

Learning enhancement through deploying personal learning environment, network and problem-based learning assessment

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Abstract. Intended to foster students' self-directed learning and research ability at the postgraduate level, this educational research evaluated the implications of personal learning environment & network (PLE&N) and problem-based learning (PBL) assessment as student-centric and student-driven pedagogic approaches. Compared to conventional instructional paradigms, the PLE&N platform presents an agile and interactive platform that empowers students to partake in collaborative discourse while orchestrating their learning journey through the judicious utilization of communal resources. The vitality of the PLE&N model is substantiated by the enduring engagement of peers, teachers, professionals, and external experts in the field, fostering a milieu of enriched knowledge exchange, synergistic collaboration, and personalized curation of learning approaches. In contrast, the PBL assessment was designed by incorporating intricate scenarios similar to the real world, thereby affording an avenue for cultivating students' cogitation and adroit problem-solving skills within a guided learning environment. By integrating constructivist and connectivist pedagogies, the PBL assessment facilitated teamwork while engaging students in independent research and empowered their knowledge construction on selected topics. Students' self-evaluation through the survey indicated their enhancement in self-directed learning behavior and competence building for complex problem-solving tasks. Moreover, peer feedback and suggestions received through both PLE&N and PBL were highly beneficial for students to analyze information and learning resources from diverse perspectives, which further helped to expand their learning horizon. This study underscored the significance and advantages of modern student-centric approaches such as PLE&N and PBL. These pedagogical paradigms stand as seminal strategies for nurturing nascent post-graduate students, thereby endowing them with indispensable proficiencies in self-directed learning and robust competencies in scholarly inquiry.

Keywords: PLE&N, PBL, Constructivism, Connectivism, Pedagogy, Self-directed learning.

INTRODUCTION

The evolution of higher education practices is an imperative requisite for cultivating competent graduates and skilled professionals. Sustaining global standards mandates continuously updating pedagogical approaches, learning tools, and engagement strategies within universities (Tikhonova and Raitskaya, 2018). At the postgraduate level, students' knowledge acquisition and

research skill advancement hinge on their commitment to self-directed learning, as actively engaged students tend to address their intrinsic learning needs and develop a deeper understanding of the subject. Consequently, fostering students' self-directed learning capability emerges as an important goal within higher educational institutions (Morris, 2019). In this context, student-centric

and student-driven modern pedagogies are often incorporated into the university curriculum to augment students' engagement and active learning (Damşa and de Lange, 2019). This study is rooted in applying two contemporary pedagogic approaches, namely personal learning environment & network (PLE&N) and problem-based learning (PBL) assessment, with a specific aim of augmenting students' self-directed learning and research ability at the postgraduate level.

Perception and benefits of personal learning environment & network

Exponential growth in information and increased availability of web-based high-quality open educational resources are prompting learners to update their knowledge and skill continuously. Considering ever-increasing information and learning resources, it might be more reliable to acquire knowledge from trusted networks consisting of peers, professionals, and relevant experts in the field (Dabbagh and Kitsantas, 2012; Leone, 2013). Besides, to ensure the effectiveness of the tertiary-level teaching and learning system, it is critical to address students' diverse learning abilities and personal preferences. In this case, students necessitate additional support and guidance in navigating authentic and useful learning content while satisfying their individual learning needs (Kühn, 2017). Importantly, a considerable focus should be placed on developing a connected, deep, and personalized learning environment that can accommodate students' unique learning needs instead of a disconnected and generalized system for all. A deeply connected and personalized learning environment may nourish students' self-directed learning ability and promote their life-long learning disposition (Tsang and Tsui, 2017). Educational researchers have elucidated PLE&N as an emerging pedagogy, often characterized as a multidimensional digital learning platform that facilitates the integration and personalization of learning resources, tools, applications, etc., while also fostering collaboration among connected users and relevant experts (van Harmelen, 2006; Ebner and Taraghi, 2010). PLE&N is conceptualized as "A combination of social media-enabled systems, applications, and services which help learners to take control of their learning by aggregating, manipulating, and creating digital contents and learning artifacts, and sharing them with others." (Saadatmand and Kumpulainen, 2013). PLE&N, as a learner-centric interactive system, might enable students to handle and personalize their learning resources and tools, communicate and share relevant content with other connected users or learning communities (i.e., students, instructors, graduates, experts, etc.) while taking control of their own learning goals and the overall learning process (Iyer *et al.*, 2022). Therefore, implementing PLE&N as a pedagogical approach can potentially catalyze self-directed learning

