Journal of Engineering Education Transformations,
Volume No. 37, January 2024 Special Issue, eISSN 2394-1707

Redesigning of Signals and Systems Course to Emphasize Problem/Project Based and Experiential Learning

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***Abstract*: The prime trait of engineering education which persistently challenges to tide over classroom and real-world scenario is its cornerstone on fortifying future technocrats to design and implement various systems of engineering. This paper introduces the experimental study of signals and systems course in an under graduate(UG) program by using problem/project-based learning at Anurag University, which makes the learners to acquire iterative and collaborative skills to solve real world complex problems in practical approach subjects. The major objective of this framework is to enrich the conventional course of study with value creation, responsive content, practices and larks providing a competitive scope to learners. The specified approach do enhances the learning spirit among the learners by doing the things which intern results in experiential learning. The problem/project based learning enactment frame and constructive alignment of course outcomes, teaching/learning methods and assessment are specified in the paper.**

Keywords*: *Constructive alignment, Engineering education, Problem/Project-based learning, Signals and Systems

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I. INTRODUCTION

Problem based learning (PBL) is an instructional student centered teaching approach that propounds the latent to help students to incorporate flexible understanding and lifelong learning skills. Holgaard, J. E et al (2017) specified that the problem based learning advocates experience-based education and may not be simply hands on activity but involving the students to learn by doing. It brings positive insights for student learning with the integration of theory and practice, which inculcates the motivation to learn. The teacher facilitates the learning task rather than to provide knowledge. It makes the students to become the drivers of their learning education strategy. It creates more student-centered classroom environment and makes the teachers more to be a facilitator in addition to subject delivery. It promotes development of critical thinking skills, problem solving skills, creativity skills, team working culture, deeper involvement of students in learning, collaboration, decision making, social emotional learning, personalized learning, multiple stage analysis of problem taken, improving the understanding capability of concepts at a deeper level. Students do get engaged in self-directed learning which helps them to apply their gained knowledge to the problem. It helps the students to develop flexible knowledge and intrinsic motivation, and to learn concepts instead of just absorbing the facts which improves analyzing skills. The general constructive alignment framework is shown in Figure 1.

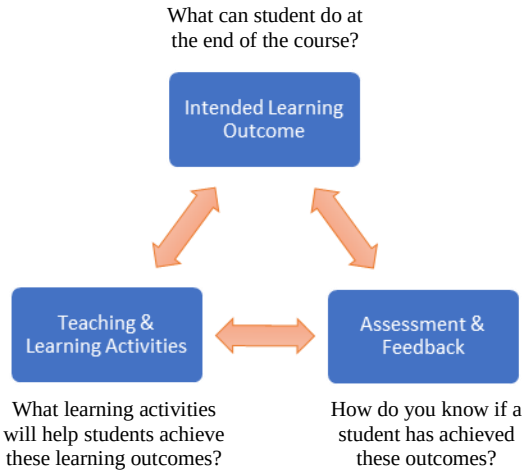

Figure 1. Constructive Alignment Framework

Du, X.Y. & Lundberg, A. (2021) specified that the learning via projects, often known as Project-based learning (PJBL), is widely regarded as an effective instructional method. It places an emphasis on learning that is learner-centered and is guided by the principle of learning by doing, which improves critical thinking, the capacity to solve issues, teamwork, cooperative learning, and dedication to reaching the goals. Students' learning capacities may be improved via the use of the engaging summary that is produced by PBL and PJBL. It is an educational method that is focused on the learner and is centered on inquiry. This strategy encourages learners to interact with a complex, ill-formed topic that requires more exploration. Du, X.Y. & Naji K. E et al (2021) specified that the spirit of meta cognition, as well as self-motivation and tweeting up in learning, may be inculcated in learners via cooperative and inquiry-based learning. On the other hand, in PJBL, the issue is taken as the beginning point, and the project is regarded to be the driving grid to sort out a solution for the problem that was selected for. In PBL, the problem is believed to be the centerpiece of the learning element. However, in PJBL, the problem is taken as the centerpiece of the learning component. The restrictions may be understood in terms of the time and resources that are now available. Du, X.Y. & Kolmos, A. et al (2021) specified that the PBL/PJBL implementation strategy requires significant planning and management expertise. In the current context, problem-solving topics such as signals and systems are among the disciplines with a great deal of research potential. PBL/PJBL will undoubtedly provide students with the practical and project-based experience necessary to comprehend and determine solutions for problems involving various concepts of signals and systems. This paper's primary objective is to describe how PBL/PJBL significantly enhances experiential learning by harmonizing course outcomes, teaching/learning methods, and assessment. In general, the signals and systems course is signalized with a high level of mathematical analysis and abstract thought. When students must consider both the frequency and temporal effects of signals, comprehension and analysis become mathematically challenging. As an experimental approach with one of the subjects which has the content of theory and practical approach, we emphasized best learning methodology in student centric environment. The Signals and Systems (SS) course is offered in 2nd year of a 4-year undergraduate program at Anurag University. The redesigned course is offered as 4 credits and covers the basics of different types of topics in signals & systems course like Signal sampling & reconstruction, evaluation of Fourier series of signals, analysis of Continuous time signals & systems using Fourier and Laplace transformations, analysis of discrete time signals and systems using Discrete Time Fourier Transform (DTFT) and Z transforms.

