Available online at **www.joac.info**

ISSN: 2278-1862

Journal of Applicable Chemistry

2019, 8 (4): 1603-1610

(International Peer Reviewed Journal)

Chemical Education

Novel Pedagogical methods for Effective Learning of Chemistry in Engineering Education

P. Padmavathi* and K. Madhavi

Department of Humanities and Sciences, VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad, **INDIA**

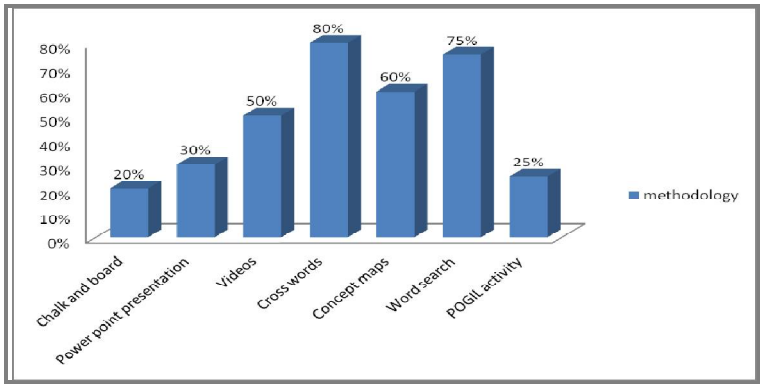
Email: padmavthi_p@vnrvjiet.in

Accepted on 10th May, 2019

ABSTRACT

Chemistry is considered as a central science as it connects to all other sciences like physics, biology, geology etc. Basic knowledge of chemistry helps even a common man to understand how things around us are made and react. Hence learning chemistry is essential for a science student to explore their core domain more effectively. Chemistry is a mystery to a majority of the students as it involves equations and formulas which demand more attention and memory from the student. Students especially engineering students give more priority to their core subjects and the faculty dealing the subject experience tough time to get their interest towards chemistry. Hence there is a need to develop new teaching and learning strategies to improve the learning process by the students. With the help of active learning techniques which brings involvement of each and every student made it easy to unravel the mystery of chemistry and make the study simple. Activities like crossword puzzle, word search, match the following, concept maps have been designed on various threshold topics in Engineering Chemistry subject and implemented. The response from students is enormous.

Graphical Abstract



Percentage of students in favor of various activities.

Keywords: Learning Chemistry, effective teaching, students, activities, Involvement, Improvement.

INTRODUCTION

Knowledge of Chemistry is essential as it plays a major role in everyday life .It is present in food we eat in liquids we drink, in air we take in medicines we use and fabric we wear. Learning chemistry according to present generation is memory based hence they are showing least attention towards chemistry compared to other subjects which has some logic and reasoning according to the student perception. Therefore it is essential to find new pedagogical methods to make chemistry more interesting and useful. Teaching is one of the main components in educational planning which is a key factor in conducting teaching methodologies [1].

At present discusses on the various methods or strategies adopted to teach some threshold topics in chemistry through active teaching learning methods. These methods engage, involve in understanding the concept and also help the students to improve their communication skills while presenting their activity. Effective teaching always focuses to encourage students to realize their responsibility for their own learning. Rapid changes in the modern world have caused and resulted the higher education system to face a great variety of challenges in making the students, draw interest towards the subject by developing novel pedagogical methods [2].

