CHEMISTRY AND CHEMICAL ENGINEERING: APPROACHES, OBSERVATIONS, AND OUTLOOKS

By

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ABSTRACT

Chemical Engineering is the distinct branch of the Engineering profession. Chemical engineering activity is mainly concerned with the exploitation of chemical reactions on commercial scales. Chemistry is one of the basic and important subjects to build the best chemical engineers. The basic aim of the present work is to understand the 3rd year chemical engineering students' approaches, observations and outlooks towards chemistry and chemical engineering subjects they learnt. They learn 3-4 chemistry subjects in 1st year and 2nd year of chemical engineering and almost all major chemical engineering subjects. Certain questionnaire was formulated to collect the respective data. The data of 64 students of chemical engineering have been collected and analyzed with respect to their experience of chemistry learnt in the first and second year of chemical engineering and its concerns for chemical engineering. The results are presented in terms of bar charts and exhuastively interpreted. Overall, the results suggest that, the students' experience for urban students is better than the rural student in all aspects. Further, more specific teaching – learning system should be developed to create the interest of the students in chemistry and so on chemical engineering.

Keywords: Chemical Engineering, Chemistry, Approaches, Observations, Outlooks.

INTRODUCTION

Universal and Compulsory Education for all children in the age group of 6-14 was a cherished dream of the government of India. The setting up of the entire system was more or less derived from the British Education System [1].

The Indian Education System [2] has six levels: the Pre primary or Nursery (age 3-6), the Primary (grade 1-5, age 6-11 years), the Secondary school (grade 6-10, age 11 to 15 years), the Higher Secondary (grade 11-12, age 15 to 17), the Graduation (age 17-22 years), and the Post Graduation (2 year course) [3-4]. Muralidharan et. al [5] and Nirav [6] have well documented about the Indian Education System.

1. Literature Review

Chauhan [7] discussed exhaustively the Indian education system starting from the ancient period to the modern education system. Also, various bills, laws, and other issues related to higher education have been analyzed and mentioned their perspectives.

Lall [8] placed the current issues facing by Indian Education System in a historical context. Since Independence, successive Indian governments have had to address a number of key challenges with regard to education policy, which has always formed a crucial part of its development agenda. Currently, while Indian institutes of Management and Technology are world-class, primary and secondary schools, particularly in rural areas, face severe challenges. While, new governments commonly pledge to increase the spending on Education and bring in structural reforms, this has rarely been delivered in practice.

Nordic Recognition Information Centres [9] have given the report on the system of education in India. The glimpse of Indian Education system is discussed in the following section.

2. Indian Education System

Pre-primary education is considered to be very important

for the child as it is the first step towards entering the world of knowledge as well as a healthy and purposeful life. Pre-primary education helps children become more independent and confident as well as promoting the overall development of the children. Children who have been to pre-primary schools tend to learn more rapidly through an organized curriculum, learning aids, and by interacting with other children. The main purpose of pre-primary education is to prepare children physically, emotionally, socially, and mentally for formal schooling and to prevent poor performance and early drop out. It also helps older children, particularly girls, to attend their schools making them free from responsibility of sibling care especially in rural areas and low income families. Thus it can be said that, pre-primary education is necessary for all children of 3-6 years old irrespective of their socio-economic background. The Preprimary or the Nursery has the Lower Kinder Garten (LKG or KG-I) and the Upper Kinder Garten (UKG or KG-II), where the basic reading and writing skills are developed.

The Primary school has the children between the ages of six to eleven. The primary school is the first stage of the compulsory education which goals towards achieving basic literacy and numeracy amongst all pupils, as well as establishing foundations in Science, Mathematics, Geography, History, and Social Sciences. It has an organized classes from one to five.

Secondary education is a gateway to the opportunities and benefits of economic and social development. The Secondary school children are between the ages of eleven to fifteen and the classes are organized from six to ten. The secondary education is also provided by a number of private schools and these schools will either follow the National curriculum or the State curriculum. In some states, the classes between six and eight are also referred as the Middle schools and those between eight and ten are referred as the high schools. There are many different streams available in Secondary Education.

