry. In relation to this, authors such as Houston (1986:350); Phyc and Andre (1986:175); Goldman (1986:135), Cohen (1991:166) note that problem solving involves thinking components, emotional or motivational components, a feeling of confidence in one's ability to solve the problem. It is also true that one's view of the chemical world is determinants of an individual's problem solving behavior about self, the chemical environment, and about the chemical topic, (Mc Cormick and Pressley 1997: 373).

The knowledge structure of poor problem solvers is deemed to be fragmented, and unconnected, Glasser (1984, 1990, 1992); and Marshal (1980:1993) in Sugrue (1994:8). In this study a part from the rest group of CSTs, third year preparatory origin CSTs were poor problem solvers and their APSK level was statistically significantly below fourth year and third year freshman origin CSTs. As it has been discussed in theoretical section, this might be also due to the fact that other problem solving cognitive components of third year preparatory origin students were below the situation demands. Another reason might be that this group of students also not properly applied their APSK to the problem situation.

5.3 Perceived Ability (Self-efficacy)

There were some positive aspects of this finding with regarding to self-efficacy. The students were able to exhibit high self-efficacy (perceived ability) beliefs on chemistry self-efficacy scales. The descriptive part of this study presents that total mean self-efficacy was 60.50, just above the moderate self-efficacy belief category. Third year freshman origin CSTs' the mean self-efficacy belief score ($X= 63.36$) was the highest of third year preparatory origin ($X= 56.18$), and fourth year self-efficacy belief ($X=59.29$), where as third year preparatory origin CSTs self-efficacy belief was the least. However, this difference was not reach to statistically significant. Although the difference did not research to statistically significant difference, these slight variations about the boundary of moderate and high-self-efficacy categories might be due to some various reasons. For instance from informal talks with teachers and CSTs' problem solving performance on chemistry tasks third year freshman origin CSTs were relatively successful over third year preparatory origin counter parts. This could lead them to develop confidence to work on chemistry tasks. Such confidence of CSTs to solve chemistry problems has a positive contribution to problem solving behavior (ability). Once more from informal talks I had with instructors, I understood that third year freshman origin can perform well and acquire better grades over third year preparatory origin CSTs. This success of performance on exams and

assignments could give bases for this group of CSTs to develop self-confidence. As a result they might develop a belief that they are intelligent students over third year preparatory origin CSTs.

The other reason as presented in the perceived attractiveness section of analysis, subjecting students with two different backgrounds: freshman origin and third year preparatory origin CSTs to the same evaluation, year level, and classroom environment could have its on impact on self-efficacy differences between them. Students of freshman origin have got better chance to learn introductory courses by well-qualified instructors, and experienced with the evaluation systems, teaching-and learning environments of the university level than preparatory origins. Therefore this could also lead freshman origin students develop a better self-efficacy belief. The above argument might work for self-efficacy belief difference observed between fourth year and third year preparatory origin CSTs, too.

Holding strong perceived ability belief not only influences cognitive processing met cognitive strategies, but motivation, and amount of persistent effort investment. The present study gives evidence that chemistry students teacher have just above moderate self-efficacy beliefs to work with chemistry tasks. It has also a significant implication that chemistry student teachers expected to be successful problem solves.

Some authors address the paramount importance of perceived self-efficacy beliefs in the process of problem solving. Others also point how self-efficacy beliefs can be strengthened. For instance, Bandura (1997) in APA (2001: 55) describes the role of self-efficacy in cognitive processing, as "the belief in one's capabilities to organize and execute courses of action required producing given attainment". Bandura explains that self-efficacy belief influence the particular courses of action a person choose to pursue, the amount of effort that will be extend, the perseverance in the face of challenges and failures, resilience, and the ability to cope with the demands associated with the chosen course of action.

With the light of this view, the researcher of this study was expecting that, CSTs would better perform persistently in solving chemical problems and other academic environments. However, this expectation failed to be true. As studies cited in APA (2001: 55), on mathematic problem solving, children with high self-efficacy belief found to persist longer (Bouffard, Bouchard, parent, and Larivee, 1991) and to use more efficient problem solving strategies (Collings, 1982) than low self-efficacy learners. This implicitly tells us that positive self-efficacy beliefs towards chemistry tasks determine the level of engagement in solving chemical problems.

Authors in Ames, (1992: 262) note that, active engagement is characterized by the application of effective learning and problem-solving strategies, and students' use of these strategies is dependent on a belief that effort leads to success and that failure can be remedied by a change in strategy.