The following are the challenges/problems regarding the existing signals and systems course:

- Syllabus was in abstract level, where the focus is only on basics of signals & systems.
- There was no application centric approach towards teaching of the concepts.
- No proper formulation of rubrics to assess students work.
- No proper integration between the theory lecture & laboratory work.
- Focus is more on grades prior to improving the capabilities.
- Students acquire content or conceptual knowledge but fail to inculcate the habit of writing and communication. With the support of PBL/PJBL, the above stated challenges can be solved at a maximum extent.
- Students will find that the majority of the concepts covered in the new curriculum may be better understood and learned via the use of simulation studies.
- The use of real-world issues to illustrate theoretical principles is crucial.

- The development of rubrics is a viable solution to assessment issues, whether they may be summative, formative, or tests for comprehension.
- Student's interest in learning will remain high and develop steadily.
- Hybrid teaching strategy can be implemented. (Student centered learning + Facilitator based teaching)
- PBL/PJBL centric teaching inculcates motivation acknowledgement, provide many places in curriculum and in courses for students to take ownership and make choices, Reflection, Collaboration instead of competition, Change focus away from grades and to capabilities, Continuous developmental feedback.
- Bridging the gap between theory and practice through reflective learning.
- Integrating course material with an applicable project motivates students to engage in real-world application.

II. REDESIGN OF COURSE BASED ON PBL/PJBL

The aforementioned difficulties may be mitigated to a greater extent with the support of PBL/PJBL to attain the following goals, so as to make the learners:

- To participate actively in learning by problem solving.
- To gain interest and motivation to solve problems in teams.
- To be accountable in individual & team.
- To relate the knowledge gained to solve real time problems.

The Constructive alignment of course outcomes, teaching/learning activities and assessment framework for the signals and systems course are shown in Table 1.

A. Descriptive Exam & MCQ's

Descriptive (closed book) examination consists of 5 essay type questions and student need to write any 3 and the same is evaluated for 15 Marks. MCQ's examination consists of 20 questions and student need to attempt all and the same is evaluated for 5 Marks. Duration for closed book examination& MCQ's is 90 minutes Assessing criteria for the above is as follows: Exemplary: If a student scores in the range of 13-15 in Descriptive exam & 4-5 in MCQ's examination Satisfactory: If a student scores in the range of 6-12 in descriptive exam & 2-3 in MCQ's examination Needs improvement: If a student scores in the range of 0-5 in descriptive exam & 0-1 in MCQ's examination.

B. Simulation Based Test (Individual Activity)

Instructor poses problems to the students and they are directed to perform simulation-based implementation of the same. The problems for the students will be posed on:

a) Evaluation of Fourier series & Fourier transform of various signals.

b) Signal sampling and reconstruction.

The criterion which is used to assess the learner's problem-solving abilities is: Mathematical Frame work & Analysis of the Problem (5M), Implementation (5M), Testing & validation of results (5M) and Viva-Voce (5M). The rubrics for assessment of simulation-based test are shown in Table 2.

Table 1: Constructive alignment of Outcomes, Teaching/Learning activities and Assessment

Course Outcomes	Intended Course Outcomes	Assessment	Teaching & learning activities
1	Define, represent and differentiate types of signals and systems in continuous, discrete time domains and can perform various mathematical operations on them.	Descriptive Exam &Multiple ChoiceQuestions (MCQs)	Traditional teaching, animated videos, problem solving exercises
2	Evaluate Fourier series of periodic signals and determine Fourier transform of various signals.	Simulation based Test/ Simulation based Assignment (Project)	Traditional teaching, Experimental learning through MATLAB
3	Analyze the properties of continuous time signals and systems using Laplace & Fourier transforms and determine the response of LTI system to known inputs.		
4	Illustrate signal sampling and its reconstruction.		
5	Analyze the properties of discrete time signals and systems using DTFT & Z transforms and determine the response of LTI system to known inputs.		

