

WHAT MAKES CHEMISTRY DIFFICULT?

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ABSTRACT

According to many students, introductory chemistry is difficult. We are investigating what makes students believe Chemistry is difficult and what can be done to overcome these difficulties. Our investigation includes an initial Free-response survey given to approximately 100 students in an introductory chemistry course and a second survey, which was given to approximately 93 students in another semester, distilled from the responses to the first survey. Also Department members and technical assistants (TAs) for chemistry courses were asked to complete the second survey. Our findings show that the perceptions of the students and department members are different in terms of difficulties which students have in a chemistry course. The perceptions of teachers and TAs are mostly the same. Both students and department members agree that student-related factors, such as scientific language literacy have the most influence on students' successes in chemistry. [AJCE 4(2), Special Issue, May 2014]

INTRODUCTION

Many students from secondary schools to universities in many countries struggle to learn chemistry and many do not succeed [1]. Research has shown that many students do not correctly understand fundamental chemistry concepts [2]. And also many of the scientifically incorrect ideas held by the students go unchanged from the early years of the schooling to university and sometimes beyond [3]. By not fully and appropriately understanding fundamental concepts, many students have trouble understanding the more advanced concepts that build upon these fundamental concepts [4].

Many high school and university students experience difficulties with fundamental ideas in chemistry [5]. Despite the importance of the foundation of chemistry, most students emerge from introductory courses with very limited understanding of the subject [6]. Chemistry had been regarded as a difficult subject for students by many researchers, teachers and science educators [7-8] because of the abstract nature of many chemical concepts, teaching styles applied in class, lack of teaching aids and the difficulty of the language of chemistry. All these cause students, from primary level to the university, to develop poor understanding and misunderstandings. Misunderstanding of concepts in chemistry has attracted attention over the last three decades [9-13]. A number of studies have been conducted on different topics in chemistry [14-15], and in other areas such as biology, physics, or in general, in science [16-19].

An examination of studies on students' learning of basic physical and chemical concepts clearly demonstrates that most of the basic concepts were poorly learned [20-21]. More research needs to be done to identify what sort of difficulties students face in the learning of physical and chemical concepts. Learning difficulties are important for both teaching and learning. Both science educators and cognitive researchers agree that efforts to understand and improve science

education should be focused on fundamentally important knowledge domains [22]. Hence, it has been concluded that it is worthwhile to conduct a research study about chemistry undergraduates' learning difficulties.

PURPOSE OF THE STUDY AND RESEARCH QUESTIONS

The purpose of this study was to identify and classify the chemistry undergraduate learning difficulties and to determine the reason why students find these topics/concepts difficult. More specifically, the following research objectives were sequentially investigated:

- a. Identify and classify the learning difficulties experienced by chemistry undergraduate introductory students in Ethiopia.
- b. Determine the reasons why students, instructors and laboratory technicians find principles identified in phase I of this investigation difficult to learn.

The specific question that guides this study is “What makes chemistry difficult in selected universities in Ethiopia and what are the factors that make these difficulties?” In addressing this question, the research considered the following sub-questions:

1. What are the learning difficulties in introductory chemistry undergraduate students in Ethiopia?
2. Where do these learning difficulties arise? What are their sources?

METHODOLOGY

Research Context

The introductory chemistry course for chemistry majors is offered in the fall, first semester, and summer semesters of the Dire Dawa and Haromaya universities in Ethiopia. The

number of students varies each semester. The course includes three 50-minute lectures, one two-hour recitation in which students work on conceptual and numerical problems, and one two-hour lab every other week consisting of concept pretests on the web, hand-written homework, reading quizzes on the web, and discussion quizzes in the recitations sessions. Teaching Assistants (TAs) are available in a help center during weekdays and weekends. Old exams and lecture notes can be obtained from the course website.

Data Collection

The Initial Survey

We administered a one-page free-response survey to approximately 100 students in reaction sessions near the end of the fall semester. The students were asked to write five responses to each of the two questions: (i) what makes chemistry difficult? And (ii) what can be done to overcome these difficulties?

After examining all students' responses, we separated the most common replies into three categories: (i) factors that were environmental related, (ii) factors that were course-related, and (iii) factors inherent to students, and (iv) factors that are staff-related.