The higher secondary school students are between the ages of sixteen to eighteen and the classes are organized as eleven and twelve. The higher secondary education is designed to allow for diversification and specialization, while preparing students for higher education. The Higher Secondary Education in India aims at providing education to specialize in a particular field (mainly Arts, Science, and Commerce) and includes many technical schools, colleges, and universities. The schools in India are controlled by various boards such as the Central Board of Secondary Education (CBSE), the Council for the Indian School Certificate Examinations (CISCE), the State Government boards [10], the National Open School [11] and the International schools [12]. Students have to learn a common curriculum largely (except for regional changes in mother tongue) till the end of high school.

After passing the Higher Secondary Examination (the grade 12 examination), students may enroll in general degree programs (or graduation) such as Bachelor's degree in Arts, Commerce or Science, or professional degree programs such as Engineering, Law, or Medicine. The Indian Universities offer various courses in the following main disciplines [13]:

- Engineering and Technology.
- Computer Sciences, Information Technology, Biotechnology and Bio-informatics.
- Medical, Dental, Nursing, Pharmacy and Paramedical.
- Agriculture/Veterinary Sciences, Dairy Technology and Fisheries.
- Arts & Fine Arts, Humanities, Social Sciences, Commerce, Science and Management.
- Hotel Management & Catering Technology, Travel and Tourism.
- Fashion Design & Technology etc.

The most prevalent and known one is Engineering. There are many engineering colleges in India [14], and even more coming up every year. Engineering itself is a vast arena, being divided into four main streams as [15]:

- *Civil Engineering:* Related to design and construction of public and private works, such as infrastructure (airports, roads, railways, water supply and treatment etc.), bridges, dams, and buildings.
- *Mechanical Engineering:* The design of physical or mechanical systems, such as power and energy systems,

aerospace/aircraft products, weapon systems, transportation products engines, compressors, power trains, kinematic chains, vacuum technology, and vibration isolation equipment.

- *Electrical Engineering:* The design and study of various electrical and electronic systems, such as electrical circuits, generators, motors, electromagnetic/ electro mechanical devices, electronic devices, electronic circuits, optical fibers, opto-electronic devices, computer systems, telecommunications, instrumentation, controls, and electronics.
- *Chemical Engineering:* The application of physics, chemistry, biology, and engineering principles in order to carry out chemical processes on a commercial scale. It involves unit operations and unit processes.

Modern fields sometimes included as major branches are Ocean, Mining, Aerospace, Computer, Electronic, Petroleum, Systems, Audio, Software, Architectural, Bio Systems, Biomedical, Industrial, Materials and Nuclear Engineering. The focal point in this paper would be to focus on the students taking up Chemical Engineering as their branch.

The achievements of a chemical engineer are discussed in [16]. Chemical engineering started emerging in 1880's as a new science of Chemistry [17-18]. The evolution in Chemical Engineering is presented in [19]. Chemical engineers work in areas such as chemicals, biotechnology, pharmaceuticals, food, energy, environment, consumer products, electronics, nanotechnology, advanced materials, and finance. Chemical engineers have jobs in research, design, development, manufacturing, optimization, teaching, and consulting. Chemical engineers work in laboratories, plants, and offices. Some of the key responsibilities of a chemical engineer involve designing, supervision, construction, installation, operation and maintenance of plants and equipments for manufacturing chemical products, as well as gauging problems and improving the methods of production. They also deal with extracting chemicals from waste materials, developing chemical processes to convert raw materials or chemicals into valuable forms, evolving synthetic products to replace depleting natural resources and solving other environmental problems such as waste and water treatment and energy conservation. Chemical engineers also play an important role in the availability of modern high-quality materials that are essential for running an industrial economy.

Focusing on India, mainly IIT's (Indian institute of Technology) and NIT's (National Institute of Technology) are well known to offer Chemical Engineering degrees and pathways to study Chemical Engineering at college level. This subject catalog lists the information resources relevant to Chemical and Process Engineering. Advancing towards the agenda, the deductions and end results presented towards the end are based upon a planned survey carried out on a particular number of subjects, relevant for the same.

3. Objective

The basic aim of the present work is to understand the 3rd year chemical engineering students approaches, observations and outlooks towards chemistry and the Chemical Engineering subjects they learnt. They learn 3-4 chemistry subjects in 1st year and 2nd year of chemical engineering and almost all major chemical engineering subjects.

