A PARADIGM SHIFT IN ENGINEERING EDUCATION IN PAKISTAN

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ABSTRACT

This paper reflects upon cooperative learning integrated in professional learning for students in disciplines of Chemical and Civil Engineering. Outcome Based Education (OBE) has brought a paradigm shift in higher education institutions offering Engineering Education in Pakistan focusing on student achievement and not just instruction by teachers. In this research, spanning over three years, instructional methods were modified in selected courses of Chemical and Civil Engineering both at undergraduate and postgraduate levels to become student-centered, encourage deep learning, and increase student achievement. Multidisciplinary approach towards development of understanding of complex engineering problems is introduced and its results are shared for generating insights. Need to internalize the concept of complex engineering problems is highlighted from the results of the courses taught at undergraduate and postgraduate level using system dynamics methodology. A model for continuous quality improvement is proposed based on the insights gained through observations and feedback.

KEYWORDS

Outcome Based Education, complex engineering problems, continuous quality

improvement, engineering education.

INTRODUCTION

Ever since Pakistan Engineering Council (PEC) became a member of the Washington Accord, Outcome Based Education (OBE) has resulted in a paradigm shift in engineering education in Pakistan. The Higher education institutions, offering Engineering degrees, having adopted this system and accredited by the Pakistan Engineering Council have to ensure and demonstrate attainment of their academic aims, and learning objectives for graduates (PEC, 2014; PEC, 2019).

Engineering Accreditation Board of Pakistan Engineering Council oversees the accreditation process, i.e., quality assurance to validate self assessments by higher education institutions in terms of effectiveness in meeting educational objectives. A detailed account of the accreditation and re-accreditation process, qualifying requirements, and evaluation criteria may be found elsewhere (PEC, 2019). This new paradigm, i.e., outcome-based education, intends to maximize success in terms of learning outcomes by individual students.

The Washington Accord attributes, or the Program Learning Outcomes (PLOs), emphasize on complex engineering problems, understanding of which may be varying in extent across higher education institutions in Pakistan. The complex engineering problem, complexity needs to be internalized by the teachers and the students in higher education institutions offering engineering education. Morevoer, as Slavin (2012) states, education in general is essential for providing 21st century skills to students, and may be organized in the following four categories:

1. Learning and innovation skills including creativity, critical thinking and problem solving.
2. Life and career skills including self-direction and initiative.
3. Technology, Information and media skills.
4. 21st century themes and core subjects including mathematics, language arts, science, financial literacy and global awareness.

LITERATURE REVIEW

Learning may be considered as the transformation in an individual through experiences (Ahmad et al. 2021). Educational instituions bring about this transformation through instruction and varying activities within the classroom. The teaching methods may have to transform from being teacher-centered and become student-centered, in order to maximize student achievement in terms of learning outcomes. A brief review of relevant previous research related to constructivism is presented in this section, focusing on cooperative learning. Constructivism views learning as internalization of various concepts through discovery and application of ideas by learners. The ideas proposed by Piaget and Vygotsky are the basis of constructivism or student-centered learning.

They suggest that a process of disequilibration that helps connect new knowledge to previous conceptions of a learner is required for learning, implying that every piece of new information or concept would need to be processed with reference to some background or previous knowledge. Thus, learning may be visualized as a journey in which learners benefit from the experiences of more proficient peers. Vygotsky placed much emphasis on this social aspect of learning (Slavin, 2012) within our zone of proximal development.

'Learner-directed-learning' was proposed by Barry Richmond which comprises of an educational process being one of the evolutionary threads, alongwith two other evolutionary threads that are *learning tools* and *thinking paradigm.* The combination of these threads brings about such permanent changes that we desire for our learners of the 21st century which would not have been possible by each thread evolving independently (Richmond, 1993).

Cooperative learning

Cooperative Learning is built on the idea that the teacher is not the sole source of valid information within a classroom, and that the voice and choice of students can be allowed in a structured manner (Bennett et al. 1991). Thus we may treat cooperative learning as the experiences offered to learners that may help them discover and grasp difficult concepts through discussions with peers as well as with their teachers (Slavin, 2012). A detailed account of various student-centered strategies for achieving course learning outcomes may be found elsewhere (Bennett et al. 1991; Kagan and Kagan, 1994; Slavin, 2012).