The methods adopted should pave the way for a student to reach his goal with confidence supported by in-depth knowledge. Modern education system is encouraging creativity during teaching the lessons [3]

As the traditional methodologies like chalk and talk demands memorization and repetition to make students learn thoroughly while the modern methods engages the students through interaction and hence is productive. Most of the recent research has been on "active learning methods" in comparison to the traditional lecture method in which students are passive [4]. Additional teaching methods supporting traditional teaching method improve learning styles [5]. Chemistry is a subject with formulae and chemical equations which needs great memory. If the chemistry topics are designed in the form active learning methods students spend a significant fraction of time in learning and can avoid memorizing [6], Khairiyah [7]. This paper concentrates on interesting methodologies to make chemistry learning easy and flexible. The end results of the students after implementation is found to be quite remarkable and especially the involvement of weak students in these activities is quite impressive. It is the need of hour for all the engineering teachers to expertise in active learning technologies to enhance the learning styles of students [8]. When the conceptual learning is enhanced innovations will make their way into the science arena [9, 10]. To make the chemistry learning lucid and simple novel pedagogical methods in the form of activities have to be designed and implemented. Active learning methods improve the performance of students [11]. Technology aids both teaching and learning methodologies [12]. Usage of active learning techniques helps to understand the mechanism in organic reactions [13]. The studies done by various researchers in different fields inspired to implement activity based learning in chemistry.

MATERIALS AND METHODS

Creating different models as teaching aids is the primary phase of active learning methodology. A number of activities have been designed to untangle the secret of chemistry. Though designing different teaching methods chemistry is a gigantic mission but succeeded in creating simple yet constructive activities. The various activity worksheets designed on various topics and implemented are discussed below.

Activity-1 Pogil: Pogil is a student-centered, active learning style where students work in small groups on material provided by the teacher [14]. It is a student centric activity where the teacher is the facilitator. Lead acid battery is a rechargeable secondary battery used commonly in cars. So to make the student learn the mechanism of reactions involved in charging and discharging reactions involved in this battery the following **Pogil activity** (Process Oriented Guided Enquiry Learning) is designed

and implemented in the classroom. The Class of 60 students are divided into 15 groups of 4 each and asked to look into the picture and answer the questions related to that picture. Some prerequisites are also given about the battery. The reactions involved in lead acid battery are made to understand from the figure before teaching with the help of a small diagram and hints given in the question form.

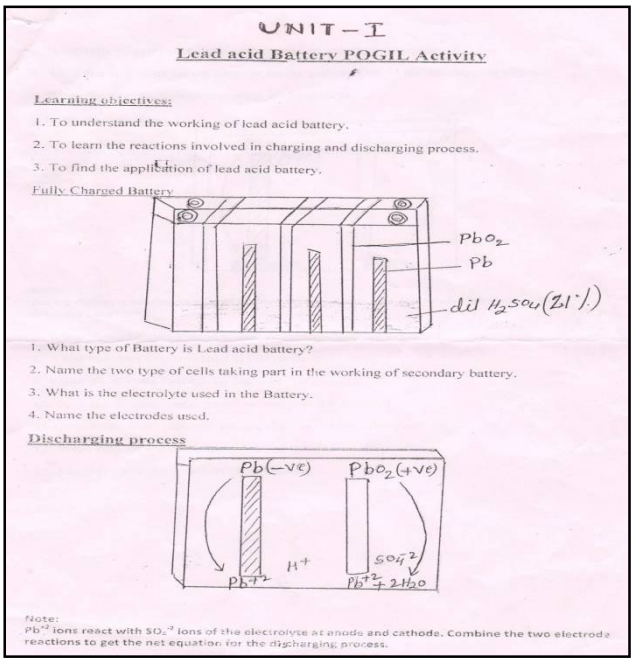


Figure 1. POGIL activity on Lead acid battery.

Activity-2 Concept Maps: Concept mapping is one of the instructional strategies that help the learners to link key concepts by framing and analyzing information. Concept maps can be successfully used to teach conceptual thinking, thus increasing students' competence in critical thinking in the modern paradigm. They are considered as the learning tools to deal with concepts like classifications and type [**15**].

Corrosion in metals is a common phenomenon. Mechanism involved in corrosion is explained and the factors affecting the rate of corrosion is given as an activity in the form of **Concept map** as shown in the figure 2. A class of 60 students are made into 15 groups of 4 each and asked to discuss and write briefly their findings in the map itself.

