

Enhancement of Learning Levels in Engineering Chemistry through Effective Use of Tutorials

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Abstract: Chemistry plays a major role in building backbone for engineering education. To fulfill needs of rapidly changing society it is mandatory for engineering professionals to understand developments in chemistry. Tutorials are one of the methods of pedagogy. Existing research didn't point to any precise estimation of improvement in understanding of the course by weak students through tutorials. With this aim, a student sample was administered with tutorials for entire engineering chemistry course content of 1st year B.Tech students in the college. As a first step, the course in chemistry was completed through conventional teaching pedagogy and a pre-test was conducted. Thereafter a structured tutorial containing demonstration, lecture, video and experimentation was administered to the students in all five units of the syllabus. This was followed by a post-test to estimate enhanced learning of the students in the subject. By comparing students' performance in pre-test and post- test, it emerged that learning levels of weak students has substantially increased as compared to the bright students

Keywords:

Engineering chemistry, Tutorials, Integrated pedagogy, enhanced learning

1. Introduction:

The science of today is technology of tomorrow. ABET 2000 criteria brings out the use of tutorials for refining design process [1]. Elsewhere in a different field, the tutorials were used for identifying differences in CMMI levels in computer science course [2]. The design of the tutorial was based on model analysis by CSI inspectors through time division technique for different topics [3]. Certain universities in the USA have utilized tutorials for placement of students in department of chemistry very effectively and this led to adoption of tutorial methodology in chemistry for improving student scores [4]. Newly designed tutorial as compared to traditional tutorial can lead to better performance of the participants if the structure follows time division for different pedagogical tools (video, demonstration, lecture and experimentation) on selected topics [5]. Better grades in the university, improved behavior and enhanced motivation among students are possible by conducting tutorials [6]. A paper on improving performance of students on Data Structures brought out that enhanced performance of students is possible through tutorials [7]. While developing curriculum in the universities it was observed that the value addition can be accrued by tutorial design [8]. Tutorials as one of the pedagogy tools was recommended both by students and faculty for better comprehension [9]. Among the several techniques employed for improving students' active learning, tutorials was found to be an effective method in Agricultural Engineering [10]

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Literature survey establishes that the tutorials as a pedagogy contributes to better understanding of the courses and even refining the design process. However, they don't bring out any estimation of the improvement in understanding and performance particularly by weak students as compared to bright students. This paper is an attempt in bridging this gap in the existing research. It is an endeavor to estimate the improvement in performance of the weak students as compared to bright students through well-structured tutorials in chemistry.

2. Methodology:

Research design: Engineering Chemistry(EC) course as laid down by the university for B.Tech first year, contains five units on water and its treatment, batteries, polymers, fuels and combustion and cement and its constituents. The entire course was taught to a sample size of 107 students of the first year, through conventional teaching pedagogy and a pre-test was conducted which consisted of both subjective and objective questions.

Thereafter the following method was followed for the research.

Method of conduct:

- (i) A tutorial consisting of selected topics from each unit of the syllabus, which were important from the university examination point of view (to attract the attention of the students) was prepared. All together 10 tutorials were conducted in Semester-I in a span of 16 weeks. Each tutorial contained

various teaching methodologies such as video presentation, experimentation, lecture and demonstration.

- (ii) Guidelines for conduct of tutorials for 2hrs schedule sub-topic wise were issued to students. The absentees were asked to solve given problems at home and read prepared material prior to conduct of tutorials. This planning led to smooth implementation and better understanding by students.
- (iii) Help of a co-faculty was taken for conduct of tutorial classes. The sample of 107 students was divided into two sections.
- (iv) Tutorials of 2 hours duration, consisted 20mins introduction to topic, 70mins discussion on the topic by following pedagogy such as demonstration of 15mins, lecture of 10mins, video of 15mins and followed by live example/ solving problem for 35mins, and a test of 30mins.
- (v) Post-test was conducted out of 100 marks (75+25), which included both subjective and objective parts respectively.
- (vi) Students were divided into 6 groups of 10 each for evaluation with four performance parameters of excellent, good, average and poor, to bring in comparative performance and competition among them.
- (vii) Method of conduct is illustrated in the table below.