Schuitema defines cooperation as '*the intent to set up the other to succeed*' (Schuitema, 2011). Cooperative learning challenges the predominant impulse as encouraged by conventional system of education to compete with each other in the class. Thus, nurturing an intent for success of the whole group, the issue of wanting success at all costs is challenged with a noble alternative. Cooperative Learning can be considered aligned to the noblest teachings of religious traditions (Perry, 2000).

Jigsaw

Jigsaw is an interesting strategy for teaching and learning concepts through group reading. In this strategy, students are required to read about a topic in groups, say, proper punctuation in academic writing. Each member of the group reads a different section of the reading material. Afterwards, members from different groups who have read the same text discuss it in expert groups. This helps in enhancing understanding of all members of each expert group. Finally, students from these expert groups return to their original ones. The whole reading material is now discussed such that each student explains their part in proper sequence (Arinson et al. 1978). Jigaw for groups of four members each is depicted in Figure 1. It shows four geometrical shapes representing different students. Four expert groups with similar geometrical shapes are shown in the top section of Figure 1, representing students who read same text of the provided material.

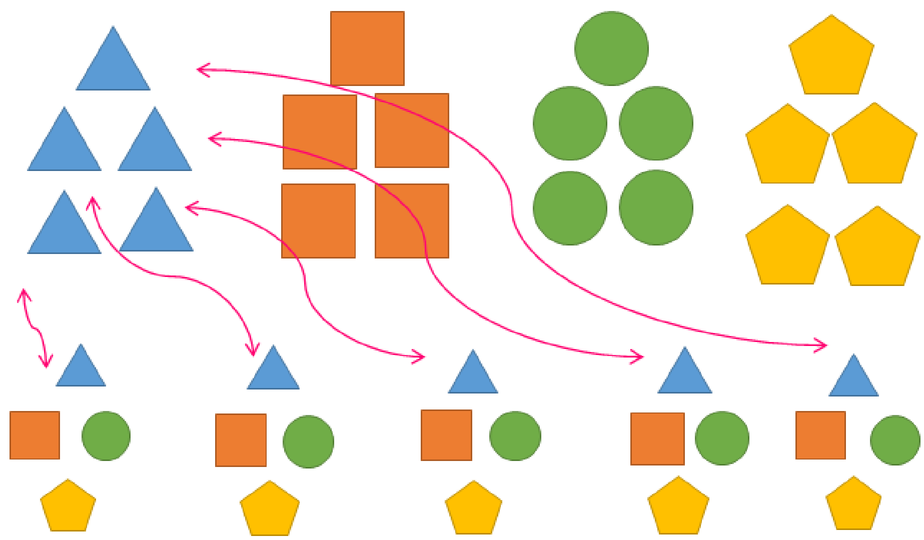

Figure 1: *Jigsaw Reading*

Assigning a unique text to each group member encourages attention being paid to every group member in order to comprehend the whole reading material.

Differentiated instruction

Students have diverse learning styles, interests, and previous knowledge and skills. In order to cater to all students with appropriate level of instruction, individualized teaching could be ideal, however, practically managing it becomes tough. Differentiated instruction (Tomlinson, 2004: George, 2005; Tomlinson, 2008) adapts instruction to the level and pace of different students according to their diverse needs in a regular classroom (Slavin, 2012).

A typical example would be a problem-solving math class in which a teacher may select ten problems, easier ones in the beginning, for revising the basic concepts and skills, followed by greater difficulty level problems allowing students to internalize desired learning. Lastly, tasks or problems that challenge advanced learners will be provided. Figure 2 depicts a pyramid of learning through differentiated instruction.