The Second Survey

The second survey listed the 10 most popular items in each of the four categories noted above. We asked about 100 students in first semester as well as 12 chemistry staff members with experience teaching the course, and three TAs of the course to choose the five most important items in each of the three categories. In addition we asked which of the categories has or should have the most influence on success in a chemistry course. Of the 100 students surveyed, 93

replied. Six of the 12 staff members replied and 3 teaching assistants replied. Responses of each group are listed expressed in diagrammatic representation as a result of this study.

RESULTS

There were several areas which staff members and students, and TAs and students agreed. Also there were differences in some areas. We categorized the perception of instructors, students and technical Assistance with the following for perceptions and discussed each area separately:

- *Learning environment related*
- *Course related,*
- *Student related*
- *Staff related*

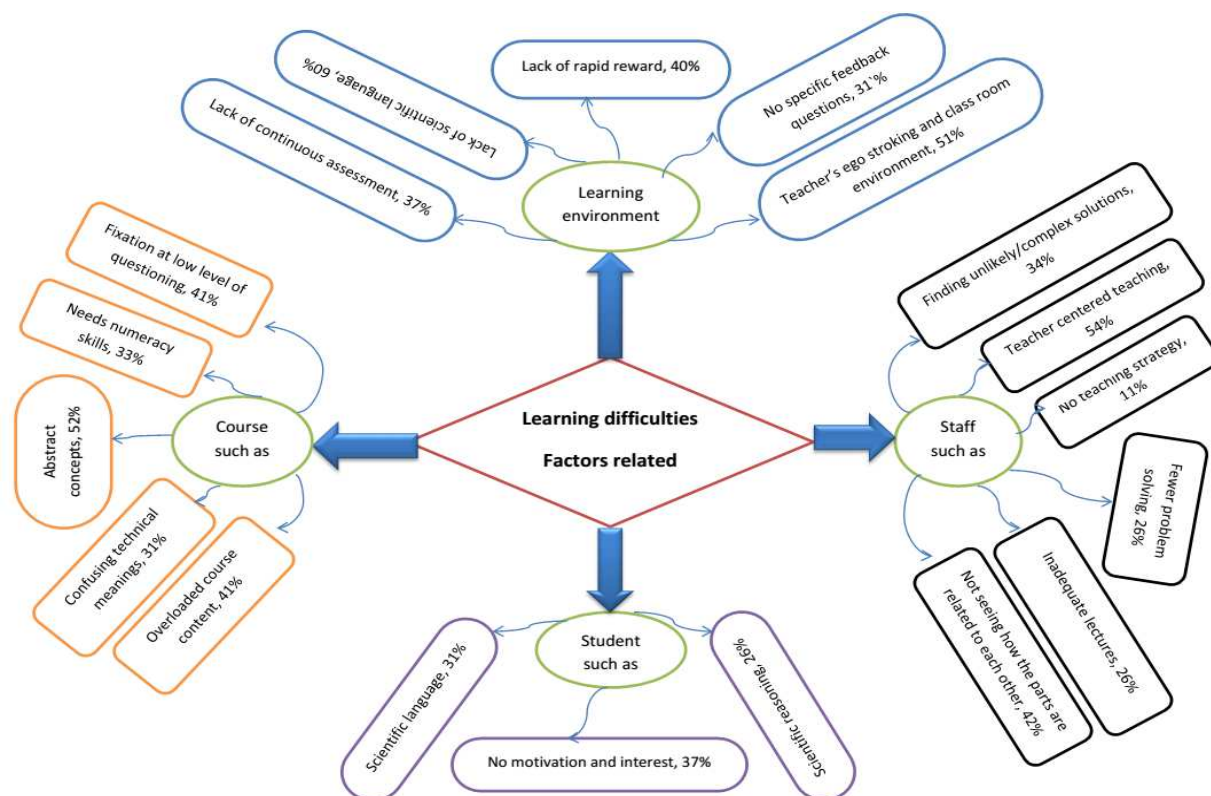


Figure 1. students perception of learning difficulties in chemistry

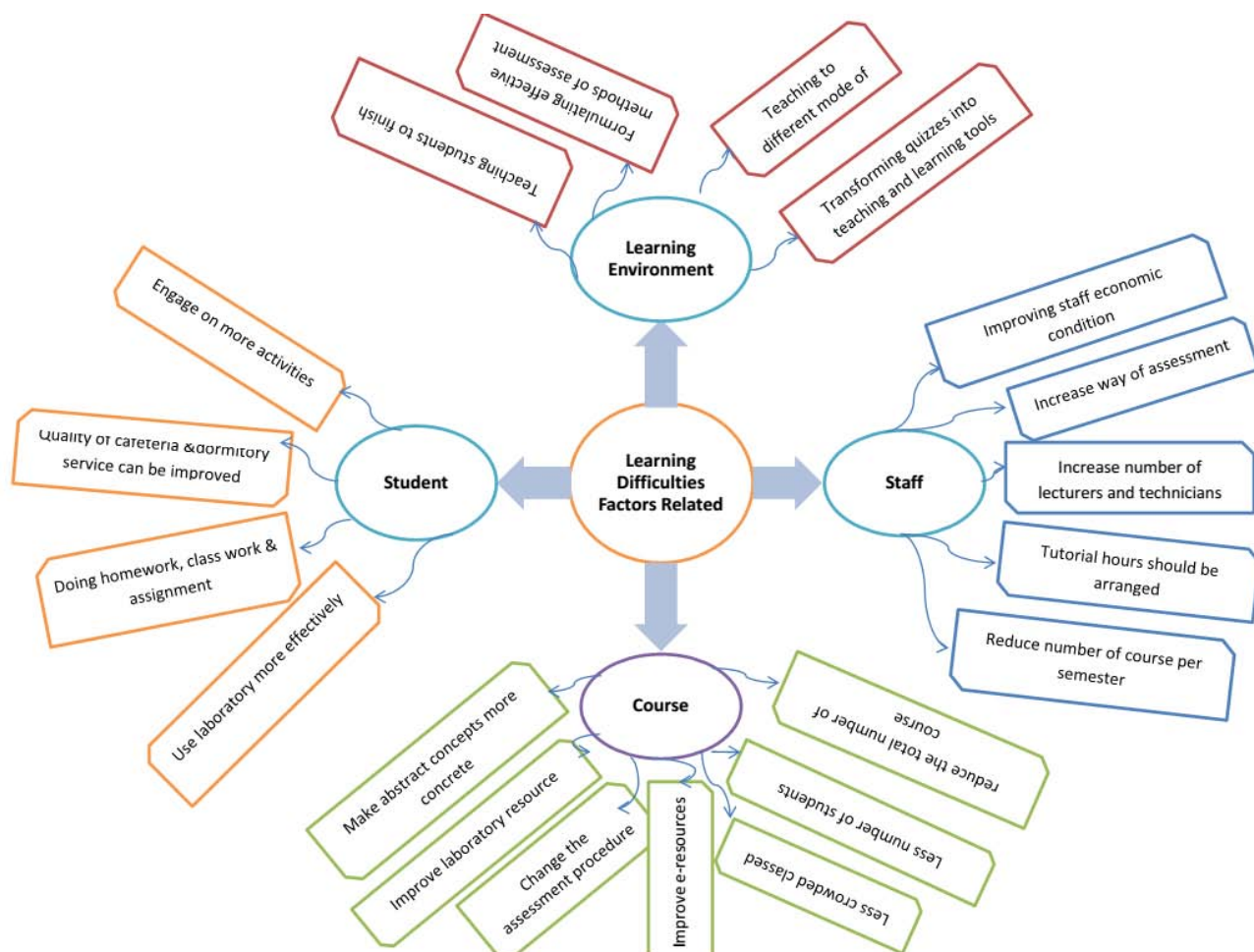


Figure 2.lecturers and TA perception of learning difficulties in chemistry

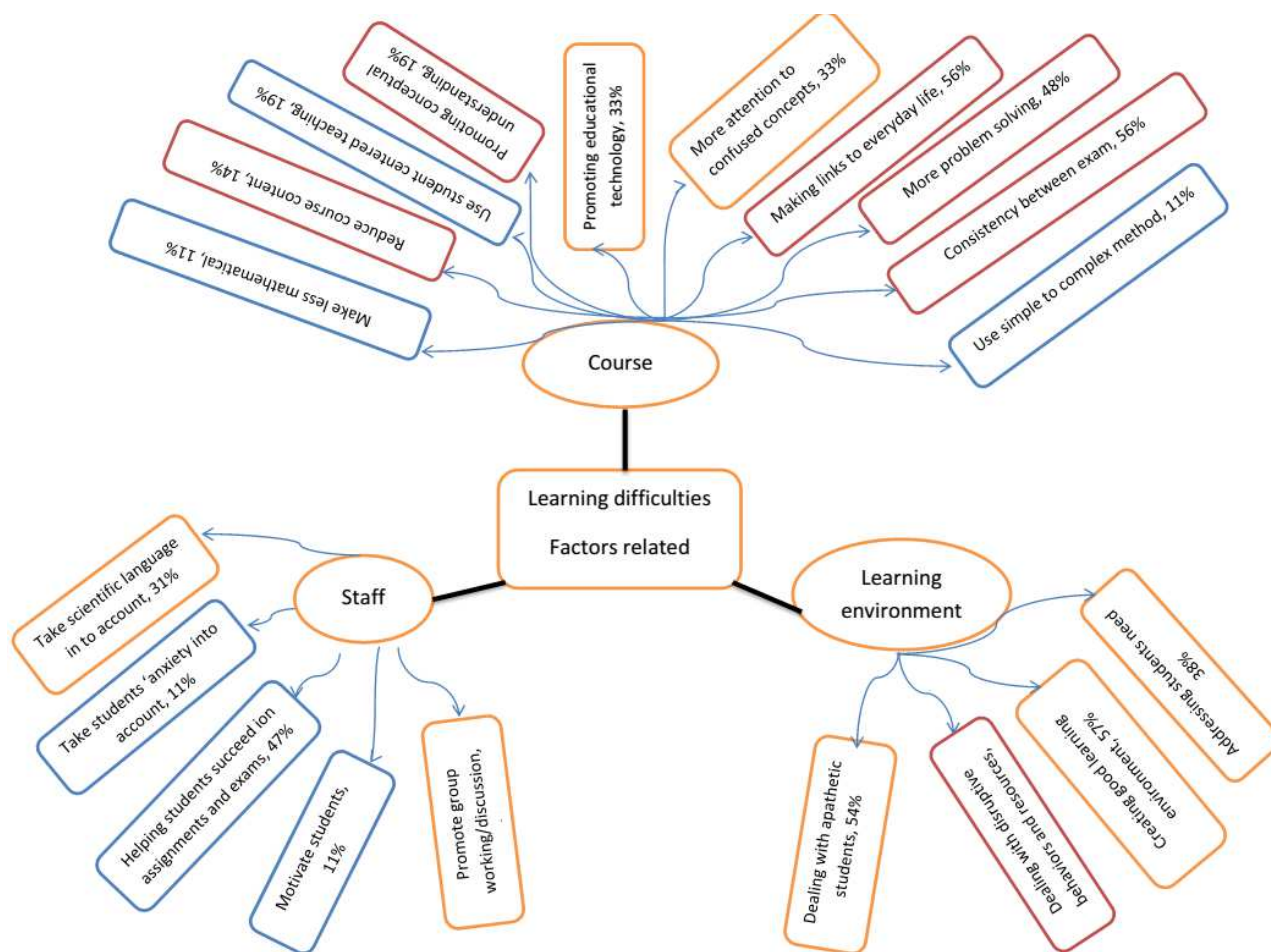


Figure 3. students perception of solutions to learning difficulties in chemistry

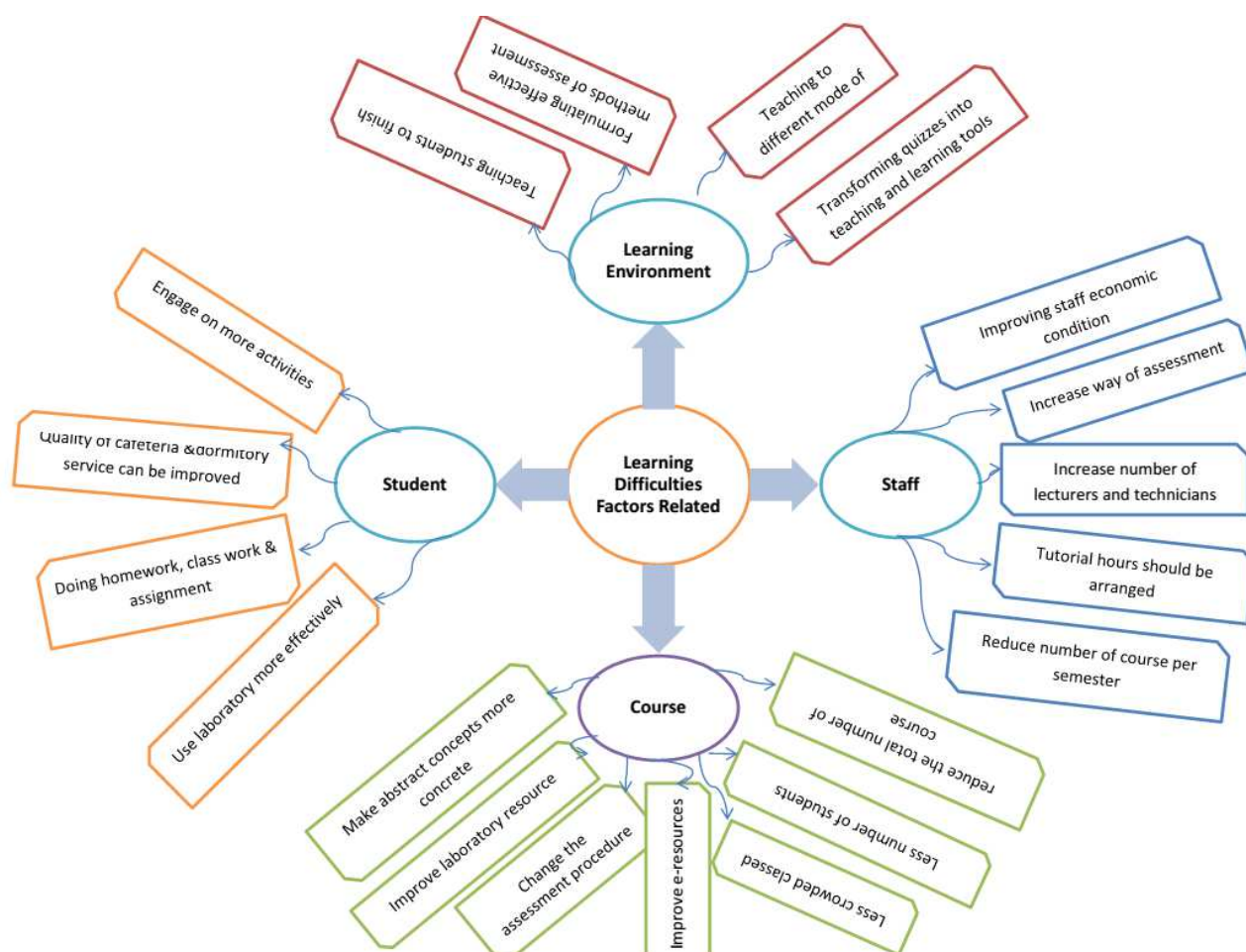


Figure 4. lecturers and TA perception of solution to learning difficulties in chemistry

DISCUSSIONS

This study looked at the student and staff perceptions of students' learning difficulties in Chemistry and their possible solutions. Some of the results from this study confirm the results of a previous study [23] on what makes physical chemistry difficult as related to the perception of Turkish chemistry undergraduate students. The result was similar to another study [24] that explored students' conceptions of equilibrium and fundamental thermodynamics concepts in college Physical chemistry of the University of North Colorado. The results have some similar contextual function with the major exception such as the fourth factors learning environmental

style was considered explicitly in this research in addition of confusing the technical meaning and ordinary meaning of chemical function, lack of resource, numeracy skills, scientific language, overcrowded class, staff economic condition, teachers ego-stocking, specific feedback questions and scientific reasoning. Whereas these explicit factors were highly reflected on Ethiopian students, they were not considered for the Turkish and North Colorado universities.

Although it is not appropriate to generalize from a single study, the findings suggest that students and staffs sometimes perceive the learning difficulties differently. The results showed that lecturers and students were partly in agreement on the students' learning difficulties which are related to the course, and there were discrepancies about student and staff related difficulties as well as some course related difficulties. Students were critical of the course content, the resources available, the lecturers and their teaching methods. However, only a few students blamed themselves that they do not do the work on their side.