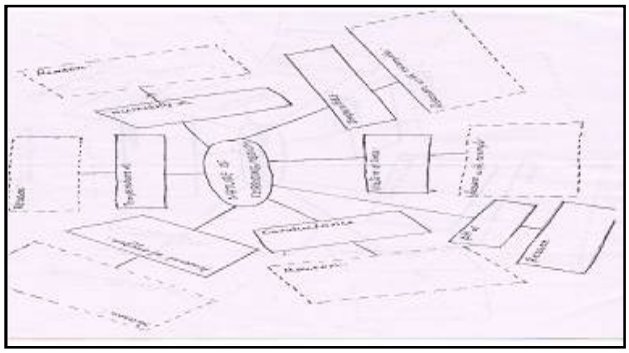
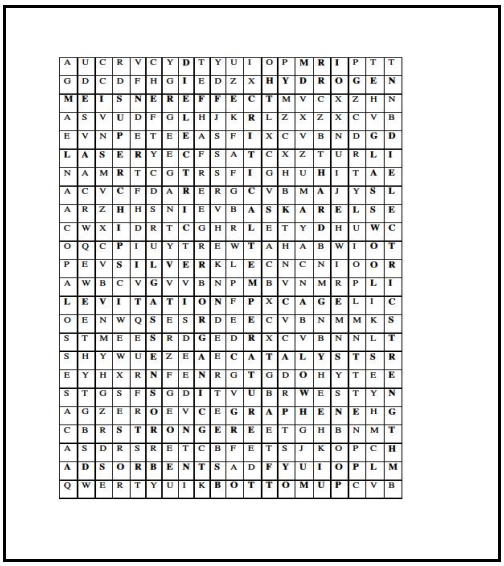


Figure 2. Concept map on factors effecting rate of corrosion.

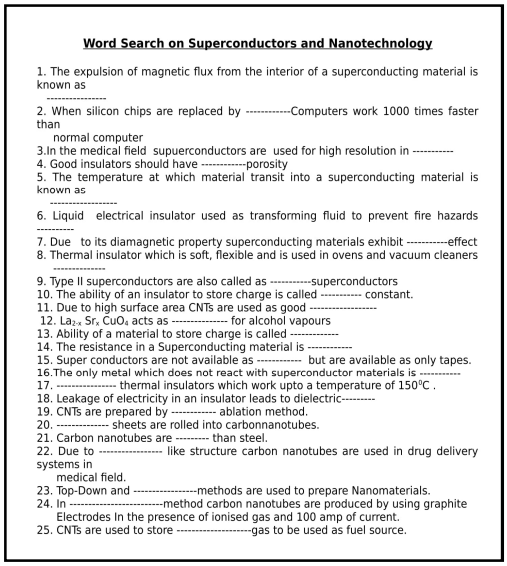
Activity-3 Word Search: Learning followed by memory is required to understand a concept in complete manner [**16**]. Word search activity is an activity of building memory. It is kind of brain exercise which improves the encoding skills of a student. Topics like superconductors

.Nanotechnology involves new terminology hence to help the students learn those definitions and other phenomenon in a lucid way through fun following **word search** activity is designed shown in figure 3 and given to the students. This activity is done in groups of two each and time limit is given for searching the answers with the help of clues given as fill in the blanks manner as shown in figure 4.