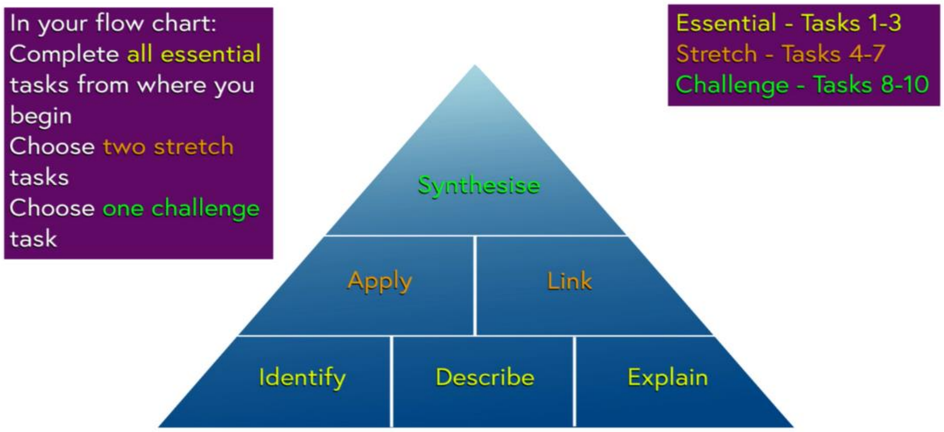

Figure 2*: A pyramid of learning through differentiated instruction*

The difficulty level increases as we move upwards in the pyramid starting from essential tasks and moving towards challenge tasks. The pyramid shown in Figure 2, can be considered a taxonomy of learning outcomes, its base consists of basic concepts or skills whereas higher order thinking is towards the top. Peer tutoring is another useful strategy for differentiated instruction both in cross-age and same-age tutoring formats.

Peer tutoring can increase achievement of both the students, i.e. the tutees and the tutors (Fantuzzo et al. 1992; Simmons et al. 1995, King et al. 1998, Van Keer, 2004 cited in Slavin 2012). Peer tutoring in same-age format is easier to manage in terms of running timetables (Rohrbeck et al. 2003).

Self-regulated learning

Self-regulated learners are aware of various learning strategies and can decide when and how to use them (Slavin, 2012). It has been observed that students who struggle in recalling and retrieving their learning, do so because of the lack of such strategies, on the other hand smart students use these spontaneously (Biggs and Tang, 2011). A discussion on metacognitive strategies can be found elsewhere (McCormick, 2003; O'Malley et al. 1990).

Project Based Learning

Project Based Learning (PBL) in its early forms was giving groups of students a task outside the classroom, as proposed by Jerome Bruner in 1966. PBL has evolved with advancements in information and communication technology, teachers' understanding of PBL, i.e. fostering deep learning through multiple intelligences (Gardner, 1980), learning taxonomies (Marzano, 2015) and artificial intelligence (Papert, 1993). Project Based Learning or Problem Based Learning has been reported to focus on voice and choice for students (Spencer, 2020) and may result in increased student achievement in terms of learning outcomes through opportunities to solve real-life problems (Malmia et al. 2019).

Micro-worlds for learning

The term micro-worlds is ubiquitously used in system dynamics literature where computer-based environment is used to model different systems for development of insights and learning about the systems both qualitatively and quantitatively (Richmond, 1994).

Qualitative modeling essentially causal loop diagramming requires a pen and paper only, however, it can be done using other environments specifically tailored for such modeling such as Vensim and Stella Architect. The Stella and Vensim are used for quantitative modeling of the complex adaptive systems wherein, students can learn by experimenting various 'what if' scenarios and undertake higher order thinking that happens during such learning activities.

Application of Student-Centered Learning Strategies

In this section we reflect upon strategies tried and tested in two B.Sc. Chemical Engineering undergraduate courses (2016-17), one B.Sc. Civil Engineering undergraduate course (2017-18), and one M.Sc. Urban Infrastructure Engineering postgraduate course (2017-18) at The National Institute of Urban Infrastructure Planning of UET Peshawar. Course instructors employed student-centered learning strategies through project-based learning and group investigation methods.

Technical Report Writing & Communication Skills

Our first implementation of cooperative learning was in Fall 2016 semester with students of B.Sc. Chemical Engineering (5th semester). This module was offered as a lab course in which students worked in groups ranging from three to six students per group in various tasks. The outcomes of this cooperative learning led to a research paper and poster presentation at a Conference organized by the Department, i.e., Sustainability in Process Industry (SPI 2016).

Jigsaw was chosen for learning reading material, i.e., text on punctuation such as the use of commas, semi-colons etc. was assigned to groups of six students each. Students who read similar sections discussed in expert groups as shown in Figure 1 and then returned to their original groups to explain their topics, thereby the whole reading material was understood well through cooperative learning strategy. Another innovation brought to lecturing was integrating TED talks periodically on relevant topics such as *eight secrets of success*, *how to speak so that people want to listen*, and *non-verbal communication*, followed by discussion to summarize key points and reflect upon the learning through students expressing their views, collectively evaluating ideas worth spreading in light of their personal experiences.

Energy Engineering

Project based learning has been observed to be particularly beneficial in Engineering education as was implemented with 5th semester students of the Department of Chemical Engineering at UET Peshawar in Fall 2017. Course Learning Outcomes (CLOs) as shown in Table 1, were achieved through integrating classroom instruction and project activities undertaken by groups of 3-5 students.