and knowledge construction among postgraduate students. However, adopting effective learning strategies and appropriate design of the learning environment would be crucial in developing the desired skills among students.

Prospects of problem-based learning approach

PBL has emerged as a pedagogical mainstay bridging the gap between traditional classroom learning and complex environment in real workplace scenarios. It invigorates student engagement and participation within higher education institutes globally (Yew and Goh, 2016; Tsang *et al.*, 2018; Yiu *et al.*, 2021). Adopting the PBL approach, students can embark on the self-directed learning process by working on a problem or question relevant to their subject, with the course instructor serving as a facilitator. Collaborating in groups, students navigate the intricacies of these problems, perform research independently, negotiate possible solutions, and find their way to reach the final resolution. In this context, it is of utmost importance to construct the specific problem/question with realistic, complex, and ill-structured scenarios, which can properly stimulate students' genuine interest in learning and research. The ultimate goal of implementing the PBL approach is to nurture intrinsically motivated learners, which might be advantageous in developing considerable critical-thinking skills and problem-solving skills among students (Hmelo-Silver, 2004).

To augment students' effective learning and comprehensive understanding of the subject of interest, multiple learning theories can be combined under the PBL approach, such as constructivism and connectivism. Constructivist pedagogy underscores the individual and contextual nature of learning, emphasizing the role of prior knowledge and experiences in shaping the learning process of an individual learner. "Constructivists believe that knowledge is essentially subjective in nature, constructed from our perceptions and mutually agreed upon conventions. According to this view, we construct new knowledge rather than simply acquire it via memorisation or through transmission from those who know to those who don't know." (Bates, 2019). In a constructivist learning environment, students would be signified as active knowledge seekers who organizes new relevant experiences into a personal representation concerning their previous knowledge base or educational background (Yew and Goh, 2016). In contrast, connectivist pedagogy views knowledge as a network of ideas and identifies learning as the process of connecting specialized nodes or information sources. Connectivism acknowledges that resolutions in the real world necessarily depend on the rapidly altering knowledge base. As new information is continuously being evolved, it is critical to distinguish between important and unimportant ones in order to recognize vital information or ideas that might have a significant influence in the future (Siemens, 2017).

