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Impact of Integrating Self-Study Module in Chemical Engineering Course

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Abstract: In the current day method of instruction contextual education is the unique method to express learners the concepts that are being trained in a subject domain to physical industrial problems. Students are open to real-life problems to assimilate and increase the knowledge proficiencies from multidisciplinary developments that can enhance their engineering awareness talents, ability to work in diverse team. On other hand through self-study teacher gain deeper understanding of how to nurture motivation technique of teaching in classroom. Assessing students on basis of their critical thinking, creativity, attitude towards task, and approach towards the solution of engineering problem play a critical role in motivational technique of teaching learning process.

Motivation derives from quantifying the students learning. This paper compares attainment of program outcomes (POs) and Course outcomes (COs) for comprehensive course with and without incorporating self-study module. Finally it is found that more percentage of outcome is achieved through implementation of self-study programme. The main findings from the self-study showed progressive outcomes regarding learning, organizing, time disbursed in the laboratory, creative thinking and student insight.

Keywords: course outcomes, self-study, program outcomes, engineering skills

1. Introduction

Self-study encourages students to learn by their own with proper supervision and motivation from the course instructor. A part of the course can be included as self-study component that covers different aspect of learning objectives. The self-study components includes open ended experiment, case study, problem solving using modern software tools, analysis and presentation of real world applications and problems. The outcomes of the course are achieved with the help of these components by improving students' knowledge, skill and attitude towards learning. Desired outcomes are attained by well-organized and continuous improvement of teaching components. In conventional course with pre-defined laboratory, students have very few opportunities to apply their critical thinking, innovative ideas and think out of the box . Open ended experiment provides students a platform to develop model, design and carry out experiments by applying their innovative ideas and get desired and sustained product . Case study, analysis and presentation of real world problems as a part of self-study gives student an opportunity to understand and analyses the real world problems by their own and apply their knowledge and skill to solve those problems and present effectively the outcomes

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of their contribution . Problem solving using modern software tools as a part of self-study component gained interest among students for effective and easy tackling of problems. This provides precise result and consumes less computing time to solve problems . Though various self-study components gained tremendous interest among students but some time it fails due to lack of constant motivation and supervision form the instructor . In this article it is shown that introduction of Self-study and constant motivation from instructor improves student's attitude towards learning and better attainment of program outcomes.

2. Methodology

To perform the investigation chemical engineering course for set of students were chosen namely Mechanical Operations.. This course is presently called as integrated course as courses is tied up with theory - 3 credits, lab component - 1 credit according to the curriculum. After including self-study module - 2 credits these were termed as comprehensive course in the new designed curriculum. Set of 70 students were assigned different activities such as open ended experiments, hands on experiences using MS Excel, Presentation on industrial application based topics related to course content. Open ended experiment in the sense that new alternative experiment was framed by students based on the available resources and students were made free to choose their own initiative and creativity. Most of the experiments were aimed to do comparative study over the conventional lab experiments.

Undergraduates were allocated into groups each consisting of maximum four members. To each group one lab experiment is allotted to perform open ended experiments. Students were guided by teacher well in advance what is expected as input and outcome from experiments, where the role of teacher is a facilitator. As open experiments were identified as comparative study, students were asked to submit report in the form of IEEE format for presentation and publication of their work. This activity proved to satisfy the program outcomes related to design alternative chemical process, interpret data to provide valid conclusion, team work and function effectively as a supporter or forerunner in different groups.

Hands on experiences using MS excel made students to learn how to carry out calculation work effortlessly and most importantly how to analyze and interpret the data using plotting tool. Students were taught in special sessions how to use MS Excel and later were questioned to perform tedious lab calculations such as plotting data and finding area under curve. Idea of teaching MS Excel in third semester was to make sure they develop computing and analyzing skill with an understanding of limitations to complex engineering problems. This activity proved to be satisfying the program outcome related to life- long learning, selecting and applying modern engineering IT tool.

Presentation is another activity which is incorporated under self-study. Each group is given a topic related to application aspects in today's need of sustainability. Students were assessed based on their technical content delivery, effective communication, time management, and team work. This activity too proved to satisfy program outcomes related to individual and team work, communicate effectively and usage of modern tool.