Table 1: ***CLOs for the subject 'Energy Engineering'***

S. No	Course Learning Outcome	Cognitive level
1	Students should be able to perform material and energy balances relating to combustion reactions.	C3, i.e., application.
2	Students should be able to conduct energy audit of a process, i.e., a local industry.	C4, i.e., analysis.
3	Students should be able to select suitable fuel and equipment for heating in a process.	C5, i.e., evaluation.

The energy audit of local industries in KP, served as a complex engineering problem, demanding team work and cooperative learning for achievement of course learning outcomes. A detailed account of purpose and procedures for carrying out energy audit is beyond the scope of this paper and may be found elsewhere (Thumann and Younger, 2008), however, typical tasks undertaken by students are shown in Table 2.

Table 2*: Tasks undertaken by students in energy audits of local industries (Thumann and Younger, 2008)*

Pre-Site Work	Site Visit	Post-Site Work
Collect and review utility data.	Ensure safety with appropriate Tools.	Review and clarify your notes.
Obtain drawings (layout and process flow diagrams).	Discuss with Production Manager, operation and maintenance practices.	Review and revise energy conservation measures and operation and maintenance measures.
Prepare data collection forms.		

Calculate energy usage index (EUI). Prepare a list of candidate measures for improvement in the process.	Confirm drawings (layout and process flow diagrams). Fill data collection forms. Check the equipment highlighted in pre-site work. Take pictures as you walk through and make notes on lighting as well.	Process photographs, number them, and note location on floor plan. Organize all the collected data, viz. documentation, notes and photos. Prepare Audit Report.

The overall assessment comprised of project work carrying 25% marks based on energy audit report and poster presentation, and two examinations.

Sustainable Development and Disaster Risk Management

This course was taught in 8th semester of B.Sc. Civil Engineering in UET Peshawar. Students were encouraged to find stories from news articles, other subjects addressing country's problems focusing on sustainable development to model both qualitatively and quantitatively, the problem being identified.

The methodology of developing a Silver paper described by Dianna M. Fisher (Fisher, 2005) was explained to the students at the start of the semester and students were required to complete their project during the semester. The projects were assessed on the basis of the rubrics, as shown in Table 3, that were mapped with the course learning outcomes and program learning outcomes as per requirements of outcome-based education system.

Table 3*: Rubrics for a Complex Engineering Problem in Sustainable Development and Disaster Risk Management subject*

S.No	Rubric	%
1	The article must contain data preferably some behavior-over-time-graph (BOTG) representing the pattern of the behavior of the system over time. The graph or data could be used to validate the model you will sketch. Draw at least one BOTG that represents the data in your write-up either at the beginning or the end of the summary. Dynamic behavior pattern of the most important variable(s) may be represented. [CLO 2, PLO 6]	10
2	Briefly explain the problem/system described in the article. (Summary should be about a half type written page. [CLO 1, PLO 7]	20
3	Identify the stocks in the system, the flows, and some of the converters. Build, in Stella, a rough model diagram map (two stocks) of the core part of the dynamic system described (no numbers or equations are	30

	required). Pay attention to units. A model may contain at least one feedback loop that includes more than three components. This feedback will probably connect two stock concepts. [CLO 3, PLO 5]	
4	Identify at least one feedback (more than three components) after analyzing the diagram you drew for step 3. Draw a feedback causal-loop diagram, indicating polarity (+/-) on each arrowhead. Explain the feedback. Determine whether the behavior demonstrates reinforcing feedback or counteracting feedback (Recall that counteracting feedback tries to bring the system into some kind of equilibrium). If you have counteracting feedback, what do you think causes the system to come back into balance? [CLO 3, PLO 5]	30
5	Include the article or a photocopy of the article, including the data and source. [CLO 1, PLO 7]	10

It may be worthwhile to note here that students were assessed based on five levels, viz. Poor (<55%), Fair (55-65%), Good (66-75%), Very Good (76-85%), and Excellent (>85%) based on the rubrics shown in Table 3.

Dynamics of Urban Infrastructure Systems

Richmond (1993) proposed an educational process with systems thinking and system dynamics as tools for achieving deep learning and maximizing achievement by students. Our experiment to offer an environment to learn systems thinking by simulating real world systems using system dynamics software such as *Stella* helped post graduate students, at the National Institute of Urban Infrastructure Planning (NIUIP) of UET Peshawar in fall 2017 semester, study interconnectedness and dynamic behavior of systems thereby gaining insights into various complex problems.