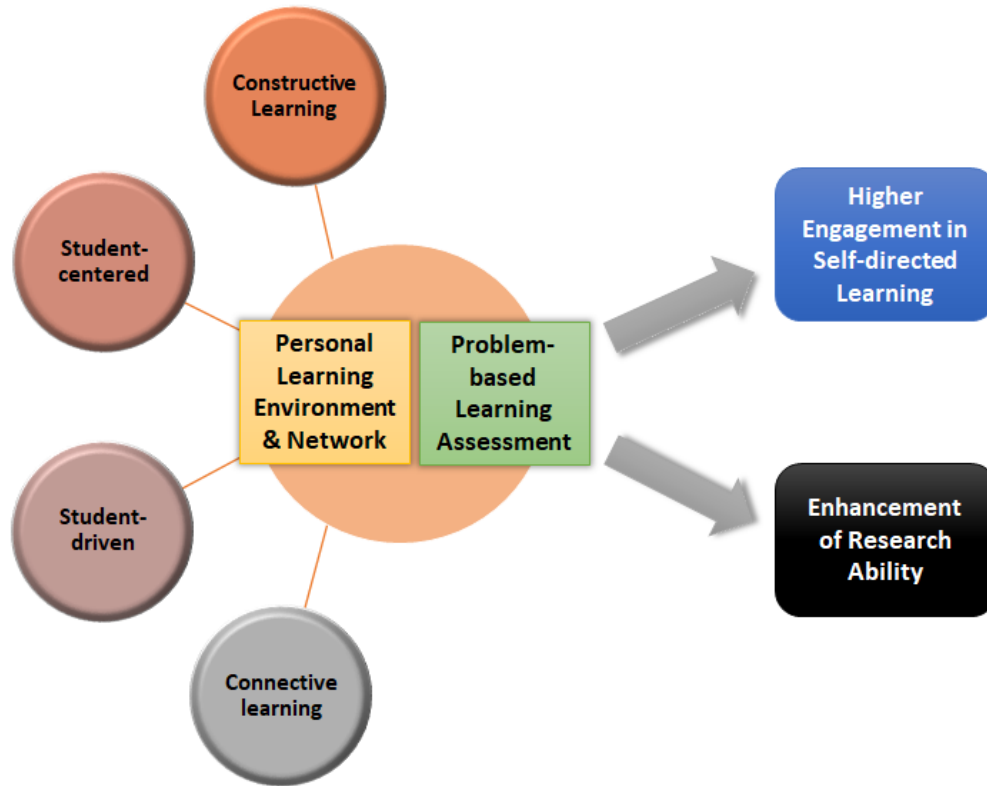


Figure 1. Teaching and learning framework implemented in this study

Accordingly, advancing skills to connect, build, and expand the knowledge network and developing the capability to identify the knowledge gap in relevant fields should be emphasized in a connective learning environment. Considering the potential synergistic benefits, constructive and connective learning might be integrated under the PBL approach to cultivate self-directed learning behavior and research aptitude among postgraduate students.

Scope of this study

This educational research project implemented PLE&N and PBL as student-centered pedagogic approaches (Figure 1) at the post-graduate level to foster students' active engagement, collaboration, and knowledge construction. Under the guidance of the course instructor, a digital knowledge-sharing platform was co-created by students and the learning community to serve the purposes of the PLE&N approach. Contrastingly, students participated in the problem-based assignment where their learning outcomes were assessed and counted as a part of the final subject grading. The main objective of this study was to enhance students' self-directed learning and research ability by adopting the PLE&N and PBL approaches, which were evaluated through students' self-

assessed questionnaire survey and interview end of the study period.

METHODOLOGY

Students' engagement with PLE&N

This study was implemented at The Hong Kong Polytechnic University (PolyU) under the course "CSE505 - Contaminated Land and Sediment Remediation" with 45 full-time Masters students enrolled in the subject. A tailored PLE&N platform was developed where students collaborated with the course instructor, tutors, graduates, and experts/professionals in the field. Following the demonstration by the course instructor, students created an RSS reader account, i.e., Inoreader, as well as an account on a social networking site, i.e., MeWe. Leveraging the inherent functionality of RSS feeds, students effortlessly accessed the latest information and learning materials, thereby circumventing the rigors associated with conventional web-based searches characterized by time-intensive and laborious endeavors. Moreover, students joined the subject-specific group in MeWe and posted new content/information on a weekly basis to facilitate knowledge construction through the PLE&N platform. To boost students' engagement and

Table 1. Questions designed for the survey regarding PLE&N adoption and PBL assessment