A	U	C	R	V	C	Y	D	T	Y	U	I	O	P	M	R	I	P	T	T
G	D	C	D	F	H	G	I	E	D	Z	X	H	Y	D	R	O	G	E	N
M	E	I	S	N	E	R	E	F	F	E	C	T	M	V	C	X	Z	H	N
A	S	V	U	D	F	G	L	H	J	K	R	L	Z	X	Z	X	C	V	B
E	V	N	P	E	T	E	E	A	S	F	I	X	C	V	B	N	D	G	D
L	A	S	E	R	Y	E	C	F	S	A	T	C	X	Z	T	U	R	L	I
N	A	M	R	T	C	G	T	R	S	F	I	G	H	U	H	I	T	A	E
A	C	V	C	F	D	A	R	E	R	G	C	V	B	M	A	J	Y	S	L
A	R	Z	H	H	S	N	I	E	V	B	A	S	K	A	R	E	L	S	E
C	W	X	I	D	R	T	C	G	H	R	L	E	T	Y	D	H	U	W	C
O	Q	C	P	I	U	Y	T	R	E	W	T	A	H	A	B	W	I	O	T
P	E	V	S	I	L	V	E	R	K	L	E	C	N	C	N	I	O	O	R
A	W	B	C	V	G	V	V	B	N	P	M	B	V	N	M	R	P	L	I
L	E	V	I	T	A	T	I	O	N	F	P	X	C	A	G	E	L	I	C
O	E	N	W	Q	S	E	S	R	D	E	E	C	V	B	N	M	M	K	S
S	T	M	E	E	S	R	D	G	E	D	R	X	C	V	B	N	N	L	T
S	H	Y	W	U	E	Z	E	A	E	C	A	T	A	L	Y	S	T	S	R
E	Y	H	X	R	N	F	E	N	R	G	T	G	D	O	H	Y	T	E	E
S	T	G	S	F	S	G	D	I	T	V	U	B	R	W	E	S	T	Y	N
A	G	Z	E	R	O	E	V	C	E	G	R	A	P	H	E	N	E	H	G
C	B	R	S	T	R	O	N	G	E	R	E	E	T	G	H	B	N	M	T
A	S	D	R	S	R	E	T	C	B	F	E	T	S	J	K	O	P	C	H
A	D	S	O	R	B	E	N	T	S	A	D	F	Y	U	I	O	P	L	M
Q	W	E	R	T	Y	U	I	K	B	O	T	T	O	M	U	P	C	V	B

Figure 3. Word search on superconductors and Nanotechnology.



Word Search on Superconductors and Nanotechnology

1. The expulsion of magnetic flux from the interior of a superconducting material is known as
---
2. When silicon chips are replaced by ----------Computers work 1000 times faster than
normal computer
3.In the medical field supuerconductors are used for high resolution in ----------
4. Good insulators should have ----------porosity
5. The temperature at which material transit into a superconducting material is known as
---
6. Liquid electrical insulator used as transforming fluid to prevent fire hazards ---------
7. Due to its diamagnetic property superconducting materials exhibit ----------effect
8. Thermal insulator which is soft, flexible and is used in ovens and vacuum cleaners
---
9. Type II superconductors are also called as ----------superconductors
10. The ability of an insulator to store charge is called ---------- constant.
11. Due to high surface area CNTs are used as good ----------
12. La_{2-x} Sr_x CuO_4 acts as ---------- for alcohol vapours
13. Ability of a material to store charge is called ----------
14. The resistance in a Superconducting material is ----------
15. Super conductors are not available as ---------- but are available as only tapes.
16.The only metal which does not react with superconductor materials is ----------
17. ---------- thermal insulators which work upto a temperature of 150°C .
18. Leakage of electricity in an insulator leads to dielectric---------
19. CNTs are prepared by ---------- ablation method.
20. ---------- sheets are rolled into carbonnanotubes.
21. Carbon nanotubes are --------- than steel.
22. Due to ---------- like structure carbon nanotubes are used in drug delivery systems in
medical field.
23. Top-Down and ----------methods are used to prepare Nanomaterials.
24. In ----------method carbon nanotubes are produced by using graphite Electrodes In the presence of ionised gas and 100 amp of current.
25. CNTs are used to store ----------gas to be used as fuel source.

Figure 4. Clues as Fill in the blank.

Activity-4 Cross Word Puzzle: Cross word puzzles are considered as one of the active learning tools [17], as they actively engage the student in the learning process and represent an interesting way for students to learn threshold topics in chemistry.