4. Methodology

In order to obtain the students' views, and attitudes, a questionnaire was designed and distributed to the third year Chemical Engineering students (Batch: 2009-13) of Visvesvaraya National Institute of Technology, Nagpur India, to obtain students approaches, observations and outlooks. The questionnaire was prepared based on Perry's questionnaire [20]. Total of 64 students from a class took part in the study. The sample questionnaire is given in Annexure – I, which contained the following topics:

- Demographics data includes students' age, gender, domicile state, percentages in 10th and 12th along with the CGPAs in all the semesters, AIR (All India Rank) rank in AIEEE (All India Engineering Entrance Exam) exam, place of the study, and whether the institutions in which they have studied are located in rural areas or urban areas.
- 1st and 2nd year engineering chemistry students during

the 4 year degree course in chemical engineering.

- Chemical engineering in general.
- Students' perceptions on their own roles in learning, assessment and on the role of lecturer.
- Students' perceptions on the nature of scientific knowledge.
- Preferred topics in science lessons.

5. Results and Discussion

The survey data were analyzed and presented in the form of bar charts. All results are grouped together and are shown in percentages. The results of the present study will provide the perception, views and attitude of the 3rd year chemical engineering students towards chemistry and chemical engineering they have learnt. The students are in the age group of 19-22 and have joined the chemical engineering four year degree course after completion of their higher school education.

5.1 Perception on 1st & 2nd Year Engineering Chemistry

Chemical engineering does not only include chemistry as its base subject; but, also various aspects of physics and mathematics. It has been found that, students are not completely satisfied with the organization of courses in 1st and 2nd year chemistry (Figure 1). Additionally, students' satisfaction with the assessment methods is also low. On the contrary, students have a good support from the academic staff. Most of the students have given a good rating for the teaching style, faculty and the examination system. But poor results are obtained, when it is asked whether their interest in chemistry had increased with the respective courses. The reason can be that the students are more involved in the extracurricular activities and they do not give more preference to academics. They do not give themselves sufficient time to think over all these subjects. Most of the students feel that, the topics which the students have studied are useful to study in deep during their higher studies. 40% students said that, the courses are more of wrote-learning and 25% students said that it is of both understanding and wrote-learning one. The results show that, the students are interested in doing practical work (73%) , solving problems (74%), in applying course to everyday life problems (71.4%) and thinking more creatively while studying (66.7%). On a positive note, this shows the positive attitude of students towards solving real life problems.

Analyzing the reasons for the students to find the course more of wrote-learning and understanding, major part of the course involves learning a lot of theory and a lesser part in solving real life problems. The practical study is also not sufficient to understand the course completely, because, course involves large number of contents and all that cannot be covered and understood in practical. To add to this, conducting a practical study for all the topics is not an easy task for the faculty as well, for instance, in electrochemical cell theory, student studied about hydrogen fuel cell. As it is difficult to store hydrogen