Continuous Quality Improvement (CQI)

A model is proposed for continuous quality improvement (CQI) to meet quality assurance requirements based on the aspirations of the Pakistan Engineering Council as emphasized in the OBE Manual 2014. Figure 3 shows the proposed model for continuous quality improvement with three tiers starting with course learning outcomes directly assessed by teachers through assignments, quizzes and exams.

Achievement of students in these assessments is required to meet key performance indicators (KPIs) set for individual courses. For example, key performance indicators for a course may be such that more than 50% of the students should achieve more than 50% marks for demonstrating satisfactory achievement of course learning outcomes in direct assessment. However, if more than 50% of the students achieve less than 50% marks a ‘Cohort Failure’ may occur.

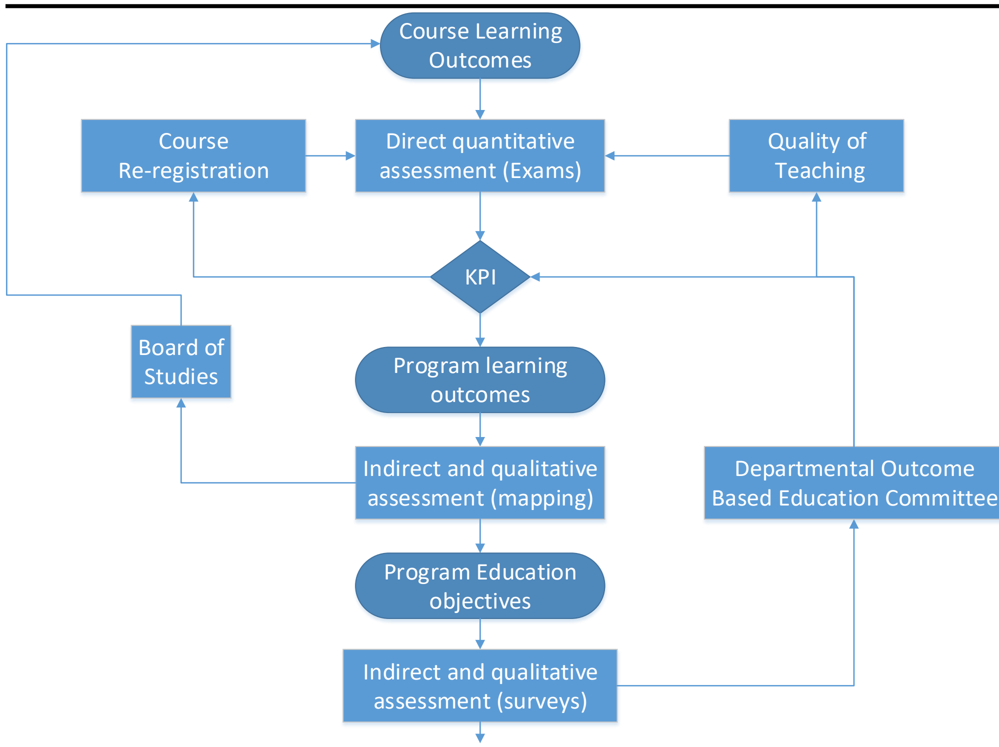

Figure 3: *Proposed model for CQI in engineering education*

It may be observed from Figure 3 that students would be required to re-register a course in case of unsatisfactory performance. CLOs of all individual subjects are linked to program learning outcomes (PLOs), prescribed by the PEC, through mapping. These PLOs are synonymous to Washington Accord attributes (WAAs). Graduates are expected to be able to demonstrate these attributes. PLOs may be assessed indirectly and qualitatively based on feedback from graduating students elicited through surveys as well as from achievement of course learning outcomes.

PLOs are linked to the program educational objectives (PEOs) aligned with the mission of a Department and vision of the higher education institution. An engineering graduate is expected to be able to meet program educational objectives during early professional career, i.e. performance indicators for the first three to five years after graduation. It may be worthwhile to note here that once an institution successfully implements outcome-based education, the key performance indicators may need to become stringent to raise its standards.

Our proposed model incorporates feedback from key stakeholders, with changing needs of the society, to revise learning outcomes, raise benchmarks for achievement, to improve quality of instruction and assessment. The continuous quality improvement cycle and corrective actions at various levels are discussed in the following Sub-Sections.