Course Outcomes	Assessment Method	Marks
CO1	Descriptive Exam & MCQs	20
CO2 & CO4	Simulation based Test	20
CO3 & CO5	Simulation based Assignment (Project)	60

C. Simulation Based Assignment (Team Activity)

a) Students need to work either on the problem areas related to Continuous time signals & systems; LTI systems and need to analyze the same using Laplace &

Fourier transforms or need to work on the problems identified related to Discrete time signals & systems, LTI systems and need to analyze the same using DTFT & Z transforms.

b) Active learners are given flexibility to choose the problem statements related to continuous or discrete time signals and systems, and form teams on their own.

c) Slow learners are given choice to form in teams and are informed to identify the issues for the given problems by referring to the literature in signals & systems.

d) The simulation-based assignment will be evaluated in four phases shown in Figure 2 and at the end of each phase every team need to present the status of workflow in the form of presentation and report & get feedback. The rubrics for different phases of simulation-based assignment are shown in Tables 3, 4, 5 and 6 respectively. The redesigned course structure provides students to take ownership and makes choice for students to identify the gaps in the subject, conduct research and apply their learning to develop solutions for the problems opted which will be submitted as a report for evaluation.

Table 2: Rubrics for Simulation Based Test

Criteria	Exemplary (5 Marks)	Satisfactory (3 Marks)	Needs Improvement (1Mark)
Mathematical Framework & Analysis of Problem	Problem is well analyzed and shows a deep understanding of the topic with mathematical framework.	Problem is partially analyzed and shows a limited understanding of the topic, not quite a fully developed mathematical framework.	Problem is not well analyzed and shows no understanding of the topic with no mathematical framework.
Implementation	Developed code for the problem and design steps are clearly understood and found to be correct.	Partially developed code for the problem and design steps are correct and are not relevant.	Code is not well developed for the problem and design steps are not included.
Testing & Validation of Results	Executed the code, assign the inputs for the developed code and can troubleshoot the code. Results are evident and clearly able to evaluate the problem and provide solution for any set of specifications.	Executed the code, assign the inputs and unable to troubleshoot the code. Results are partially evident and able to evaluate the problem for few specifications.	Code is not executed and unable to assign the inputs & troubleshoot the code. Results are not obtained for any set of specifications.
Viva-Voce	Demonstrated deep knowledge and answer all the questions with explanation and elaboration.	Adequate knowledge of most topics and answer the questions, but fails to elaborate.	Superficial knowledge of topic and only able to answer basic questions.

The course outcomes, teaching/learning methods and assessments are constructively aligned regarding the redesigned course syllabus of signals and systems which really enhances the problem-solving ability among learners. The course is redesigned so as to emphasize the Problem/Project based and experiential learning, so that the learners can apply the theoretical knowledge in practical exercises related to signals and systems. The adaption of learner-centric approach for this course really makes the learners:

- To identify the difference between analog & discrete models of signals and systems.
- To describe the main implications in discretization.
- To analyze and interpret the behavior of various signals and systems either in continuous or discrete domain.

Table 3: Rubrics for Simulation Based Assignment – Phase 1

Phase	Criteria	Exemplary (5 Marks)	Satisfactory (3 Marks)	Needs Improvement (1 Mark)
1	**Team Formation**	Team responsibilities delegated fairly. Each member contributes in a valuable way and all members always attended meetings and met deadlines for deliverables.	Some minor inequities in the delegation of responsibilities. Some members contribute more heavily than others but all members meet their responsibilities. Members regularly attended meetings with only a few absences, and deadlines for deliverables were met.	Major inequities in delegation of responsibilities. Group has obvious freeloaders who fail to meet their responsibilities or members who dominate and prevent others from contributing. Members would often miss meetings, and/or deadlines were often missed.
	Problem identification/ Definition	Detailed and extensive explanation of the problem.	Average explanation of the problem.	Poor Explanation of the Problem.
	Literature Review	Literature review is well organized and explain previous studies related with good	Literature review is somewhat disorganized and explain previous studies, with insufficient	Literature review is not organized and explain previous studies, but no discussions on pros and cons.

		discussions on pros and cons and finally explain the need of the study.	discussions on pros and cons.	