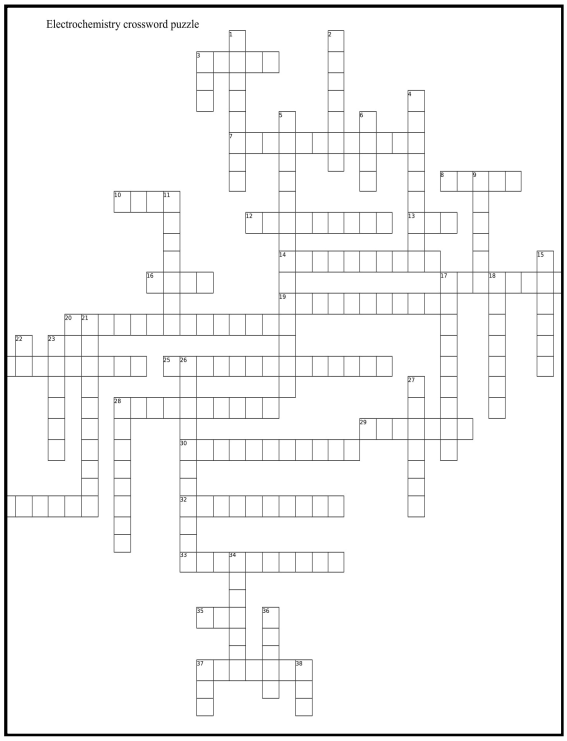
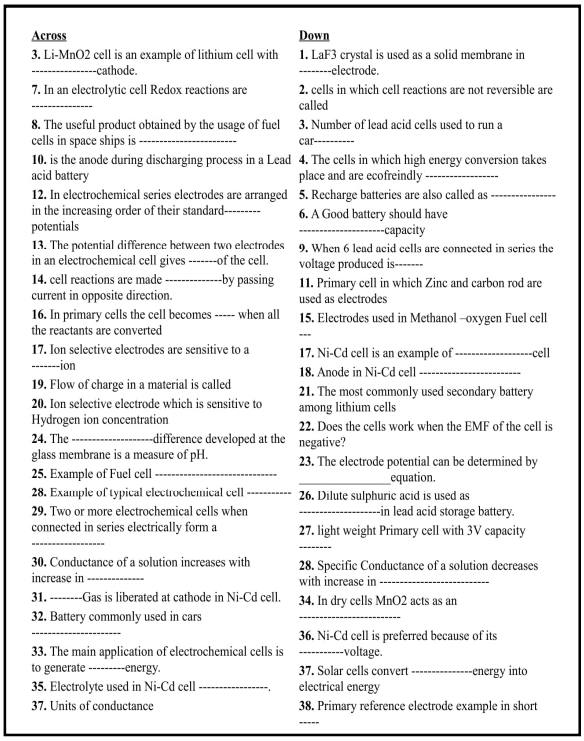


Figure 5. Crossword puzzle on Electrochemistry.



Across

3. Li-MnO2 cell is an example of lithium cell with ----------cathode.

7. In an electrolytic cell Redox reactions are ----------

8. The useful product obtained by the usage of fuel cells in space ships is ----------

10. is the anode during discharging process in a Lead acid battery

12. In electrochemical series electrodes are arranged in the increasing order of their standard--------- potentials

13. The potential difference between two electrodes in an electrochemical cell gives -------of the cell.

14. cell reactions are made ----------by passing current in opposite direction.

16. In primary cells the cell becomes ----- when all the reactants are converted

17. Ion selective electrodes are sensitive to a --------ion

19. Flow of charge in a material is called

20. Ion selective electrode which is sensitive to Hydrogen ion concentration

24. The ----------difference developed at the glass membrane is a measure of pH.

25. Example of Fuel cell ----------

28. Example of typical electrochemical cell ----------

29. Two or more electrochemical cells when connected in series electrically form a ----------

30. Conductance of a solution increases with increase in ----------

31. --------Gas is liberated at cathode in Ni-Cd cell.