CQI at Course Learning Outcomes level

The course learning outcomes are developed and revised by faculty in view of the needs of stakeholders such as industry, academia, and society. The course learning outcomes are aligned to HEC approved curriculum and as per requirements of PEC and are approved by Departmental Board of Studies. The achievement of these course learning outcomes is assessed directly and quantitatively through quizzes, assignments, presentations, projects, and mid and final term exams.

Corrective Action Reports may be generated by Subject Teacher for corrective measures taken in their respective subjects to allow students to improve achievement in course learning outcomes. However, corrective measures may only be taken based on quizzes, assignments, or project work, i.e., in sessionals accounting for up to 25% of the total subject marks.

CQI at Program Learning Outcomes level

If a student achieves course learning outcomes, in that case whether the program learning outcomes are achieved or not is assessed in two ways:

Firstly, the course learning outcomes are mapped to program learning outcomes leading to the inference that achievement of course learning outcomes leads to achievement of those program learning outcomes to which the respective course learning outcomes may have been mapped. An advisory could be issued to students regarding shortcomings/failure to achieve program learning outcomes. Students may opt to improve achievement in program learning outcomes through re-registration in courses thereby improving achievement in course learning outcomes.

Secondly, graduating students provide their feedback on achievement of program learning outcomes. In case some PLOs are not achieved the course learning outcomes would need to be re-visited in light of the needs of stakeholders. This process of revision would be subject to review, recommendations, and approval of the Board of Studies.

CQI at Program Educational Objectives level

Finally, the program educational objectives may be assessed indirectly and qualitatively through feedback from Employers, and Alumni who graduated at least three years ago. Such evaluation may be presented to an Industrial Advisory Board for

observations and recommendations. In case any discrepancies are observed, corrective actions may be proposed by the Departmental OBE Committee, as shown in Figure 3. The Departmental OBE committee would probe to find out whether improvement is required in quality of teaching and assessment, or the KPI needs to be revised. The authors believe that capacity building programs for professional development of teachers are an effective means of improving quality of instruction. The institutions that have significantly contributed in capacity building of teachers in higher education instiutions in Pakistan are as follows:
Learning Innovation Division of Higher Education Commission, Islamabad.
Teachers' Development Centre, Karachi.

RESULTS AND DISCUSSION

The paradigm shift in engineering education in Pakistan requires moving to cooperative learning from conventional lecturing, wherein the role of a teacher may be facilitating and coaching in the classroom. Furthermore, teachers would need to engage proactively in preparing for experiences or challenges that would be offered to learners. We may summarize that professional learning in classrooms may transform such that students discover their own meaning through discussions, group work, and reflections facilitated by teachers (Slavin, 2012).

The Quality Enhancement Cell (QEC) at UET Peshawar solicits feedback from students regarding each subject taught through online surveys. Feedback for the subject Technical Report Writing & Communication Skills is shown in Table 4. Table 4 presents the feedback provided by 48 respondents through an online questionnaire in the form of mean and standard deviation for a 5-Point Lickert scale with 1 corresponding to 'strongly disagree' and 5 corresponding to 'strongly agree'. Reliability, Cronbach's Alpha, was found to be 0.985 for the five items shown in Table 4.

Table 4 shows that the learning as perceived by students was conducive for maximizing achievement in terms of learning outcomes. Students may be engaged in active learning through provision of use of readily available technological aids such as smart phones to explore ideas, and evaluate problem solving approaches through discussions amongst each other and with advanced learners and facilitators.

Table 4*: Feedback for the subject Technical Report Writing & Communication Skills*

S. No	Item	Mean	Std. Deviation
1	The teacher encourages students to participate in class discussions and ask questions.	4.52	0.875

2	The teacher explains the concepts and course contents clearly.	4.40	1.026
3	The teacher provides supplementary material apart from the textbook.	4.50	0.825
4	The teacher provides citations regarding current situations with reference to Pakistani context.	4.42	0.895
5	The teacher maintains a positive environment conducive to learning.	4.46	0.898

Results of Table 4 support this inference about provision of discussions in classrooms may contribute towards maximizing student achievement. Classroom instruction was modified to allow group work based on cooperative learning. Challenge in the form of writing a research paper and presenting a poster in a National Conference intrinsically motivated the students.