According to Bandura (1986) in Soodak and Podell (1998: 89), efficacy beliefs influence the choices people made and the effort they expend in realizing their goals. Self-efficacy beliefs have the mediating effects of cognitive and effective processes and it related to students' confidence in mastering academic subjects, which can in turn predicted grades in schooling.

As different authors in (APA, 2001:55) put forth the idea that students high in academic self-efficacy belief make great use of effective cognitive strategies in learning, managing their time, and learning environment more effectively, integrating, revise, interpreting, and implement a large diverse information's are better monitoring and regulating their effort. Goal setting is one of the first steps to be done in the process of problem solving that comes with formation of problem space. Goal setting provides basis for self-regulation by providing standard for adequate effectiveness of goal relevant effort and strategy to solve problems

Bandura (1993) in Soodak and Podell (1998: 78) argues that goal influences cognitive processes and individual's self-appraisal of his/her ability achieves goals, and his/her selection of goals. To this point some authors remark that students' ability to use self regulatory strategies and knowing when and how to apply them (McCombs, 1984; Pintrich and DeGroot, 1990); low-achieving children may lack knowledge to make of these strategies to the degree that they are unwilling to make commitment to effort utilization (Covington, 1989, 1985). As Bandura (1997) in APA (2001: 56) point's self-efficacy also has its most powerful motivational effects through the process of cognized goals. In connection to this idea Bandura theorizes that:

An individual's behavior is the product, not purely of immediate outcomes (i.e. reinforcements), but of aggregate consequence, the expectation that particular circumstances are necessary for certain outcome to be reached mediates the power of the reinforce.

Therefore, Soodak and Podell (1998: 77) marked self-efficacy beliefs influence three important outcomes. Such as: the tendency to initiate behavior; the degree of effort that will be exerted in executing behavior; and the extent to which the behavior will be sustained when obstacles encountered.

CHAPTER SIX

6. Summary, Conclusion, and, Implications of the Study

6.1 Summary

The purpose of the study was to disclose the level of CSTs components of problem solving ability namely: APSK, PBS, PSE, PDT and to see any observed difference in these variables with reference to students' origin and year level. In order to meet the purpose of the study, the research problem detailed in to basic questions that could be addressed through moderately defined procedures/methods of attack. The basic questions of the study were:

1. What were the levels of problem solving ability of students in some selected and life related problems of chemistry?
2. What was the self-efficacy (perceived ability) level of chemistry student teachers' in solving chemistry Problems?
3. What were the Levels of Easily Accessible and Problem Specific form of Knowledge Structure of chemistry student teacher?
4. What was chemistry student teachers' perceived attractiveness belief towards chemistry?
5. What was chemistry student teachers' perceived difficulty belief towards chemistry?
6. Was there a difference in solving chemical problem on the basis of student teachers origin and year level?
7. Was there a Difference in Problem Specific and Easily Accessible form of knowledge Structure on the basis of Students Origin and Year Level?
8. Was there a Difference in chemistry student teachers' Perceived Self-Efficacy on the Basis of Year Level and Origin?

In order to address each of these questions, I used to group these basic questions in to two on the basis of their nature to device appropriate methods of attack. Variables (questions) related to behavior (performance), namely: problems solving performance, knowledge structure, and self-efficacy (perceived ability) beliefs attacked using quantitative researching methods. Problems related to intent, motives, and beliefs, namely: perceived attractiveness and perceived difficulty beliefs towards chemistry investigated through qualitative means of attacking problems.

The quantitative aspects of data gathered using chemistry tasks, and self-efficacy scales. These quantitative data subjected to descriptive and inferential statistical treatments. Descriptive statistical instruments such as mean, median and standard deviation were used to describe and then to point out typical behavior of the subjects on these variables. Furthermore, it subjected to inferential statistical treatment. So as to check whether there was a significant difference observed or not among the parameters APSK, problem solving performance, and self-efficacy beliefs with reference to year level and origin, a t-test and one-way ANOVA was applied.

The descriptive part of this study revealed that all CSTs ranged in moderate level for the variable APSK. The problem solving behavior (performance) of third year freshman origin and fourth year CSTs on the tasks were at a moderate level whereas third year preparatory origin performed poorly. For self-efficacy belief except third year freshman origin (reported high self-efficacy belief), third year preparatory origin and fourth year students reported themselves in moderate level of self-efficacy belief ranges.