Section 1: PLE&N
Q1: You can find relevant and valuable professional knowledge beyond classroom lectures through PLE&N.
Q2: You can ensure accurate and up-to-date knowledge that is relevant to the latest technology development in your subject.
Q3: You can personalize the learning contents and resources based on your learning preferences and research interests.
Q4: You can critically review and evaluate the online information and learning resources shared by peers and professionals.
Q5: You can enhance your skills to identify uncertainties or unknown parameters (i.e., gaps in knowledge) in your field.
Q6: You can engage yourself in self-directed learning activities through PLE&N.
Q7: You have been stimulated by peer feedback and comments shared in PLE&N, which serve to broaden knowledge and outlook from multiple perspectives.
Q8: Please give an example to demonstrate the prospects or benefits of PLE&N regarding your learning enhancement.
Q9: Please give an example of the constraints of PLE&N and, if possible, provide suggestions for future improvement.
Q10: Please provide your suggestions on learning approaches and activities for further enhancement of your research ability and self-directed learning behavior.
Section 2: PBL Assessment
Q11: You can comprehend new knowledge and the latest technology development during the course of the PBL assessment.
Q12: You can create meaning and understanding through active learning activities involved in the PBL assessment.
Q13: You can transfer the acquired engineering knowledge and skills to solve new problems in the real world.
Q14: You can identify uncertainties or unknown parameters (i.e., knowledge gaps) in your field of study.
Q15: You can apply the acquired knowledge and information for better planning and conducting new research studies.
Q16: You can enhance your self-directed learning activities through PBL assessment.
Q17: Peer feedback and comments received during the PBL assessment can foster your critical thinking and self-reflection.
Q18: Please give an example to demonstrate the prospects or benefits of PBL approaches for your learning enhancement.
Q19: Please give an example of constraints of PBL assessment and, if possible, provide suggestions for future improvement.
Q20: Please provide your suggestions on PBL activities for further enhancement of your research ability and self-directed learning.

knowledge sharing, their contribution to the PLE&N was rewarded with 10% of the total marks for the given subject and counted towards the final grading. Notably, the initial phase of the study was underscored by a comprehensive elucidation of the requisite parameters governing PLE&N contributions. The course instructor thoroughly explained the requirements for PLE&N contributions and respective grading criteria for evaluation.

Students' engagement with the PBL assessment

In contrast, the PBL assessment was designed based on the pedagogic theories of constructivism and connectivism to stimulate students' self-directed learning and research ability. This summative assessment, overseen by the course instructor and tutor, hinged on defined scoring criteria. Notably, a formative peer assessment was also incorporated within the assessment framework to encourage peer learning and reflective thinking among students. Two group projects (conducted midway and end of the course) were included in the assessment, contributing 40% of the total subject grading. Initially, the course instructor provided a brief lecture on project topics

and consequently explained the requirements and assessment rubrics. Engaging in teams, students were instructed to prepare 10-min presentations on chosen topics. In total, 11 groups were formed under the guidance of the course instructor, and each group consisted of 4 to 5 student members as needed. As an essential component of this exercise, 2 to 3 other student groups were assigned as peers for each group presentation, providing constructive feedback and suggestions on the overall process.

Questionnaire survey and Semi-structured interview

To gauge students' learning enhancement in this study, a dual-pronged approach, i.e., questionnaire survey and semi-structured interview, was employed with participating students on a voluntary basis to self-assess their learning experiences associated with PLE&N adoption and PBL assessment. Both close- and open-ended questions were included into the post-project questionnaire surveys (Table 1). In recognition of their contribution, a bonus mark (2%) was provided to the students who participated in the survey. A seven-point Likert response scale was adopted

to quantify students' self-assessment in response to the specific point in the questionnaire, with 1 signifying "Not Confident", 4 signifying "Neutral", and 7 signifying "Very Confident". The scores in individual categories and mean scores of responses were calculated for further interpretation. Furthermore, face-to-face semi-structured interviews were conducted with selected groups of students (voluntarily participation) to solicit qualitative feedback on the learning process and other relevant issues. Additional questions were raised when needed to attain deeper insights into students' opinions and experiences.