3. Analysis

As part of curriculum and course design review, course outcomes of the courses in a program are mapped to the primary program outcomes. Program mapping supports the association of course level effects with the program outcomes. It permits faculty to create a visual plan of the program. It is also used to explore how students are meeting program-level outcomes at the course level. Outcomes mapping mainly focuses on student learning. There are some benefits of outcome mapping like how the necessary courses add to the success of program outcomes, rises

Table 1. Program outcomes

Program Outcomes (PO's)	
PO1	Engineering Knowledge
PO2	Problem Analysis
PO3	Design/development of solution
PO4	Conduct investigations of complex problem
PO5	Modern tool usage
PO6	The engineer and society
PO7	Environment and sustainability
PO8	Ethics
PO9	Individual and team work
PO10	Communication
PO11	Project Management and finance
PO12	Life – long learning

learner success in meeting program effects, reveals gaps in curriculum design, reduces the amount of formative assessment required as much focus can be shifted towards program assessment projects based learning. The overview of Program Outcomes (PO's) is mentioned in Table 1. Mapping of course outcomes to respective program outcome for the undergraduate stuides is mentioned below in Table 2.

The course outcomes are mapped to particular Program outcomes in such a way that they satisfy respectively as shown in Table 2. Student is assessed self-study component on three modules like open ended experiment, presentation and usage of modern tool as specified below with well-defined rubrics in Table 3, 4 and 5. There are total of 64 students in class enrolled for Mechanical Unit Operations. They were divided into 15 groups each group having 4 people. Each group is supposed to complete all the three modules namely open ended experiment, presentation and drawing graphs using MS Excel (modern tool usage). During this process students were allowed to converse, work in group and deliberate among peers for the complete development of laboratory investigation until the finish of technical article submission. This course is a core chemical engineering course so it has lab component attached to it. Apart from conventional lab instruction-based laboratory approach students are assigned an open ended experiment. In both the cases the results were characterized as determined as it is in accordance to the application theme and apparatus accessibility. For both cases, the application phases were characterized into theoretical, investigational work, analysis (comparing/inference) and description text.

Table 2. As Per the Curriculum Mapping of CO to PO for Tutorial/ Lab/ Self-Study Components

Course Title	Course Outcome	Program Outcome
Mechanical Unit Operations	CO 1. Apply the basic working principles of different size reduction equipment for particle size analysis	PO4
	CO2: Design and analyze the flow of fluids through bed of solids and fluid layers.	PO1/PO3
	CO3: Familiarize with the different types of mixing, agitation and solid conveyers.	PO2
	CO4: Acquaintance of the principles of separating high value solids.	PO2
	CO5: Conduct experiments for particle size analysis separation of high value products by filtration, sedimentation and decantation techniques	PO5/PO9/ PO10/PO12

Table 3. Rubrics for Open Ended Experiment

Assessment Component	Parameter of Assessment	Range Score Criteria				PO	Marks Weightage
		Inadequate	Average	Admirable	Excellent		
Problem Identification/ Statement	Literature Review	Irrelevant	Relevant but insufficient	Sufficient information	Sufficient and up to date in formation	PO2	20%
Design of Experiment	Design a procedure/process	Insufficient for adequate understanding	Understanding but not presented clearly	Sufficient information and effectively presented	Sufficient information and exceptionally presented	PO3/ PO 12	20%
Conduction	Select, Execute and Tabulate	Inappropriate format	Properly formatted	Most appropriately formatted	Everything formatted properly	PO4	20%
Results Analysis	Plot, Calculate and Analyze	Data hard to read	Majority of data clear	Most of the data clear and well formatted	All data clear and well formatted	PO4/ PO5	20%

Report Writing	Document	Not documented properly	Documented but not presented properly	Documented and effectively presented	Well explained and documented and exceptionally presented	PO4	10%
Peer review	Evaluation among the group	Not evaluated	Evaluated	Evaluated effectively	Evaluated effectively with justification	PO 12	10%

Table 4. Rubrics for Presentation

Assessment Component	Parameter of Assessment	Range Score Criteria				PO	Marks Weightage
		Inadequate	Average	Admirable	Excellent		
Presentation (Model/PPT/Video)	Organization of concepts and information	Hard to follow	Understandable	Information is in sequence and easy to follow	Information presented in well logical sequence	PO5/ PO3	20%
Technical content	Industrial application and advanced research	Material not related to topic	Material sufficient with atleast one industrial application	Presented with sufficient information	Relevant information with related applications and advanced research	PO2/ PO3	20%
Communication Skills	Effective and clear oral presentation	Low audibility	Clear in pronunciation	effectively presented with good eye contact	Exceptionally presented with good gestures and facial expressions	PO 10	20%
Understanding on Topic	Questions answered on topic	Not able to answer basic questions	Able to answer few questions	Able to answer most of the questions	Answered all questions elaborately	PO1/ PO 12	20%
Time Management and Team Work	Prioritization Skills/ Foster creativity and learning	Too short or dragging	Dragging on few parts	Well-paced	Well-paced throughout appropriate	PO9	20%