Project based learning as implemented in the subject of Energy Engineering offered exposure to a complex engineering problem in the form of group work to undertake energy audits of local industries. Tasks associated with the complex engineering problem were broken down into smaller tasks and activities undertaken by students in mixed ability groups. Assigning each group member, a unique task made students dependent on each other serving as a basis to help each other succeed. For example, during the site-visit group members would undertake different tasks such as taking photographs of process equipment, collecting utility data, sketching layout of the plant, collecting process data, and making notes such as power rating of motors etc.

Classroom activities offered differentiation to address diverse learning abilities and preferences of students and were an integral part of project-based learning based on the concept of pyramids of learning as shown in Figure 2. Table 5 shows direct assessment of course learning outcomes for the course on Energy Engineering. It may be noted that students of 5th semester not only undertook energy audits of local industries successfully but also presented their findings in the form of poster presentations in a dedicated seminar organized by the same students.

Table 5*: Assessment of achievement of learning outcomes by students in the subject 'Energy Engineering'*

S. No	Course learning outcomes	Students Achieved %
1	Students should be able to perform a) material and b) energy balances relating to combustion reactions.	a) 77 b) 50
2	Students should be able to conduct energy audit of a process.	100

3	Students should be able to select suitable fuel and equipment for heating in a process.	84

Post graduate students at NIUIP were not comfortable with the software and methodology of System Dynamics based on the observations by the subject teacher, however, 80 percent students were able to achieve the course learning outcomes set for the postgraduate course "Dynamics of Urban Infrastructure Systems". Thus, it may be inferred that the methodology described by Dianna M. Fisher in Creative Learning Experience for High School students in United States was proving to be difficult for M.Sc. students. The students were observed to be hesitant to draw free hand graphs showing trends in the systems, and were forced out of their comfort zone in order to develop proficiency in the field.

On the other hand, undergraduate students in Civil Engineering Department were able to cope with the body of knowledge and skills covered in the subject "Sustainable Development and Disaster Risk Management" and were able to complete their assigned projects. Three out of forty groups were able to present their articles in conferences and later submitted manuscripts to peer reviewed journals. Course assessment indicated that students were proficient in learning the software, but the underlying concept of complex engineering problems remained ambiguous to more than a few students.

Results indicate that implementing cooperative learning, differentiated instruction, and project-based learning facilitated learning of engineering students through student-centered learning. Furthermore, the element of collaboration built-in within cooperative learning incorporates meaningful interactions within peers and with facilitators along with reflection to increase student achievement (Ahmad et al. 2021).

Outcome based education (OBE) offered in higher education instutions being monitored by the Pakistan Engineering Council has resulted in a paradigm shift in engineering education in Pakistan. The OBE paradigm demands not just delivery of course materials in a linear fashion rather achievement by students as well as incorporating feedback mechanism within higher education institutes and from external stakeholders. A model of continuous quality improvement, based on such feedback is proposed in this work. The presence of feedback loops renders such an educational system, a complex and adaptive system for which internalizing the concept of complex engineering problems both by students and teachers is emphasized. Student-centered learning through cooperative learning and PBL was implemented to maximize achievement of learning outcomes, particularly for students who were at risk, struggling, and were found to benefit from differentiated instruction and peer tutoring, gaining 21st century skills to tackle complex problems of the rapidly changing world.

RECOMMENDATIONS

Professional learning in classrooms may transform if students are encouraged to discover their own meaning through discussions, group work, and reflections facilitated by teachers. The element of collaboration built-in within cooperative learning incorporates meaningful interactions within peers and with facilitators along with reflection to increase student achievement.

It is recommended for teachers in current paradigm to learn facilitation for students and provide enabling environment for student centered learning. A continuous learning cycle is ahead for teachers wherein they need to learn new techniques and become abreast with the tools that address complexity and uncertainty.

Capacity building programs for professional development of teachers may effectively improve the quality of instruction in higher education institutes.

ACKNOWLEDGEMENTS

Authors would like to acknowledge efforts of the following:
1. Mr. Abbas Husain, Director Teachers' Development Centre, Karachi for support in the form of training and mentoring that helped implement student centered learning presented in this paper.
2. Engr. Azeem Abbas in preparing schematics for representing learning strategies presented in this paper.
3. Engr. Shehbaz Ahmad for editing this paper.

REFERENCES

Ahmad, M. I., Khan, I. A., Ahmad, M., Husain, A., & Jamaludin, R. (2021). Entropy in Education System: Transformation of an Individual Through Meaningful Interactions in a Community of Inquiry. *Systemic Practice and Action Research*, 1-16.