RESULTS AND DISCUSSION

Students' learning experiences and enhancement through PLE&N

The PL&N platform provided an excellent opportunity for postgraduate students to communicate and collaborate with their peers, graduates, experts, and professionals within the field of interest. Through synergistic contributions of the learning community, students were able to locate suitable and relevant learning content for their subject and beyond from continuously evolving educational resources, which would be otherwise highly challenging. Identifying and assessing appropriate content and sharing information with the network was highly beneficial for students to stay at the forefront of higher education. Noticeably, students' engagement and posting in the PLE&N were positively influenced by the 10% allotted marks of the total subject grading as provided as an incentive to value their consistent effort in building the knowledge repository. As clarified by the course instructor in advance, students' contribution to the PLE&N was acknowledged in the following ways, (i) creating new posts to share relevant information, (ii) discussing and commenting on existing posts, (iii) reposting existing threads to/from other relevant groups. Frequency and quality of posts were both considered, and full marks were rewarded in the case when students shared relevant content along with their original interpretation of the specific posting. Notably, perfunctory or arbitrary postings devoid of personal reflection, even if contextually relevant, did not accrue any marks.

Subsequently, end of the project, the efficacy of PLE&N in elevating students' learning enhancement was subjected to scrutiny via a self-assessed questionnaire survey and semi-structured interview. The survey first explored the perceived relevancy and utility of PLE&N content among students. Approximately 89% of surveyed students were confident when asked if "You can find relevant and valuable professional knowledge beyond the classroom lectures through PLE&N" (Figure 2a). Students feedback indicated that the contents shared through this platform were contemporary, engaging, and instrumental

in deepening subject understanding while broadening the professional knowledge base. Around 87% of students agreed that they could ensure accurate and up-to-date knowledge relevant to the latest technology development in the subject (Figure 2b). The semi-structured interviews provided further insights into students' learning experiences related to the PLE&N approach. For example, one of the students commented "Through this platform, I learned the latest news and information about environmental protection. It helped to deepen our understanding of the existing situation related to plastic pollution in the real soil environment. There were also some postings in the PLE&N related to marine pollution and air pollution, which expanded my learning horizon." Students' high agreement and satisfaction with the perceived usefulness of learning content indicated that their combined effort through PLE&N was worthwhile in finding authentic and valuable learning contents among rapidly evolving learning resources. In contrast, approximately 82% of students conveyed various degrees of confidence regarding the personalization of learning content and resources based on their learning preferences and research interest (Figure 2c), while other 18% expressed either neutral or skeptical views. In this case, students might require additional guidance and support to personalize learning resources addressing their individual needs and learning abilities. In contrast, survey results revealed that PLE&N implementation highly improved students' research skills, which is significant particularly for postgraduate students considering their potential research endeavors or career prospect in the future. Approximately 84% of students rated with considerably high to very high scores (score: 5-7) as inquired whether they could critically review and evaluate the online information and learning resources shared by peers and professionals (Figure 2d). Remarkably, more than 90% of the students demonstrated confidence when questioned, "You can enhance your skills to identify uncertainties or unknown parameters (i.e., gaps in knowledge) in your field" (Figure 2e), thereby indicating enhancement of students' research ability due to PLE&N integration to the conventional classroom learning system. Students' relevant comments from the interview are quoted below that reflect their concerted effort to improve research competence.

"The sharing in PLE&N helped us understand the frontiers and prospects of industrial development and made us think deeply about its prospects and constraints."

"For example, the instructor described some research findings about batteries in detail during the lecture, and I was amazed by this work. It pushed me to find more advances, technical knowledge, and information about what I don't know and what is happening worldwide, which I could later share with my classmates via PLE&N."