Table 5: Rubrics for Use of Modern Tool – MS Excel

Assessment Component	Parameter of Assessment	Range Score Criteria				PO	Marks Weightage
		Inadequate	Average	Admirable	Excellent		
Usage of Modern Tool	Familiarity	No usage of tool	Used but with errors	Effectively used	Efficiently used	PO5/ PO 12	30%

Interpretation of data / Data Organization/Formula Calculation Features/Charts	Calculate Diameter of particle/Integral solution, Area under the curve	Inappropriate format	Explained reasonably	well formatted and clearly explained	Well organized and demonstrated clearly	PO5/ PO4	50%
Analysis/Inference	Compare with the theoretical value	No result	Manipulated result	Appropriate result	Results with Inference	PO5	20%

Table 6. Result Analysis of Students

Strategy for attainment of particular PO	Justification
No of Students Answered >50%	If marks scored by a student are greater than 50% of the total allotted mark for a particular PO it is considered that PO has been attained.
No of Students Not attempted	It is considered that remaining set of students have not achieved that particular PO
Total Marks scored by all students	Adding up all the marks scored by the students who answered the particular question (A_1)
Total Marks scored by students who have obtained >50%	Sum the marks secured by students (A_2)
Aggregate Marks to be scored by students who attempted	Sum of the marks scored by students who have attempted (A_3)
Percentage accomplishment of POs for all who attempted (M_1)	$M_1 = (A_1/A_3)*100$
Percentage attainment of POs for >50% attempted (M_2)	$M_2= (A_2/A_3)*100$

The alterations of methodology at each phase were distinguished on various perception (lab and testing measurement) assigned to students, fixed time structure, teacher and supporter role, and the organization of written report and assessment feedback/observing practices. During presentation they are asked to evaluate their peers towards their individual contribution. They are assessed in terms of problem identification, how they are going to conduct the experiment, calculate, analyze and document their findings by interacting in group. All these parameters were assessed during last two weeks before the semester end with the supporting rubrics is in Table 3.

Next coming to the presentation, students are asked to present in class with their assigned topics. These topics were based on application oriented where, they have to review research literature and visit industries to get to know what kind of unit operations are used in size reduction in various industries. During this process students were allowed to converse, work in group and deliberate among peers through the entire practice until accomplishment. Each group is allotted 8 minutes for the presentation and 2 minutes for questions. They are assessed on the basis of organization of concepts, industrial application of each unit operation and process, communication skills, understanding on the topic, time management and team work. The parameters for assessment of presentation module rubrics are in Table 4.

Coming to the usage of modern tool students are given some insights on plotting graphs using MS Excel. So even for the laboratory record work they are supposed to paste this excel graphs instead of manually drawing. By implementing this tool it is able to satisfy the program outcome relating to use of modern tool. Students are assessed on the familiarity of tool, interpretation of data and inference obtained by comparing with the theoretical values. The parameters of assessment for this module with the supporting rubrics are in Table 5.

The practical component is based on still developing the same existing apparatus and themes as in the subject learning effect and goals, only the training and knowledge application has been reformed with the introduction of self-study component. This confirms that an undergraduate not only have a thorough acquaintance in the definite program they also can have a comprehensive flexibility and acceptance. In order to accomplish the program outcome the core curriculum for the program is designed in a manner that the students become competent in all the 12 Program outcomes. The subjects/themes are taught to the undergraduates by implementing various teaching practices like class room based teaching, laboratory tests, conducting seminar and projects. Each course is aimed with specific CO's and each CO is mapped to the respective PO. The accomplishment of CO's is measured by evaluating student's performance. Their progress is organized and evaluated using MS Excel software taking all modules and continuous internal evaluation into consideration which is shown in Table 6.