Table 4: Rubrics for Simulation Based Assignment – Phase 2

Phase	Criteria	Exemplary (5 Marks)	Satisfactory (3 Marks)	Needs Improvement (1 Mark)
2	**Analysis of the Problem**	Problem is well analyzed.	Problem is partially analyzed.	Problem is not well analyzed.
	Mathematical Framework	Shows a deep understanding of the topic with mathematical framework.	Shows a limited understanding of the topic, not quite a fully developed mathematical framework.	Shows no understanding of the topic with no mathematical framework.
	Development of Methodology to solve the problem	All objectives of the proposed work are well defined; steps to be followed to solve the defined problem are clearly specified. Division of problem into modules and good selection of computing framework. Appropriate design methodology and properly justification	Good justification to the objectives; Methodology to be followed is specified but detailing is not done. Division of problem into modules but inappropriate selection of computing framework. Appropriate design methodology and not properly justified.	Incomplete justification to the objectives proposed; Steps are mentioned but unclear; without justification to objectives. Partial division of problem into modules and inappropriate selection of computing framework. Design methodology not defined properly.
		and efficient mapping of theory concepts with practical problem-solving approaches.	outcomes and moderate mapping of theory concepts with practical problem-solving approaches.	and improper mapping of theory concepts with practical problem-solving approaches.
	Testing and Validation of Results	Executed the code, assign the inputs for the developed code. Results are available with correct analysis and discussion.	Executed the code, assign the inputs and unable to troubleshoot the code Results are available with wrong analysis and without discussion.	Code is not executed, unable to assign the inputs & troubleshoot the code. Results do not meet project's objective.
	Final Report	Report is prepared according to the specified format. References and citations are appropriate and well mentioned. More relevant content, good coherence with adequate illustrations.	Report is prepared according to the specified format but some mistakes. Insufficient references and citations. More relevant content, moderate coherence with fewer illustrations.	Report is not prepared according to the specified format. References and citations are not appropriate. Less relevant content, poor coherence with inadequate illustrations.

Table 5: Rubrics for Simulation Based Assignment – Phase 3

Phase	Criteria	Exemplary (5 Marks)	Satisfactory (3 Marks)	Needs Improvement (1 Mark)
3	**Implementation**	Developed code for the problem and design steps are clearly understood and found to be correct. Can predict and defend problem outcomes	Partially developed code for the problem and design steps are correct and are not relevant. Approximately predicts and Defends problem	Code is not developed for the problem and design steps are not included. Unable to predict problem outcomes for the given input data set

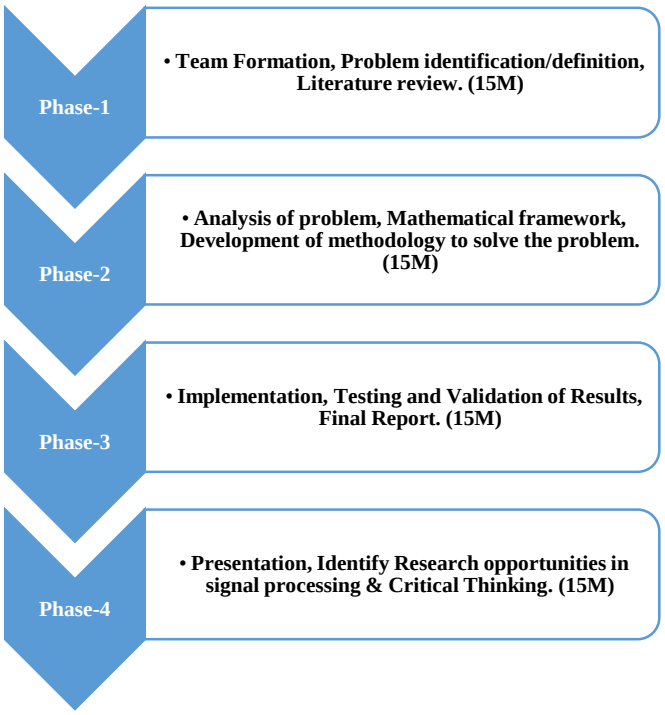

Figure 2. Phases in Simulation Based Assignment

(Project)