"I could find some useful information relevant to course

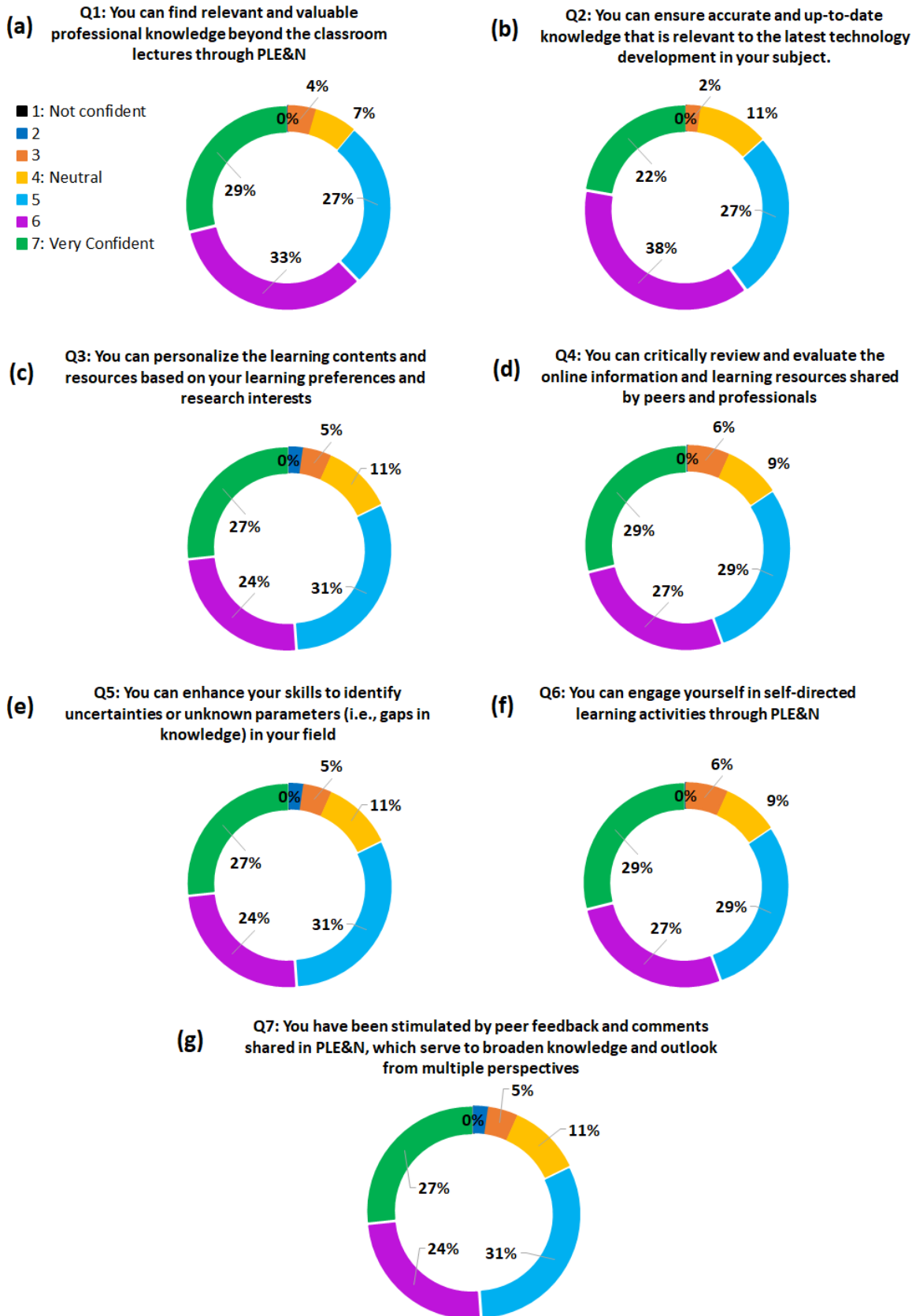


Figure 2. Students' self-assessment of learning enhancement through PLE&N.

content, such as waste management and pollution control. If I did not understand or find some difficult topics, which are too new or too professional, I would research on the internet and get more ideas about it.”