32. Battery commonly used in cars ----------

33. The main application of electrochemical cells is to generate ---------energy.

35. Electrolyte used in Ni-Cd cell ----------.

37. Units of conductance

Down

1. LaF3 crystal is used as a solid membrane in --------electrode.

2. cells in which cell reactions are not reversible are called

3. Number of lead acid cells used to run a car----------

4. The cells in which high energy conversion takes place and are ecofreindly ----------

5. Recharge batteries are also called as ----------

6. A Good battery should have ----------capacity

9. When 6 lead acid cells are connected in series the voltage produced is-------

11. Primary cell in which Zinc and carbon rod are used as electrodes

15. Electrodes used in Methanol –oxygen Fuel cell ---

17. Ni-Cd cell is an example of ----------cell

18. Anode in Ni-Cd cell ----------

21. The most commonly used secondary battery among lithium cells

22. Does the cells work when the EMF of the cell is negative?

23. The electrode potential can be determined by _____equation.

26. Dilute sulphuric acid is used as ----------in lead acid storage battery.

27. light weight Primary cell with 3V capacity --------

28. Specific Conductance of a solution decreases with increase in ----------

34. In dry cells MnO2 acts as an ----------

36. Ni-Cd cell is preferred because of its ----------voltage.

37. Solar cells convert ----------energy into electrical energy

38. Primary reference electrode example in short -----

Figure 6. Clues for the Cross word puzzle.

Electrochemistry chapter for I.B.Tech students contains the contents like electrode potentials, types of electrodes working of different batteries like primary, secondary and fuel cells and their applications. Hence to set attention and interest towards this chapter a cross word puzzle is prepared as an activity and conducted in the class which brought good response from the students. Figure 5 and figure 6 show the crossword puzzle and clues prepared in electrochemistry chapter which summarizes the whole content of the chapter.

RESULTS AND DISCUSSION

Significant differences between the two categories of students have emerged in relation with the most effective teaching strategies corresponding to traditional learning style category. Effective teaching practices definitely promote a positive environment in the classroom and help to create interest in the students towards active learning [**18, 19**].

A good teaching method helps the students to question their preconceptions, and motivates them to learn, by putting them in a situation in which they come to see themselves as the authors of answers, as the agents of responsibility for change [**20**]. Active learning methods motivate the students to engage in learning process [**21**]. Hence Conceptual changes are required in the education world which should provide learning by doing methodology [**22**]. Preparation of direct models for the concepts is a challenge [**23**].

In POGIL activity students involve in interaction with peer mates during which they gain knowledge on the concept and also improve their communication skills .This was proved when POGIL activity on Lead acid battery was implemented. The working principle and reactions involved in charging and discharging reaction are learnt thoroughly during the group learning process.

Conceptual learning is the key to success for a student. This is made easy by asking them to prepare CONCEPT MAPS or mind maps of the topics. To study the factors effecting corrosion all the factors based on metal and environment that influence the rate of corrosion in metals can be discussed with the help of a single concept map. Students were asked to draw concept map after discussing the factors in the classroom and they did it with ease.

As discussed brain do needs exercise to perform its function actively. Hence WORD SEARCH activity framed on nanotechnology an emerging science attracted students and they did it with lot of enthusiasm. Especially this activity could get the attention of 75% of the students in the class which included mostly slow learners.

CROSSWORD puzzle actively engaged the student in the learning process and created an interesting way for students to learn the concepts. Student response to the use of crossword puzzles in the classroom has been highly positive during feedback.

Table 1 shows the percentage of students who are supportive to the activity based learning. From the table below it is identified that about 80% of the students are supportive for Cross word puzzle activity and only 20% opted for chalk and talk type of learning. Even power point presentations are catching attention from only 30% of the students. As the visualization has more power than imagination videos shown related to the applications of the topics covered 50% of the students are found to be supportive. All the above activities are framed to involve and engage and enrich students towards deep learning.