Table 6: Rubrics for Simulation Based Assignment – Phase 4

Phase	Criteria	Exemplary (5 Marks)	Satisfactory (3 Marks)	Needs Improvement (1 Mark)
4	**Presentation**	Slides are error-free and logically present the main components of the problem. Presentation is clear. Demonstrates deep knowledge and answer all the questions with explanations and elaboration.	Slides are error-free and partially present the main components of the problem. Presentation is satisfactory. Adequate knowledge of most topics and answer the questions, but fails to elaborate.	Slides contain errors and lack of logical progression. Major aspects of the analysis are missing. Presentation is poor. Superficial knowledge of topic and only able to answer basic questions.
	Identify Research opportunities in signal processing	Formulation of new research ideas.	Gaps in research findings noted; opportunity cited.	Work cited with little research context.
	Critical Thinking	Can predict and defend problem outcomes.	Approximately predicts and Defends problem outcomes.	Unable to predict problem outcomes for the given input data set.

III. RESULTS AND DISCUSSION

The challenges that are faced during implementation phase of PBL/PJBL includes large class size, timing constraints in view of assessment & facilitation individually, lack of prerequisite knowledge and coding skills among the students.

The positive insights that are observed during the implementation phase includes active participation and involvement of students in learning by problem solving, curiosity in learning the concepts amongst the students, accountability in learning & executing the things both individually and as team, self exploration. The performance analysis of 147 students with assessment methods I and II are specified in Figure 3. The specifications of grading are as follows:

- Exemplary: 16-20 Marks
- Satisfactory: 8-15 Marks
- Needs Improvement: 0-7 Marks

The results describes that there is improvement in the learning sprit among the students by Problem/Project based learning than the conventional course of teaching & learning. Regarding the assessment method III, students have identified and defined the problems regarding various areas of signal and systems. The methodology for resolving the problem opted is done by simulation approach. The redesign philosophy of the course signals and systems is specified in Table 7. The feedback given by the students on both conventional & PBL/PJBL approach of study is shown in Figure 4 & Figure 5.

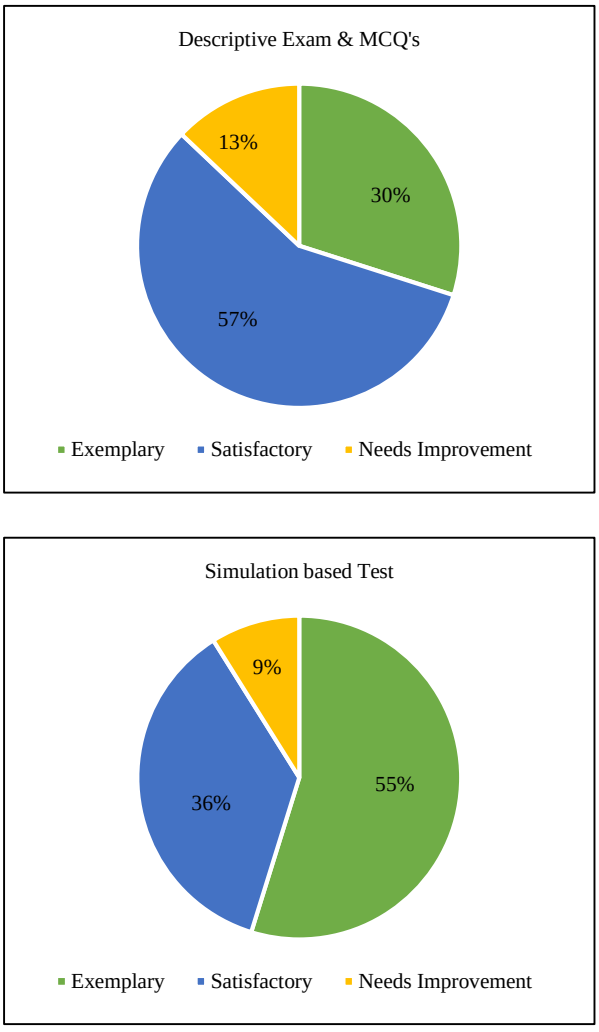

Figure 3. Performance analysis of Assessment Methods I & II

IV. CONCLUSION

The work presented in this paper specified a course level PBL/PJBL and experiential learning framework

endorsed and will be implemented in the course of signals and systems. Learners are assessed on the basis of learning outcomes-based rubrics. The framework is designed in such a way that the learners will undergo a systematic phase wise execution of solving a real-world signal processing problem by acquiring skills and knowledge with the support of simulation tool which signifies that the learners accumulate critical thinking, autonomy learning and higher order cognitive level of thinking. PBL/PJBL surely makes the students to get practical and project centric exposure to understand and sort out solutions for problems related to various concepts of signals and systems and hence is a worthwhile active experiential learning pedagogy.