Lecturers generally focused on the factors that are related to the course, such as overcrowded classes, lack of resources and staff, and indirect factors, such as student background and socio-economic conditions. Lecturers partly blamed themselves as well. The findings suggest that there is a great deal of discrepancy between staff and student perceptions, although some points about the course related difficulties were shared by both sides. These common points and discrepancies may be used to improve the quality of teaching and learning.

Among the students' difficulties, the abstract nature of the chemical concepts was a common theme. This is also recognized by the lecturers. The other difficulty which is related to the nature of the subject, or general chemistry, was the mathematical content of the course. One in three students perceived Chemistry as too mathematical.

The remainder of the difficulties relating to the course focused either on teaching methods or the physical conditions of the teaching environment. The lecturers generally emphasized the difficulties relating to the poor teaching environment which prevents better teaching. However the interview data suggests that the lecturers have not given sufficient thought to how students learn, despite the large amount of literature on that issue, for example [23-24] . This might be due to staff's lack of pedagogical content knowledge (PCK). It seems from the students' concerns and proposed solutions that there is a demand for the pedagogical aspects of teaching and learning to be considered. For example, propositions such as promoting group work and discussions, motivating students, using educational technology in teaching, focusing on conceptual understanding, establishing consistency between the exams, the lectures and the laboratory, as well as promoting student-centered teaching, may help to achieve better understanding.

The findings for this study suggest that of the four potential issues indentified in Ethiopian student situation (namely, Numeracy, Scientific Reasoning, the use of Scientific Language, Teacher's ego-stroking and Classroom Climate), Numeracy is the major issue for students studying Chemistry. Low performance in Scientific Reasoning tasks also is an issue, but this probably influenced at least in part by the numeracy issues that underpin some of the reasoning skills problem items used in the instrument. In addition both students and lectures view scientific language literacy can change classroom climate.

The research presented here allows for some solution for the particular educational context in which this study was completed (Dire Dawa and Haromaya universities). In light of the interpretive nature of this inquiry, it is also possible that these findings may serve to inform other practice in different, but related educational contexts [25-26]. As is the case in any interpretive-

based work, it is up to the reader to best judge the veracity of any transferability of research findings into his or her own educational context. These recommended solutions for what makes chemistry difficult are provided in the light of the above comments.

RECOMMENDATIONS

- Students who just meet the university entry requirement could be subject to a departmental diagnostic test (the design of which is informed by the above study) to be conducted in the first week. The purpose of this test is not to exclude students, but to identify the specific areas in which they need help.
- At risk students should be required to attend additional tutorials (on say a fortnightly basis) which target basic skills identified.
- If students were identified as being weak in a specific area, say numeracy, they could attend remedial tutorials in numeracy rather than academic content (which have in the past proven unsuccessful). But students for whom numeracy was not a problem, but who struggled with scientific language literacy might benefit from tutorials that were targeted to such learning difficulties.
- A student's learning style has to do with the way he or she processes information in order to learn it and then apply it.
- Providing a variety of approaches to the material can keep most of the students engaged in the class throughout the semester.
- A dominant "academic culture" exists in college classrooms which encourages sequential, verbal and reflective learners to progress quickly to advanced positions in a

field. It is thus important to “fit” once teaching techniques to both your course objectives and to students’ varied learning styles.

- Teacher’s behavior is an important determinant in the establishment of a safe or comfortable climate. Be aware of the fact that comments that are not fully explained invoke stereotypes or promote inaccurate conclusions. Beware that rapid acceptance of a correct answer favors the faster thinker/speaker.