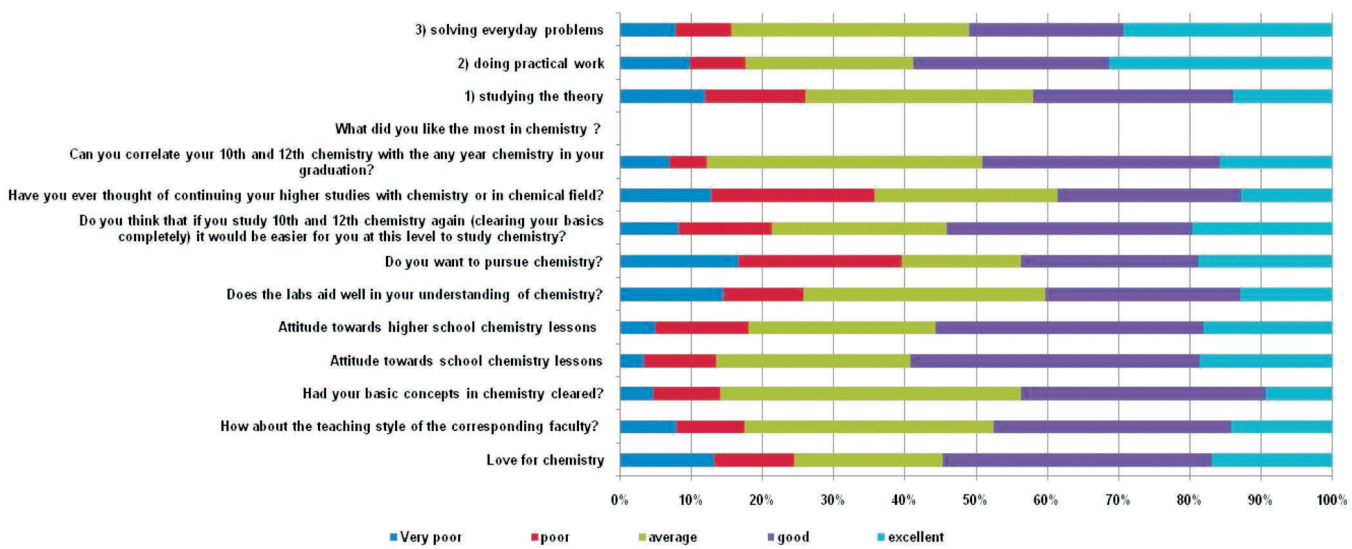

Figure 1. Students' attitude towards 1st and 2nd Year Engineering Chemistry

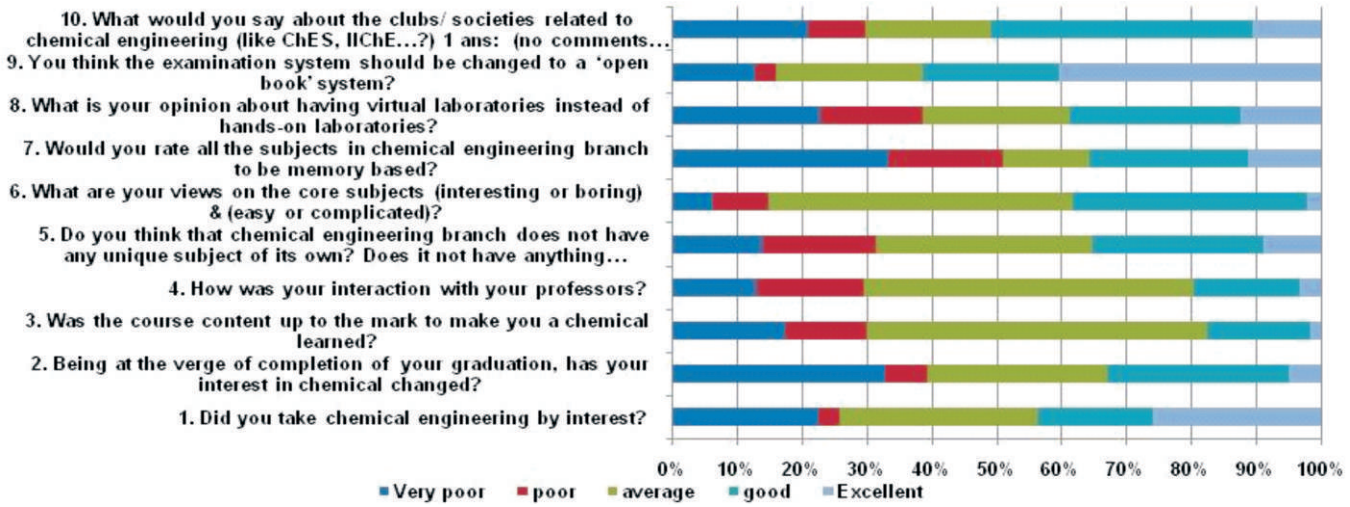

Figure 2. Students' views in Chemical Engineering

in laboratories, the practical study on hydrogen fuel cell cannot be conducted. Also, as it is not possible to maintain sufficient conditions for some reactions to occur like they may be require extreme pressure and temperature conditions, and so they cannot be conducted at laboratory scale. Also, every model is based on assumptions; and their practical proofs are not possible.

5.2 Perception on Chemical Engineering

The results show that (Figure 2), 74% students have taken chemical engineering by interest. 70% students said that, the course content was up to the mark to make each of them well learned about chemical engineering. The rating for the interaction with the professors was average. Students had different opinions about different professors. Some students might have bad experience with the professors in some situations and they might have got negative opinion and they might be scared to talk or to interact with those professors. So they might have poor interaction with these professors. Some professors behave friendly with students; so that they can interact with them, they can share their problem and they can understand the students properly; so that they can help the students in every possible situation somehow. So, students might have a good interaction with these professors.