Parameter	Before (Conventional approach)	After (PBL/PJBL approach)
Course Structure	Theory	Theory and Practical
Syllabus	Abstract Level	Concept clusters
Content Delivery	Traditional Teaching	Learn by doing, Case studies
Simulation based Test/Assignment (Project)	-	Starts from Week-4 of the semester
Assessments	Closed book examination	Summative, Formative & self, Experimental based evaluation, Report, Reflection

Table 7: Redesign Philosophy

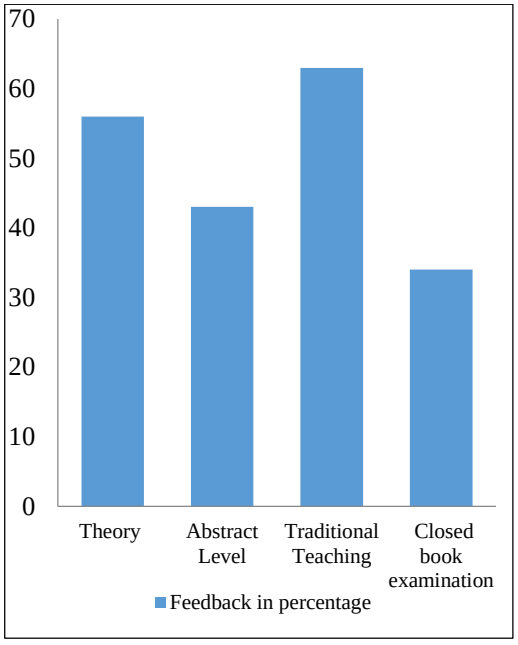

Figure 4. Feedback on Conventional approach of study

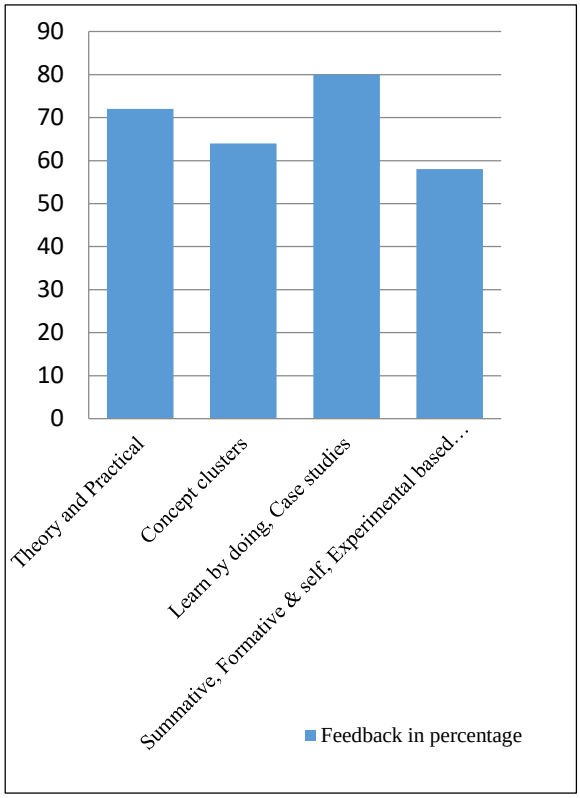

Figure 5. Feedback on PBL/PJBL approach of study

REFERENCES

Holgaard, J. E., Guerra, A., Kolmos, A., & Petersen, L. S. (2017). Getting a hold on the problem in a problem-based learning environment. *International Journal of Engineering Education, 33(3),1-8.*

Du, X.Y. & Lundberg, A.(2021).Examining emic viewpoints on pedagogical development program's long-term effects using Q Methodology. *Studies in Educational Evaluation, 7(2021)* 1-13.

Du, X.Y., Naji K. E., Ebead, U., & Ma, J.P. (2021).Engineering instructors professional agency development and identity renegotiation through engaging in pedagogical change toward PBL.*EuropeanJournal of Engineering Education, 46(1),* 116-138.

Du, X.Y., Kolmos, A., Ahmed, M.A.H., Spliid, C., Lyngdorf, N., &Ruan, Y.J.(2020). Impact of a PBL Based Professional Learning Program in Denmark on the Development of the Beliefs and Practices of Chinese STEM University Teachers. *International Journal of Engineering Education, 36(3),* 940-954.