Table 1: Five units of syllabus of course in EC, selected topics for tutorials, duration, method of conduct and remarks.

Sl.No.	Units	Tutorial conducted on selected topic	Duration	Methodology/content of tutorials.	Remarks
1.	Water and its treatment	Estimation of hardness of water	2	Experimentation and demonstration.	Experimentation was done by faculty.
2.	Electrochemistry	Batteries	2	Video presentation, real world example and problem solving.	All groups were made to strip and assemble batteries.
3.	Polymers	Plastics, fibers and Moulding	2	Video presentation, lectures, and factory visits for a day.	Discussion was held after the video and the Factory Visit.
4.	Fuels and combustion	Analysis of coal	2	Video presentation	Discussion
5.	Cement and its constituents	Refractories and lubricants	2	Video presentation and Demonstration.	Discussion

Results and Discussion:

The difference in scores of the students in post-test and pre-test were calculated. Data was analyzed by SPSS software. Descriptive statistics of range, mean, standard deviation and difference in scores between pre-test and post-test were found. Table 2 indicates the statistics.

- (i) Range: Ranges of both pre-test and post-test scores are equal to 60. This indicates that the difference in scores of the highest and the lowest before and after the tutorials remained the same. However, the minimum and maximum scores for post-test have improved substantially. The range for the post-test score is 35 minimum and 95 maximum, while for pre-test they are 20 and 80. This indicates over-all improvement of 15% in scores in the sample after administering tutorials.
- (ii) Mean: The means of post-test and pre-test scores are 75 and 59. This indicates that the mean score of the sample has increased by 16%. This exhibits a considerable jump in the scores of the students after the tutorials. Standard error and the standard deviation of the scores of post and pre-tests are nearly equal, indicating that the variance of the scores or the distributions of the scores in both the tests are similar. Also, the Histograms at figure 1 clearly exhibits the shift in the mean of the post-test scores to the right or 'Right skewed' distribution as compared to the pre-test scores. The "Individual plot of pre-test and post-test

scores' at figure 2, clearly shows the jump in the mean of the distribution (the blue line the plot). The dispersion of individual scores (dots in the figure), is more in the pretest scores below the mean, while they are clustered closely above the mean in the case of post-test scores.

- (iii) Difference in Scores: The range of 'Difference in scores' is 31, while the minimum difference is 3% and the maximum is 34%. This indicates some students have dramatically improved their scores while some others have not improved much. Such variation is good as the difference is not uniform and leads to further investigation of which category (weak or bright) students have got benefitted the most. This is supported by large standard deviation of 6.2 over a mean of 16. For further understanding of the results, the 'Difference in scores' were divided into four classes as under and are shown in a PIE diagram at figure 3 also:

- (i) Class interval 3 to 10 constituting 13% of the sample (14 students),
- (ii) Class interval 11 to 18 of 58% of the sample (62 students),
- (iii) Class interval 19 to 26 of 23% of the sample (24 students) and
- (iv) Class interval 27-34 of 6% of the sample (7 students).

Table 2: Range, Mean and Standard Deviation of Scores of students for Post-test and Pre-test and their differences.

	N(Number)	Range	Minimum	Maximum	Mean		Std.deviation
		Statistics	Statistics	Statistics	Statistics	Std.error	Statistics
Score of students after tutorial(post - test)	107	60	35	95	75	1.35	13.9
Score of students before tutorial(pre - test)	107	60	20	80	59	1.36	14.1
Difference in score between post and pre test.	107	31	3	34	16	0.6	6.2

The analysis of figures in the pie diagram reveals following points:

- (i) More than half of the sample (58% of the students equal to 62) fall in the class interval of 11%-18%

improvement in scores;

- (ii) 13% of the students equal to 14, fall in the class interval of least improvement of 3% to 10%;