Some students have poor interaction with the professors due to fear of talking to them. 85% students found the core subjects interesting. 51.1% students rated the subjects in chemical engineering are to be memory based. 61.4% students have shown positive opinion towards having virtual laboratories. 70.27% students support open book examination system; because, the students might be interested thinking practically and more creatively rather than, mugging up the things. and the examination system mostly involves in writing theory and it is more of memory based than solving practical life problems. It sometimes involves derivations and writing the mugged up formulae. Students prefer having virtual laboratories instead of having hands-on laboratories; because, the hands-on laboratories show deficiencies most of the time. The devices do not give appropriate results all the time. Because, it is not possible to maintain the necessary atmosphere. For an example, in case of wetted wall column, it is not always possible to maintain the film very thin and in the Sieve tray distillation column, the plates may not behave ideally all the times. As we go on using the plates, the plates may get corroded and hence the plates cannot be ideal always and the compositions cannot be in equilibrium all the time. Sometimes some parts in the equipment do not work properly. But in virtual laboratories, the required conditions can be maintained and proper results can be obtained i.e. theoretical values can be correlated with the experimental values.

5.3 Student Perceptions on their Own Roles in Learning and Assessment

Education is a give and take thing. The more you are inquisitive, the more you could learn and get opportunities to excel. The survey results show that, (Figure 3) 78.3% students do not totally rely on the lecturers and workout things themselves, 76.3% people think and imagine when the lecturer teaches any concept only when they find it, they accept it. It is also seen that, 91.2% students have a likely attitude to work with other students so that they could acquire correct ideas. 83.6% of students concluded that, they can learn more by discussing with other students. This can be because, sometimes the student may not understand what the author of the prescribed textbook wants to say while reading the theory; it will be get cleared while discussing, as students share their opinion and their understandings. They can share doubts and they can clarify most of them by themselves. 75.4% students have the outlook that, lecturers should provide challenges to them by introducing difficult topics. This can be because, the students are interested in facing challenges, thinking more creatively while studying and in solving real life problems. But they say that, the lecturers should provide the required knowledge.

On the other hand, 60% students have the feeling that, the lecturers should avoid teaching a few concepts which they know that, students will find difficulty in. However, most of the students feel that, even though some topics are not included in exam, they should be covered.

This attitude shows that, the students are not exam oriented, but, they want to learn more and more concepts and apply them in reality.

Coming to the examination paper pattern, 70% students feel that, short answer questions do not give a chance to explain knowledge and understanding exactly and briefly. 87% students like those exams in which, they get opportunity to show their own ideas. 85% students have the opinion that, the quality of the answers is what matters in exam, not on how much is written. 84.5% students like questions, that go beyond what is covered and they feel that, these type of questions show their ability to think. Overall, the students' interest is widely seen in thinking rather than learning (like spoon-feeding). 84.9% students voted that they would choose comments if they would be