As a case study one of the groups were given an open ended experiment on to carry out the experiment with different feed materials like coal, granite powder and cement to determine their average particle size by beaker decantation method and plot the particle size distribution curves. So in this process they have to understand the problem statement, conduct an experimental study where they have to select the equipment, execute it and later tabulate the results. Then plot the respective graphs and analyze average particle size for the different materials and document the results in a report format. So this covers two parameters like conducting open ended experiment, usage of modern IT tool where they perform the experiment and analyze the data for different materials by doing calculations. Now represent this data by using modern tool like MS Excel in the form of a graph whereby we can assess the interpretation of data, data organization, formula calculation features and charts. Compare their results with theoretical value and report their inference from the results obtained. Next parameter is presentation they were asked to discuss about the various pelletization techniques used in pharmaceutical industry. They are assessed on organization of their information related to given topic, its industrial application and advanced research in that area, how effectively they are clear in their thoughts about the concept during presenting, their understanding towards the topic and time management skills their prioritization ability, creativity and learning abilities. So based on these parameters they are assessed with the respective rubrics mentioned in Table 3, 4 and 5.

4. Findings and Discussion

Analysis is based on total registered students for this course. The performance of students is assessed as seen in Table 6. If marks scored by a student is greater than 50% of the total allotted mark for a particular question, it is considered that the specific program outcome mapped to that question has been attained. The effect of self-study on undergraduate attainment is difficult and facilitated by a series of other aspects affecting success. It is clear that their efficiency is closely related to how the technology is used as an informative tool. It is found that students understand best with self-study component by interactively involved in learning technical content. As in this course with the introduction of using MS Excel and conducting open ended experiments has enabled them to correlate, analyse and improve their thinking capability. The introduction of self study component has enabled teachers to get an overall idea of students possessing different skills.. Using technology can reassure students, predominantly underperforming undergraduates, to study. Word processing and excel usage software improves writing skills where they draft a report on the open ended experiment they have conducted by concluding it with an inference and represent their results in the form of a graph. It is seen that students have scored a higher percentage attainment of CO's and PO's compared to without the implementation of self-study component as seen in Table 7. . In table 7 its seen that though there is small change in percentage attainment of PO4 for CO1 attainment by implementing self-study. As by asking them to write a report would enable us to assess their generic skills such as technical content and computer literacy. We can try to get a better picture regarding the performance of individual on different skills they possess as they perform in groups. Skills like coordination and leadership skills, analysing given tasks, questioning, organisational and time managing abilities.Though the percentage increase is less by implementing self-study component it gives us an overall performance in which particular area students is performing better. Providing technology on its personal has slight influence on accomplishment. Substantial effort need be put into core curriculum improvement, valuation

restructuring, and formative assessment. The impact of self-study on instructors and teaching counterparts that of students comprises the teaching regularly changes from a teacher - centered classroom atmosphere to a more learner - centered setting consenting more effective use of technology tools. Students gain self-confidence, self-respect and improved inspiration in self- study situations. The correlation is up to the teaching learning development is continued in order to develop the accomplishment. If it is satisfactory the level of attainment can certainly increase by varying the accomplishment formula. So comparatively the PO attainment is higher by introducing the self study component.

Table 7. Course Outcome and PO Attainment

CO	PO Attainment by implementing Self Study (%)	PO Attainment before implementing Self Study (%)
CO1\PO4	76.34	72.35
CO2\PO1,PO3	71.25	65.43
CO3\PO2	78.4	76.19
CO4\PO2	75.58	73.35
CO5\PO5,PO9,PO10,PO12	82.85	

5. Conclusion

Result analysis shows that with introduction of self-study component the attainment percentage of program outcome has a considerable increase compared to without self-study component.

The non-traditional learning methodology nevertheless has improved student position performance and advanced course outcomes (CO) accomplishment as examined in this paper. In summary, there is comprehensive realistic support for the principal evidence of cooperative education, team work that collaboration is further effective than competition for encouraging a variety of positive learning results. These results shown in Table 7 comprise improved academic success plus a number of program results. In addition, this self-study component knowledge delivers an accepted environment to improve interactive expertise and there are sensible arguments and data to show the efficiency of teamwork in this aspect. Though the results differ in strength, this study has found support for all forms of active learning strategies by executing self-study component. It is found that all students were engaged in all the activities by which it can support us with valid conclusions about the performance of each student in various aspects. Through this special attention can be provided in the skills where they are lacking. On the other hand without the self-study component it is found that overall performance is good enough but has no idea about their performances in individual aspects. So it gives a generalized idea about individual performance, their strengths and where they are not performing better. Apart from the conventional course work by which it could achieve only few program outcomes it is seen that by making this course as a comprehensive course where the teachers were able to satisfy multiple program outcomes by acting more likely as a facilitator.

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