Least preference is given to chalk and board (20%) as shown in figure 5 and even the power point presentations (30%) also becoming an unattractive tool in the modern education world. Activities like crossword (80%) and word search (75%) catches the attention as involves fun and enthusiasm. The role of a teacher is to facilitate the activity by encouraging the students to involve in the discussions in

Table 1. Students support to various Instructional strategies

Instructional Strategy	Percentage of Students Supportive
Chalk and board	20%
Power point presentation	30%
Videos	50%
Cross words	80%
Concept maps	60%
Word search	75%
POGIL activity	25%

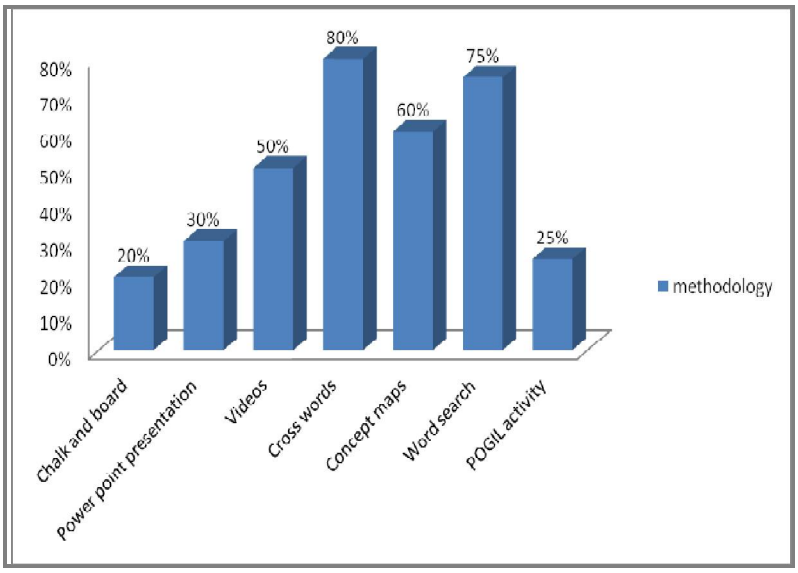


Figure 5. Percentage of students in favor of various activities.

their team and also reminding the time left in between to ensure the completion of the activity in time. From the literature study on active learning methods [**24, 25**], it is also confirmed that good active learning methods simulate authentic problem solving, and therefore teaching with these methods improves learning styles of all kinds of students.

CONCLUSION

The best teaching practice is a combination of student centric together with teacher centric, which builds a good collaboration between student and teacher. As the number of research studies has grown, it has become increasingly clear to researchers that active learning methods achieve better educational outcomes The academic results of engineering chemistry at the end of the 1st B.Tech 1st semester were found to be so promised that planning to design of more activities for all the topics are in progress at present. Hence, this paper reiterates that student centric learning can be achieved easily and can avoid the traditional concept of "I talk, you listen" style as the activity work sheets demand attention from all the types of learners in the class.

ACKNOWLEDGEMENTS

We thank our college management for giving a good exposure towards various teaching processes available like ICT technologies through workshops and conferences and giving us freedom to choose the suitable method of teaching learning styles for students.

REFERENCES

[1]. Nahid shirani bidabadI, Ahmmadreza nasr Isfahani, Amir Rouhollahi, J. Roya khalili , Effective Teaching Methods in Higher Education: Requirements and Barriers, *Adv Med Educ*., **2016**, 4(4), 170–178.

[2]. A. Anderson. The European project semester: A useful teaching method in engineering education project approaches to learning in engineering education, *Journal of Engineering Education*, **2012**, 8, 15–28.

[3]. H. Khnyfr. The higher education system in the world with strategy, *Journal of Cultural*, **2005**, l 3(9), 10.

[4]. Carl E. Wieman, Large-scale comparison of science teaching methods sends clear message, *PNAS*, **2014**, 10, 111(23) 8319-8320.