REFERENCES

1. Reid.L.(2008).Identifying threshold concepts in geosciences; Taking inventory with students and faculty alike .threshold concepts .from theory to practice conference Queen’s University,Kingston.ON.1
2. Kamisah,O.,&Nur,S.(2013) Conceptual understanding in secondary school chemistry : A discussion of the difficulties Experienced by students. American Journal of Applied Sciences,10(5):433-441
3. Sozbiler,M.&Pynarbapy,A.N.C.,T.(2010) .prospective chemistry teachers conceptions of chemical thermodynamics and kinetics .Eurasia journal of Mathematics ,Science and Technology education ,6(2),111-120,5
4. Thomas, P.L. (1997) *Student Conceptions of Equilibrium and Fundamental Thermodynamic Concepts in College Physical Chemistry*, Unpublished PhD Thesis. University of Northern Colorado, Greeley, Colorado, USA
5. Carson, J. , & Watson, E. M (2002). Undergraduate students’ understandings of entropy and gibbs free energy. University Chemistry Education, 4, 4-12.
6. Ochs, R.S. (1996) Thermodynamics and Spontaneity, *Journal of Chemical Education*, 73(10), pp 952-954.
7. Carter, C.S. and Brickhouse, M.W. (1989) What Makes Chemistry Difficult? Alternate Perceptions, *Journal of Chemical Education*, 66(3), 223-225
8. Nakhleh, M.B. (1992) Why Some Students Don’t Learn Chemistry, Chemical Misconceptions, *Journal of Chemical Education*, 69(3), 191-196.
9. Temechegn, E.(2001). Students’ alternative conception in Chemistry: challenging the challenge. Solutions: A biannual newsletter of the Chemical Society of Ethiopia, 10 (1),2:11-14.6.
10. Villani, A. (1992) Conceptual Change in Science and Science Education, *Science Education*, 76(2), 223-23.
11. K.M. (1993) the Development and Validation of a Categorization of Sources of Misconceptions in Chemistry. In Novak, J.D. (Ed), *The Proceedings of the Third International Seminar on Misconceptions and Educational Strategies in Science and Mathematics*, pp.1496- 1535. Cornell University, Ithaca, NY.

12. Ayas, A. and Demirbas, A. (1997) Turkish Secondary Students' Conceptions of Introductory Chemistry Concepts, *Journal of Chemical Education*, 74(5), 518-521.
13. Temechegn, E and Seleshi, Y. (2005) .Concept –Cartoons as a strategy in teaching, learning and assessment of chemistry concepts. Addis Ababa, KCTE, 6.
14. Griffiths, A.K. (1994) A critical analysis and synthesis of research on students' chemistry misconceptions. In Schmidt H.J. (Ed), *Problem Solving and Misconceptions in Chemistry and Physics, Proceedings of the 1994 International Seminar*, pp.70-99. University of Dortmund, Germany.
15. Garnett, P.J., Garnett, P.J and Hackling, M.W. (1995) Students' Alternative Conceptions in Chemistry: A Review of Research and Implications for Teaching and Learning, *Studies in Science Education*, 25, 69-95.
16. Driver, R. (1981) Pupils' Alternative Frameworks in Science, *European Journal of Science Education*, 3 (1), 93 -101.
17. Duit, R. (1985) In search of an energy concept. In Driver, R. and Millar, R.(Eds) *Energy Matters: Proceedings of an invited conference. Teaching about energy within the secondary science curriculum*, pp.67-101. Centre for Studies Science and Mathematics Education, University of Leeds, Leeds, UK.
18. Gil-Perez, D. and Carrascosa, J. (1990) What to Do About Science "Misconceptions", *Science Education*, 74(5), 531-540.
19. Carson, E. M. and Watson, J.R. (1999) Undergraduate Students' Understandings of Enthalpy Change, *University Chemistry Education*, 3(2), 46-51.
20. Taber, K. S. (2002), Conceptualizing quanta: Illuminating the ground state of student understanding of atomic orbitals. *Chemistry Education, Research and Practice*, 3,145-158.
21. Sozbiller, M. and Bennett,J.M.(2007). A study of Turkish chemistry undergraduates Understandings of entropy .*Journal of chemical education*, 84(7),1204-1208.
22. Risch, B. [2010]. Teaching chemistry around the world. Minster: Waxmann.
23. Ramsden, P.(1992).Learning to teach in higher education. Routledge.London.UK.267.
24. Kyriacou, C.(1986), Effective teaching in Schools. Basil Black well, oxford, Uk.206.
25. Sozibilir, M.(2004) what makes physical chemistry difficult ? Perception of Turkish Chemistry undergraduates and lecturers, *Journal of chemical education*, 81(4).
26. Thomas, P.L. [1998]. College Physical Chemistry students' conceptions of equilibrium and fundamental thermodynamics, *Journal of research in science teaching* vol. 35, No. 10, pp. 1151-1160