From the results of inferential statistical analysis at $\alpha = 0.05$ significant difference was observed between third year preparatory origin and third year freshman origin and third year preparatory origin and fourth year CSTs ($F=11.6, P=1.26; F=13.36, P=4.57$) respectively for the variables APSK and PBS' respectively. However, there was not a significant difference between the means of these groups on self- efficacy belief scales ($F=2.61, P=0.0873$).

Qualitative aspects of data collected through interview, discussion, informal talks and observations. The data chunked to reduce in to few themes that could reflect CSTs beliefs about perceived attractiveness and difficulty of chemistry. From these qualitative data, I understand that CSTs believed that chemistry is a difficult subject with little or no practical value to every day life

6.2 Conclusions

Based on the findings of the study the following conclusions have drawn:

1. The focus of Ethiopian education in particular TESO program was producing successful solvers, (TESO, 2003:38). Chemistry education is one of these programs loaded with this mission.

In connection to this, several literatures characterize the features of successful problem solvers. That is possession of an integrated, easily accessible, and problem specific knowledge structure (schemata) is one of the characterizing features. Successful solver can reduce the perceived gap exist between the initial and goal state by applying this cognitive component of problem solving. They can creatively develop a new principle from existing knowledge structures and use effectively and efficiently to solve the problem facing them. They can use various appropriate attacking methods to resolve the problem.

Successful solvers from a correct mental model (problem space) and look at the difference between the existing and desired states, and the barriers (constraints) not to achieve the desired state of problem situation.

However, as it is already presented in table 3 and 15 the finding of this study showed that CSTs lack active and well-integrated APSK, and successful problem solving behavior was not observed. It seemed that the mission of the institution in producing successful CST solvers failed to achieve. For instance, as showed in table 20 that, third year preparatory origin CSTs, who went through the new program were poor problem solvers, while CSTs of the old curriculum (freshman origin) found moderately successful problem solvers.

2. Another essential characterizing feature of successful solvers was self-efficacy (perceived ability) belief held by CSTs.

Self-efficacy belief of solver has a great influence on his/her plan, selection of operators, and executions of the selected operators. When he/she belief that could be successful (perform will) on chemistry task, he/she would persistently engaged in the task to achieve his/her level of intended success, otherwise the converse might be happened. Self-efficacy mainly depends on

students' success of achievement (mastery goals) on exams he/she has experienced on his subject area of interest.

From the finding such as in table 24, it can be concluded that third year preparatory origin and fourth year CSTs self-efficacy belief is just below the level of high self-efficacy beliefs. Although, third year freshman origin CSTs showed relatively high self-efficacy belief, it was not statistically significant. The reason that third year freshman origin CSTs have high self-efficacy belief might be the fact that they were successful in chemistry exams, and grades over preparatory origin student teachers. There was also a discrepancy between CSTs' actual problem solving behavior and their perceived ability. This discrepancy was high particularly for third year preparatory origin CSTs.

3. As different authors point out that, there exists a problem only if the solvers beliefs that, the problem has reasonable difficulty and motivating factor to work on it. A problem should motivate and invite the solver persistently engage in the solving process. It should be attractive, relevant, rewarding and reasonable difficulty, so that solvers could be exploited. On this turn, the solver should value and perceive that, the task is reasonably difficult within a range of his/her perceived ability.

However, the study revealed that CSTs hold a belief that chemistry is a difficult subject that demands extra time and effort to understand. In other words, it is difficult to conceptualize chemistry in the normal time setting. Similarly, they belief that chemistry what they learnt in school is not related to their life. They did not see any relation between the classroom chemistry and the chemical environment outside class.

6.3 Implications of the Study

This study could imply the following points:

The chemical education system guided by the new education and training policy, and TESO of Ethiopia, in particular Dilla College of chemistry education was failed to produce successful CST chemical problem solvers.

Especially the condition observed in the case of preparatory origin CSTs indicates that there should be some missing elements in the curriculum system, the classroom environment, instructor's professional quality, or the learning environment- that impedes not achieving the mission set by ministry of education.

This might provide clue to researchers to focus that why chemical education systems in higher institutions are seem questioned.

Inadequate capacity of chemistry teacher graduates of these institutions might impede to achieve the mission loaded to schools. This might also affect the quality of chemistry in general and chemistry education in particular. Therefore, in the effort of improving the outcome of the institution, the researcher called for the faculty, chemistry education department and other concerned bodies to cooperatively work on the process of training quality chemistry teachers.