[5]. Hackathorn, Jana, Solomon, D. Erin, Learning by Doing: An Empirical Study of Active Teaching Techniques, *Journal of Effective Teaching*, **2011**, 11(2), 40-54.

[6]. B. Berger, Applying active learning at the graduate level: Merger issues at Newco Public Relations Review, **2002**, 28, 191–200.

[7]. Khairiyah Mohd-Yusof, Fatin Aliah Phang, Syed Ahmad Helmi Syed, Hassan, Characteristics of Student Centred Learning from the Perspective of Engineering Lecturers, Engineering Education for a Smart Society, **2017**, 9, 343-351.

[8]. Patric Wallin, Tom Adawi and Julie Gold, Linking teaching and research in an undergraduate course and exploring learning experiences, *European Journal of Engineering Education*, **2016**, 1, 58-74.

[9]. Clóvis Luís Konopka, Martha Bohrer Adaime and Pedro Henrique Mosele, Active Teaching and Learning Methodologies: Some Considerations, *Creative Education*, **2015**, 14, 1536.

[10]. L. Rubin, C. Hebert, Model for active learning: Collaborative peer teaching, *College Teaching*, **1998**, 46, 26-30.

[11]. Freeman S, Active learning increases student performance in science, engineering, and mathematics, *Proc Natl Acad Sci USA*, **2014**, 111, 8410–8415.

[12]. Katherine McKnight, Kimberly O'Malley, Roxanne Ruzic, Maria Kelly Horsley, John J. Franey and Katherine Bassett, Teaching in a Digital Age:How Educators Use Technology to Improve Student Learning, *Journal of Research on Technology in Education*, **2016**, 3, 194.

[13]. Michael T. Crimmins, Brooke Midkiff, High Structure Active Learning Pedagogy for the Teaching of Organic Chemistry: Assessing the Impact on Academic Outcomes, *Journal of Chemical Education*, **2017**, 4, (429).

[14]. Tracy Arnold Murray, Teaching students to read the primary literature using pogil activities, *The International Union of Biochemistry and Molecular Biology*, **2014**, 24.

[15]. Johannes Wheeldon, Jacqueline Faubert, Framing Experience: Concept Maps, Mind Maps, and Data Collection in Qualitative Research, *International Journal of Qualitative methods*, **2009**.

[16]. Anthony D.Wagner, Daniel L.Schacteretal, BuildingMemories:Remembering and for getting of Verbal experiences as Predicted by BrainActivity, *Science*, **1998**, 21(281), 5380, 1188-1191.

[17]. Deborah A. Raines PhD, An innovation to facilitate student engagement and learning: Crossword puzzles in the Classroom, *Teaching*, **2010**, 5(2), 85-90.

[18]. J. T. Guthrie, K. Cox, Classroom conditions for motivation and engagement in reading. EducationalPsychology Review, **2001**, 13(3), 283-302.

[19]. Tomlinson, C. A. Tomlinson, The differentiated classrooom: Responding to the needs of all learners Alexandria, VA. Association for Supervision and Curriculum development, **1999**.

[20]. A. S. Macsuga Gage, B. Simonsen, D. E. Briere, Effective teaching practices that promote a positive classroom environment, *Beyond Behavior*, **2012,** 22(1), 14–22.

[21]. A. Dorestani, Is interactive learning superior to traditional lecturing in economics courses Humanomics, **2005**, 21, 1–20.

[22]. W. W. Cobern, Worldview Theory and Conceptual Change in Science ducation. Paper presented at the National Association for Research in Science Teaching, Anaheim, **1994**.

[23]. Van Breukelen, D. H. J., M. J. De Vries, F. A. Schure, Concept Learning by Direct Current Design Challenges in Secondary Education." International Journal of Technology and Design Education, **2016**, 1–24.
[24]. Isabelle D.erney, The effects of active learning on students' memories for course content, **2008**, 9(2).
[25]. S. Singer, N. Nielsen, H. Schweingruber, Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and engineering (National Academies Press, Washington, DC). **2012**.