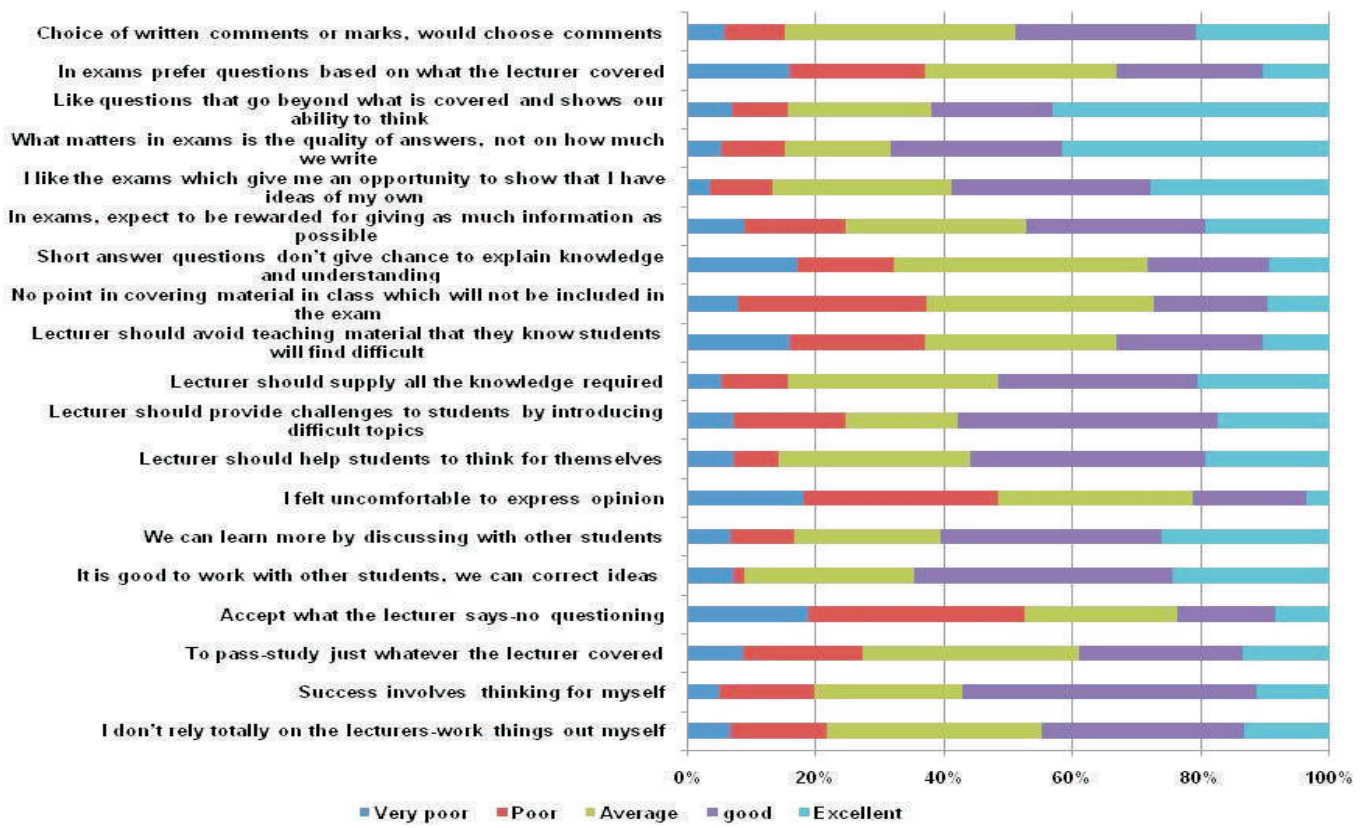

Figure 3. Students' Perceptions on their Roles in Learning, Assessment and on the Role of Lecturer

given a choice of either written comments or marks.

As per the authors' understanding, this can be because the marks show only the performance but comments highlight the performance along with giving some suggestions. Marks do not exactly show what they feel but the comments do. Moreover, marks have a high probability of generating negative competition among the students; however, comments have a scope of eliminating the negative aspect.

5.4 Students' Perceptions on the Nature of Scientific Knowledge

Science is what an integral part of the chemical studies is. Being a student, one must be equally involved in science as well. Keeping this in view, few questions were asked to assess the perspectives of students on their scientific knowledge (Figure 4). The first result that, was obtained shows that, 95% students feel that understanding science is the key to scientific study. Secondly, 81% students feel that, there is nothing to be memorized in science. Thirdly, 86% students had a view that, only scientific knowledge can be considered to be the "absolute truth".

Additionally, 28% students feel that, it is waste of time to work on problems that have no clear cut answer. To add to it, 38.2% students had neutral opinion about this. Lastly, 43.4% students feel that, everything is so clear cut either right or wrong in science and 41.5% students had neutral opinion about this.