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APPENDIX-A

FORM, SUB SCALES AND TASKS TO BE COMPLETED BY PARTICIPANTS (DILLA COLLEGE CHEMISTRY STUDENT)

I. General Instructions

Introduction to respondents

I am interested in your honest reactions to a series of questions about related to chemistry. There is a different question on each page. Please read the instructions at the top of the page carefully and answer all items. As you complete a page simply go on to the next page. Do not go back and change your responses you have finished. All your response will not be considered in your grades, but it will be highly valuable to the study. Thank you for your participation in this study.

Personal Profile

1. Age _____
2. Sex _____
3. Year level in University _____
4. Year entered in Dilla College _____
5. Please attempt all the problems set forth. When you are solving the problems, please write all related to the solution that comes to your mind on the paper provided.

II. CHEMISTRY PERCEIVED SELF-EFFICACY BELIEF TEST

Instruction: Your answers will remain strictly conditional and WILL NOT affect your grade. For each of the following items below, CIRCLE the one number that best describes your feeling.

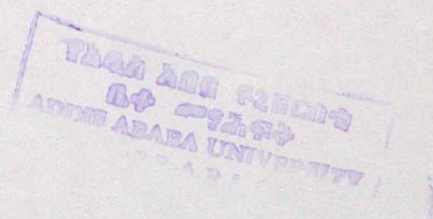
1. Strongly disagree (SD)
2. Disagree(D)
3. Neutral (N)
4. Agree (A)
5. Strongly agree (SA)

SR NO	Items	SD	D	N	A	SA
1	I am confident I have the ability to learn the material taught in chemistry	1	2	3	4	5
2	I think I will do as well or better than other students in chemistry	1	2	3	4	5
3	I do not think I will be successful in chemistry	1	2	3	4	5
4	I do not think I will be successful in chemistry	1	2	3	4	5
5	I am confident that I can understand the topics taught in chemistry	1	2	3	4	5
6	I believe that if I exert enough effort I will be successful in chemistry	1	2	3	4	5
7	I feel like I do not know a lot about chemistry compared to other students	1	2	3	4	5
8	Compared with other students in my class I think I have a good chemistry study skill.	1	2	3	4	5
9	Compared with other students in chemistry, I do not feel like I am a good student	1	2	3	4	5
10	I am confident I can do well on the lecture	1	2	3	4	5
11	I am confident I can do well on laboratory practical in chemistry	1	2	3	4	5
12	I am confident I can do well in the laboratory work for chemistry	1	2	3	4	5
13	I think I 'll get a good grade in chemistry	1	2	3	4	5
14	I do not think I 'll get a good grade in chemistry	1	2	3	4	5
15	I am confident that I could explain something learned in chemistry class to another person	1	2	3	4	5
		1	2	3	4	5

III. TASK FROM SOME SELECTED CONTENT AREAS OF CHEMISTRY

Instruction:- There are six chemistry problems designed for you. Please attempt each of the problems. The problems (s) might come across you in your every day life when you are solving each of the problems, please do not use separate paper provided for every of your works with respects to every problems. Before you are going to engage in solving the problems please restate each as what it asks in your own words. Your answers will remain strictly confidential and WILL NOT affect your grade.

1. If a reaction that is exothermic can be controlled catalytically, then by regulating the amount of catalyst available perhaps the rate of release of heat from the reaction can be regulated. How? Justify your answer.
2. You are living in rural area where there is no electricity and refrigerator, but you want to supply a Coca-Cola below the surrounding temperature. How can you cool this soft drink? Suggest method and explain every of your step(s).
3. A rain water in Norway and Germany of Western nations taste sour. What do you think the reason? What possible solution that does not harm their economy would you suggest to reduce this problem.
4. The salinity of a solution is defined as the grams of total salts per kilogram of solution. An agricultural chemist uses a solution whose salinity is 36.0g/kg to test the irrigating farmland with high salinity river water. The two solutes are NaCl and $MgSO_4$, and there are twice as many moles of NaCl as $MgSO_4$. What masses of NaCl and $MgSO_4$ are contained in 1.00 kg of the solution?
5. Suppose you are in need AgCl, but only are crystals of $AgNO_3$ and NaCl, are available in your chemical store. How would you obtain AgCl? Propose your ways/means with detail explanations.
6. Suppose, while you are cooking food with high nutritive value which can only boil at high temperature, water would bubbled and finished up before that food is well cooked. What could be the possible reason? Propose your possible ways/ procedures to cook it sufficiently?



APPENDIX B

Interview and Discussion Guides

The questions used to guide interview and discussion made about beliefs related to chemistry.

I. Questions to warm up interview and discussion

1. When did you join to chemistry department?
2. What is your year level?
3. Are you freshman origin or preparatory origin?
4. Please describe how do you find chemistry department once you joined it?