- (iii) Only 6% of the students equal to seven, fall in the class interval of most improvement of 27% to 34%;
- (iv) The outliers in the distribution can be classified into two classes as under for analysis purpose (Table 3 refers):
 - a) First class' of students of most improvement in scores from 27% to 34%, constitutes 6% of the sample equal to seven students, and are at serial numbers 24,30,37,56,57,77 and 87. All of them except one (serial number 37) have scored 52% or less in the pre-test.
 - b) Second class' of students of least improvement in scores from 3% to 10% constitutes 14% of the sample equal to 14 students, and are at serial numbers 3,6,29,40,48,51,63,64,66,76,81,93,97 and 106. In a total of 14 students in this class, exactly half each have scored above 52% and below.

Therefore, by dividing the pre-test scores into two classes as the 'First class' and the 'Second class' with scores of 52% or less and above 52% respectively, it may be seen that the 'First class' (except one student) have attained maximum improvement of 27% to 34% after the tutorials were

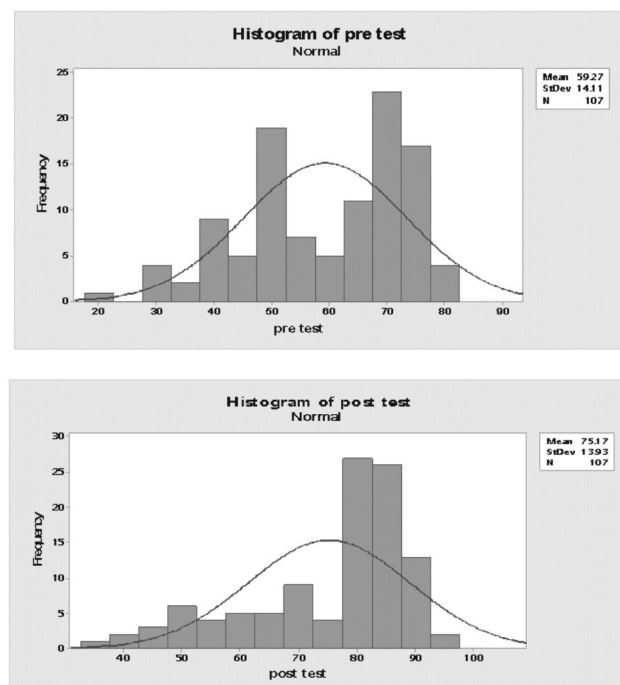


Figure 1: Histograms of distribution of the pre-test and post-test scores of students

administered. Similarly analysing the 'Second class' with least improvement of 3 % to 10%, it is evident that exactly half of this class is divided into more than 52% and less in pre-test scores. Therefore it can be inferred that the tutorials benefit weak students more than the bright ones, which is the aim of any pedagogy in teaching. This establishes the efficacy of the tutorial method of pedagogy in generating interest in the weak students to improve their performance.

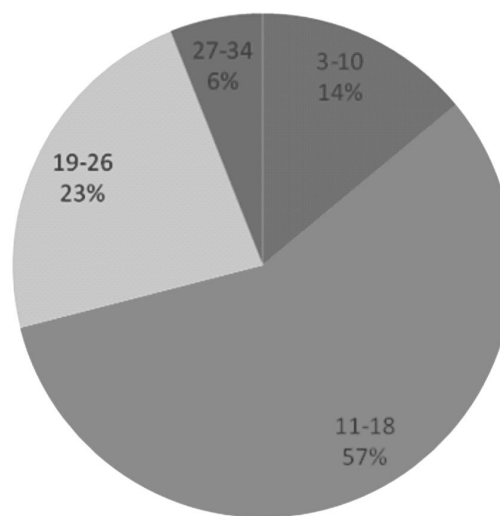


Figure 3: PIE diagram indicating four classes of improvement in scores with percentage of students in each class.