5.4.1 Preferred Topics in Science Lessons

An option is always welcomed, whether it is purchasing things, settling for a novel, playing games or even choosing one's subjects. On analyzing the students' view point on choices given in their science lessons (Figure 5), the conclusion obtained was, 38.9% students prefer studying the theory and 25.9% students had neutral

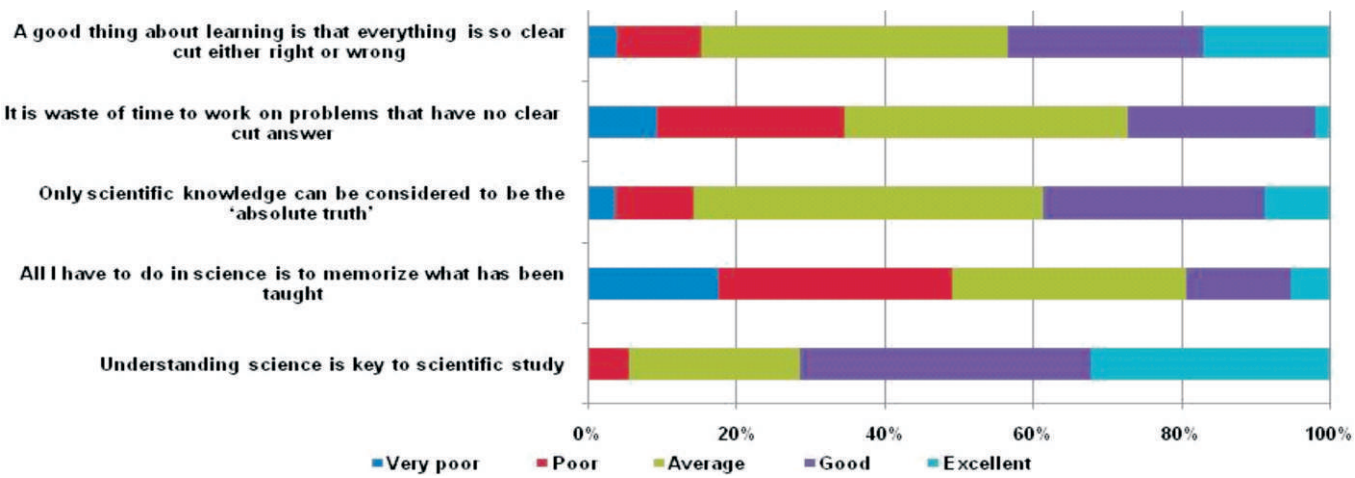

Figure 4. Students' Perceptions on the Nature of Scientific Knowledge

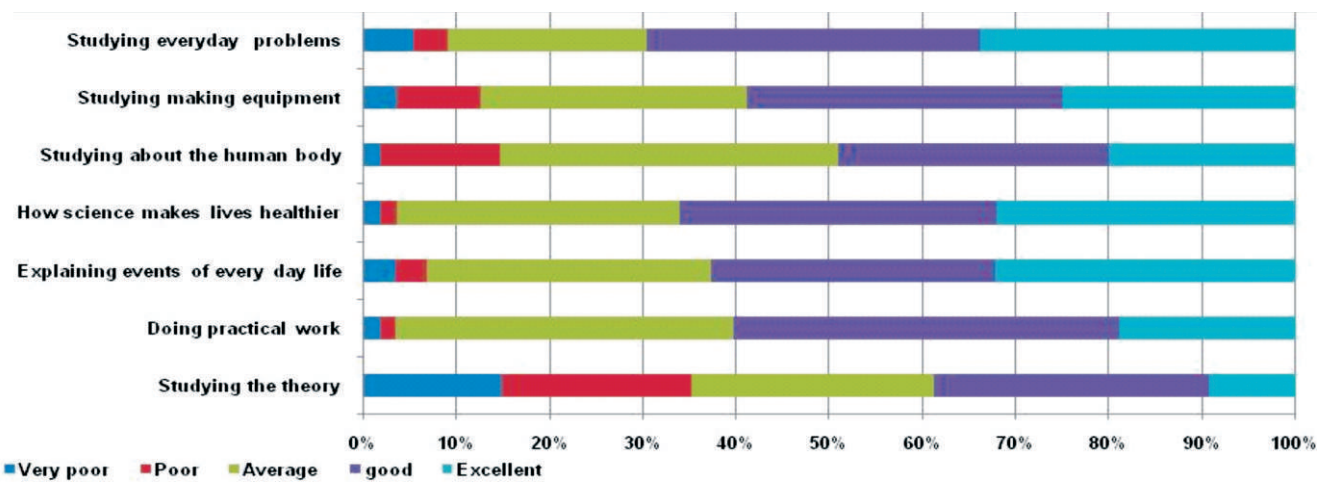

Figure 5. Preferred Topics in Science Lessons

opinion about this. 60% students shown positive attitude and 36.2% students have shown neutral attitude towards doing practical work. 62.7% students are interested in explaining events of everyday life and 30.5% students have neutral opinion for this. 66.07% students are interested in studying how science makes lives healthier and 30.55% students have neutral opinion on this. 49.1% students would prefer studying the human body. 69.64% students are interested in studying everyday problems in science. Conclusively, students are interested in learning about real life science.