Aronson, E., Blaney, N., Stephan, C., Sikes, J., & Snapp, M. (1978). The jigsaw classroom. Beverley Hills. In: Ca: Sage.

Bennett, B. B., Rolheiser-Bennett, N. C., & Stevahn, L. (1991). *Cooperative learning: Where heart meets mind: An interactive resource book*: Educational Connections Toronto.

Biggs, J., & Tang, C. (2011). *Teaching for quality learning at university*: McGraw-hill Education (UK).

Fantuzzo, J. W. (1992). Effects of reciprocal peer tutoring on mathematics and school adjustment: A component analysis. *Journal of Education Psychology, 84*(3), 331.

Fisher, D. M. (2005). *Modeling dynamic systems: lessons for a first course. Teachers and trainer's guide*: Diana M. Fisher.

Gardner, H. E. (1980). *Frames of Mind: The Theory of Multiple Intelligences*.

George, P. S. (2005). A rationale for differentiating instruction in the regular classroom. *Theory into practice, 44*(3), 185-193.

Kagan, S., & Kagan, M. (1994). *Cooperative Learning*. San clemente. In: CA: Kagan Publishing.

King, A., Staffieri, A., & Adelgais, A. (1998). Mutual peer tutoring: Effects of structuring tutorial interaction to scaffold peer learning. *Journal of Educational Psychology, 90*(1), 134.

Malmia, W., Makatita, S. H., Lisaholit, S., Azwan, A., Magfirah, I., Tinggapi, H., & Umanailo, M.C.B. (2019). Problem-based learning as an effort to improve student learning outcomes. *J. Sci. Technol. Res, 8*(9), 1140-1143.

Marzano, R. J. (2015). *Creating and Using Learning Targets & Performance Scales: HowTeachers Make Better Instructional Decisions*.

McCormick, C. B. (2003). Metacognition and learning.

O'Malley, J. M., O'Malley, M. J., Chamot, A. U., & O'Malley, J. M. (1990). *Learning strategies in second language acquisition*: Cambridge University Press.

Papert, S. (1993). *Mindstorms, Children, Computers, and Powerful Ideas*.

PEC. (2014). Pakistan Engineering Council 'Manual of Accreditation'. *Engineering Accreditation Board, 2nd Edition*.

PEC. (2019). Pakistan Engineering Council 'Manual of Accreditation'. *Engineering Accreditation Board, 3rd Edition.*

Perry, W. N. (2000). *A Treasury Of Traditional Wisdom: An Encyclopedia Of Humankind's Spiritual Truth (Wisdom Foundation Series)*. 825: Fons Vitae.

Richmond, B. (1993). Systems thinking: critical thinking skills for the 1990s and beyond. *System Dyanmics Review 9*(2), 113-133.

Richmond, B. (1994). System dynamics/systems thinking: Let's just get on with it. *System Dynamics Review 10*(2-3), 135-157.

Rohrbeck, C. A., Ginsburg-Block, M. D., Fantuzzo, J. W., & Miller, T. R. (2003). Peer-assisted learning interventions with elementary school students: A meta-analytic review. *Journal of Educational Psychology*, *95*(2), 240.

Schuitema, E. (2011). *Intent: Exploring the core of being human*: Intent Publishing.

Simmons, D. C., Fuchs, L. S., Fuchs, D., Mathes, P., & Hodge, J. P. (1995). Effects of explicit teaching and peer tutoring on the reading achievement of learning-disabled and low-performing students in regular classrooms. *The Elementary School Journal, 95*(5), 387-408.

Slavin, R. E. (2012). *Educational psychology: Theory and practice*.

Spencer, J. (2020). *Vintage Innovation: Leveraging Retro Tools and Classic Ideas to Create Meaningful Learning*.

Thumann, A., & Younger, W. J. (2008). *Handbook of energy audits*: The Fairmont Press, Inc.

Tomlinson, C. A. (2008). The goals of differentiation. *Educational Leadership, 66*(3), 26-30.

Tomlinson, C. A. (2004). Differentiating instruction: A synthesis of key research and guidelines. *Adolescent Literacy Research and Practice*, 228-248.

Van Keer, H. (2004). Fostering reading comprehension in fifth grade by explicit instruction in reading strategies and peer tutoring. *British Journal of Educational Pscyhology, 74*(1), 37-70.