3. Conclusion:

The discussion in this paper majorly contributes to the students learning enhancement through tutorials, which has been done by using various pedagogy for all the topics in engineering chemistry. Various pedagogical approaches such as demonstration, lecture and video presentation were used to impart knowledge about various topics in the course. A pretest was conducted to assess learning affected and then the treatments were applied to the sample in the form of tutorials for all 5 units in the course for a total of 10 hours followed by a post test. The results of the post-test for entire course were compiled and analyzed using by SSPS SOFTWARE (version 20.0), to bring out the effectiveness in learning enhancement. The results of the analysis have clearly shown that the mean performance of the students has improved substantially, with marked improvement in performance of poor students, as compared to their performance in pretest. Addressing

Table 3: Individual student's pre-test and post-test scores with their differences

Sl. No.	Pre test	Post test	Difference	Sl. No.	Pre test	Post test	Difference	Sl. No.	Pre test	Post test	Difference	Sl. No.	Pre test	Post test	Difference
1	77	89	12	31	55	78	23	61	68	83	15	91	68	80	12
2	65	86	21	32	68	81	13	62	73	86	13	92	78	89	11
3	40	50	10	33	72	88	16	63	69	78	9	93	78	88	10
4	42	55	13	34	66	86	20	64	71	79	8	94	68	79	11
5	50	64	14	35	65	81	16	65	50	69	19	95	55	78	23
6	32	40	8	36	28	48	20	66	48	51	3	96	74	85	11
7	70	85	15	37	60	87	27	67	68	78	10	97	57	62	5
8	78	90	12	38	42	60	18	68	55	78	23	98	69	80	11
9	50	70	20	39	45	58	13	69	35	55	20	99	28	40	12
10	30	45	15	40	48	52	4	70	75	93	18	100	51	70	19
11	60	85	25	41	70	89	19	71	69	85	16	101	72	85	13
12	58	80	22	42	51	76	25	72	41	65	24	102	67	80	13
13	65	83	18	43	48	65	17	73	72	85	13	103	69	82	13
14	76	87	11	44	47	72	25	74	73	86	13	104	68	81	13
15	77	90	13	45	50	68	18	75	71	82	11	105	48	62	14
16	55	76	21	46	61	80	19	76	71	81	10	106	72	78	6
17	62	78	16	47	65	86	21	77	52	85	33	107	64	79	15
18	56	73	17	48	35	45	10	78	77	88	11				
19	45	68	23	49	48	59	11	79	77	92	15				
20	45	66	21	50	68	84	16	80	64	82	18				
21	38	51	13	51	50	55	5	81	75	85	10				
22	80	95	15	52	68	84	16	82	75	87	12				
23	20	35	15	53	64	84	20	83	76	88	12				
24	45	79	34	54	75	90	15	84	75	88	13				
25	66	82	16	55	50	72	22	85	74	85	11				
26	52	70	18	56	48	80	32	86	40	55	15				
27	75	90	15	57	42	69	27	87	52	85	33				
28	55	67	12	58	50	75	25	88	74	86	12				
29	38	45	7	59	38	50	12	89	71	83	12				
30	52	82	30	60	65	83	18	90	69	81	12				

the gap in the existing research in estimating the improvement in the performance of weak students versus bright students, it was established that the tutorials as a pedagogy benefits the weak students more than the bright, in comprehension and performance in tests.

Moreover handling a large classroom and addressing the queries of students by a faculty was always difficult during normal teaching sessions. By administering tutorials and with the assistance of co-faculty, it was possible to guide the students and address their queries, while permitting discussion among themselves with real world examples leading to enhanced learning. In addition improvement was observed in team building, conceptual understanding, communication skills, exploratory learning, listening skills, confidence levels and time management.

Limitations:

Sample size: The research was limited to one section in the first year. In the next semester it is planned for the entire strength in all branches.

Curriculum design: Syllabus doesn't include

important topics in chemistry influencing the environmental sustainability such as 'Theory of corrosion', 'waste disposal' and 'e-waste management' and 'topics of molecular chemistry'. These topics are considered important for the engineering students to understand the impact of engineering on the 'Environmental sustainability'.

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