Conclusion and Recommendation

The study was carried out to understand the approaches and outlooks of the 3rd year chemical engineering students of a four year degree course towards chemistry learnt in the 1st and 2nd year and chemical engineering is learnt till the end of their third year. 3rd year was considered as they learn almost all the core subjects till the end of 3rd year. Total of 64 students were participated in the study. The collected data were analyzed systematically to understand their perspectives, and views. Overall the results suggest that, the students experience for urban students is better than the rural student in all aspects. Further more specific teaching – learning system should be developed to create the interest of the students in chemistry and so on chemical engineering.

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Appendix

Name(optional):			Semester:		
Enrollment no(optional):			DOB:		
Domicile City/state:	Area: Rural / Urban		AIEEE Rank:		
10th score/percentage:	12th score/percentage:				
10th City / State:	12th City / State:				
CGPA 1st yr:	2nd yr:		3rd yr:		
1st and 2nd year chemistry					
	Very poor	poor	average	good	excellent
Do you think that the courses whichever you have completed are well organized?					
Do you think that the assessment methods are good?					
Do you think that the practicals whichever you have done during the course were sufficient to understand the respective course completely?					
Do you find good support from academic staff?					
Do you think that you improved your skills during these 2 years?					
Do you think that the topics whichever you studied are useful to understand the course or to study in deep during your higher studies?					
What about the teaching style?					
How is the faculty of chemistry?					
What do you think about the examination system?					
Do you think your interest in chemistry has increased with these courses?					
Do you find the course more of a wrote-learning subject or an understanding one?					
What did you like while studying the course?					
1) studying theory					
2) doing practical work					
3) solving problems					
4) applying the course to everyday life problems					
5) thinking more creatively while studying					
Chemical engineering					
	Very poor	poor	average	good	excellent
1. Did you take chemical engineering by interest?					
2. Being at the verge of completion of your graduation, has your interest in chemical changed?					
3. Was the course content up to the mark to make you a chemical learned?					
4. How was your interaction with your professors?					
5. Do you think that chemical engineering branch does not have any unique subject of its own? Does it not have anything strikingly different in itself from other similar branches, like mechanical engineering?					
6. What are your views on the core subjects (interesting or boring) & (easy or complicated)?					
7. Would you rate all the subjects in chemical engineering branch to be memory based?					
8. What is your opinion about having virtual laboratories instead of hands-on laboratories?					
9. You think the examination system should be changed to a 'open book' system?					
10. What would you say about the clubs/ societies related to chemical engineering (like ChES, IIChE…)?					
Students' perceptions on their own roles in learning, assessment and on the role of lecturer. Tick one box in each line that closely reflects your views about learning, assessment and on the role of lecturer.					
	Very poor	Poor	Average	good	Excellent
I don't rely totally on the lecturers-work things out myself					
Success involves thinking for myself					
To pass-study just whatever the lecturer covered					
Accept what the lecturer says-no questioning					
It is good to work with other students, we can correct ideas					
We can learn more by discussing with other students					
I felt uncomfortable to express opinion					
Lecturer should help students to think for themselves					
Lecturer should provide challenges to students by introducing difficult topics					
Lecturer should supply all the knowledge required					
Lecturer should avoid teaching material that they know students will find difficult					
No point in covering material in class which will not be included in the exam					
Short answer questions don't give chance to explain knowledge and understanding					
In exams, expect to be rewarded for giving as much information as possible					
I like the exams which give me an opportunity to show that I have ideas of my own					
What matters in exams is the quality of answers, not on how much we write					
Like questions that go beyond what is covered and shows our ability to think					
In exams prefer questions based on what the lecturer covered					
Choice of written comments or marks, would choose comments					

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