II Questions to guide interview regarding to perceive difficulty beliefs of Chemistry

5. What changes of views have occurred in the following when you joined chemistry department?
 - A. Kinds and difficulty of chemistry topics, and chemistry as a course
 - B. Kinds and difficulty of chemistry problems
6. Do you believe that you will fail chemistry no matter how hard you try? Explain your answer.
7. Do you fear that you will not have time to learn all the required information in your chemistry course? Explain your answer.
8. Do you believe that you have to be extraordinary smart to learn chemistry? Explain your answer
9. Do you believe that chemists think different from other human beings? Explain your answer
10. Do you believe that students' origin has an impact on the teaching-learning process of chemistry? Justify your answer.
11. Is your introductory course taken in preparatory schools adequate to learn courses offered by the department? Describe your answer.
12. Is your background in chemistry similar to that of freshman origin students? Explain your answer, (only for preparatory origin students)
13. Do you know how to study efficiently to make the best use of your study time?
14. Do you know how to master a concept?

III Questions to guide Interviews regarding to perceived attractiveness of chemistry

1. Usually how is your mood when working with chemistry tasks?
2. Were there things you especially liked about chemistry classes? If yes, why did you like those classes?
3. Were there things you especially dislike in chemistry classes? If yes, why did you dislike those classes?
4. Do you like to work with chemistry problems? Why did you like working with chemistry problems?
5. Do not you like to work with chemistry problems? Why do not you like to work with chemistry problems?
6. How often would you interested in chemistry classes?
7. Does studying chemistry give you a headache? If yes, why do you feel a headache to study chemistry?
8. Do you put off working on your chemistry problems? If yes, explain the reason why you do not motivate to work
9. How would you describe the merit of chemistry to one of your best friend?

IV Questions used to guide the discussion made about perceived difficulty and attractiveness beliefs.

1. Do you think that students' can discover chemistry on their own, or do all chemistry lessons have to be shown to them? Please explain it.
2. In what way, if any, is the chemistry you have studied useful?
3. How do you explain the contribution of chemistry to the society?
4. How do you comment the role of chemistry education in real life practices?
5. What is your expectation of the benefit from chemistry?
6. Do you feel that your learning of chemistry in classrooms and laboratory sessions helped to solve life problems?

APPENDIX- C

Scoring Models

I. Scoring criteria (model) for problem solving behavior (Performance) exhibited on chemistry tasks

Weight	Criteria	Attributes
0 =	No correct solution:	Blank, In do not know, in correct understanding of the problem with in correct solution; Determine the goal state constraints to reach to the solution.
1 =	partially correct solution with some mistakes :	correct understanding (mental of the problem with incorrect solutions.
2 =	partially correct solutions:	Correct understanding of the problem and solving some components of the problem such as using logical methods, appropriately applying the concepts and principles.
3 =	correctly solving the problem but with in complete correct solution:	correctly understanding the problem using logical methods of attacking, applying the relevant knowledge structure, algor, then to the problem but not completed.
4 =	successfully solving the problem:	Correct understanding of the problem using correct and logical method of attack, Using relevant knowledge structure algorithms to solve the problem, giving the ultimate solution of the problem

II. Scoring criteria (model) for APSK exhibited an chemistry tasks.

Weight	Criteria	Attributes
0 =	No accessible and problem related knowledge structure to solve it:	<ul style="list-style-type: none"> - Blank - I do not know - In correct knowledge: wrong understanding of concepts and principles - I do not understand
1 =	Partially accessible problem related knowledge structure, but with some misconceptions	<ul style="list-style-type: none"> - knowledge of general problem (task) related concepts, and principles but with some misconceptions - Lacks problem specific concepts and principles to directly attack the problem
2 =	Partial accessible knowledge structure related to the task	<ul style="list-style-type: none"> - General knowledge of concepts, and principles, but no link is made knowledge with the problems. - The concepts and principles were fragmented lacks problem specific concepts, and principles to directly attack problems.
3 =	Accessible knowledge structure but with some deficit to successfully solve the problem	<ul style="list-style-type: none"> - knowledge of general concepts are principles related to the task - links made between concepts, and principles with the problem. - Knowledge of some problem specific concepts and principles to directly attack the problem but with some fragmentations
4 =	Active and well- integrated knowledge structure to successfully solve the problem	<ul style="list-style-type: none"> - general and specific concepts directly related to the problem - Integration of concepts and principles with concepts involved in the problem - Knowledge of correct algorithms correctly solves the problem.