Furthermore, students’ engagement in self-directed learning and peer interaction was investigated during the questionnaire survey. Impressively, an overwhelming 89% of students demonstrated robust confidence, expressed through scores ranging from 5 to 7), indicative of active engagement in self-directed learning activities through PLE&N (Figure 2f). This resounding affirmation alludes to the learner-centered pedagogical approach’s efficacy in fostering a higher extent of students’ involvement in knowledge construction compared to a teacher-centric and lecture-based learning environment. Meaningful engagement in self-directed learning might better enable students to remain updated on crucial information and cutting-edge technologies in the field. In contrast, approximately 82% of students expressed their confidence to various extents when asked if “You have been stimulated by peer feedback and comments shared in PLE&N, which serve to broaden knowledge and outlook from multiple perspectives” (Figure 2g). The survey results underscored the majority of students embrace of peer learning as facilitated by the PLE&N platform. Students appreciated peers’ opinions and feedback that stimulated their own learning and helped them to understand different topics from others’ points of view. Selected students’ remarks serve as poignant illustrations of this dynamic:

“Peers’ comments provided me with a lot of information. I can also find the others’ feedback directly through the emoji, and I think this is an interesting feature of the PLE&N platform.”

“Different students posted different comments with their own ideas. From their comments, I could think about the views from different angles. For example, I found some news about nuclear pollution in Japan and discussed them together with fellow classmates. So, I got a deeper understanding of the topic, which makes me more satisfied.”

Impact of the PBL assessment on self-directed learning and research ability

The PBL assessment, encompassing two distinct team projects (team project-1 & -2), was designed purposefully to stimulate students’ self-directed learning behavior by conducting independent research on a designated topic. For instance, “Hazardous Waste Treatment” was the main theme for project-1. Among 11 groups that participated in the PBL assessment, Groups 1-6 were assigned the topic “Waste incineration fly ash treatment, while Groups 7-11 worked on “Electroplating sludge treatment” under the research theme for project 1. In contrast, team project-2

focused on “Contaminated Site Remediation, where student groups presented either a contaminated site investigation (i.e., clarifying the sources, pathways, receptors, etc.) or proposed a remediation plan for a selected contaminated site (i.e., identify possible treatment options, evaluate different remedial options considering technological requirement, socio-economic analysis, environmental impact, and justify the selected remedial option). Project presentations, each lasting 10 minutes with a subsequent 5-minute open Q & A and formative peer assessment by designated student groups. Students’ performance in this PBL assessment was marked considering the following criteria: appropriateness, analysis, persuasiveness, clarity, and interaction (data not shown).

The PBL assessment evaluating students’ learning enhancement by considering their engagement in constructive learning and connective learning activities, i.e., their skill in knowledge construction based on past experiences and in connecting new nodes of information and ideas. As revealed by the post-project questionnaire survey, the majority of the students demonstrated strong confidence about the desired learning attributes end of the PBL assessment. Remarkably, mean scores in different categories ranged from 5.7 to 6.0 out of 7.0, considerably higher than the post-project mean scores obtained in our previous research on PBL assessment (Dutta *et al.*, 2022). This salient improvement in self-assessed attributes corroborates the PBL assessment’s efficacy. Survey results revealed students’ high confidence regarding comprehension of new knowledge and the latest technology developments during the course of the PBL assessment (Q-11), where around 93% of students rated with scores of 5 to 7 (Figure 3). Essentially, a constructivist classroom inspires students to apply their acquired knowledge to real scenarios, thus creating meaning and understanding through experiences (Bednar *et al.*, 1991). Impressively, over 67% of students expressed a high to very high level of confidence (scores 6 to 7), while other 27% showed moderate confidence when questioned if “You can create meaning and understanding through active learning activities involved in the PBL assessment” (Q-12) (Figure 3). This result underscores the PBL assessment’s success in nurturing students’ critical skill of meaning-making within the constructivist approach. Students’ perceptions of the PBL approach were discerned through their comments:

“My illustration and study skills were trained by the PBL method. Land remediation is a complex process, and I was not only required to understand the principles and the processes well but also to demonstrate it clearly and accurately. Therefore, the learning environment created in this subject provided me with an opportunity to gain progress in my studies.”

“The second term project of our group is to illustrate a

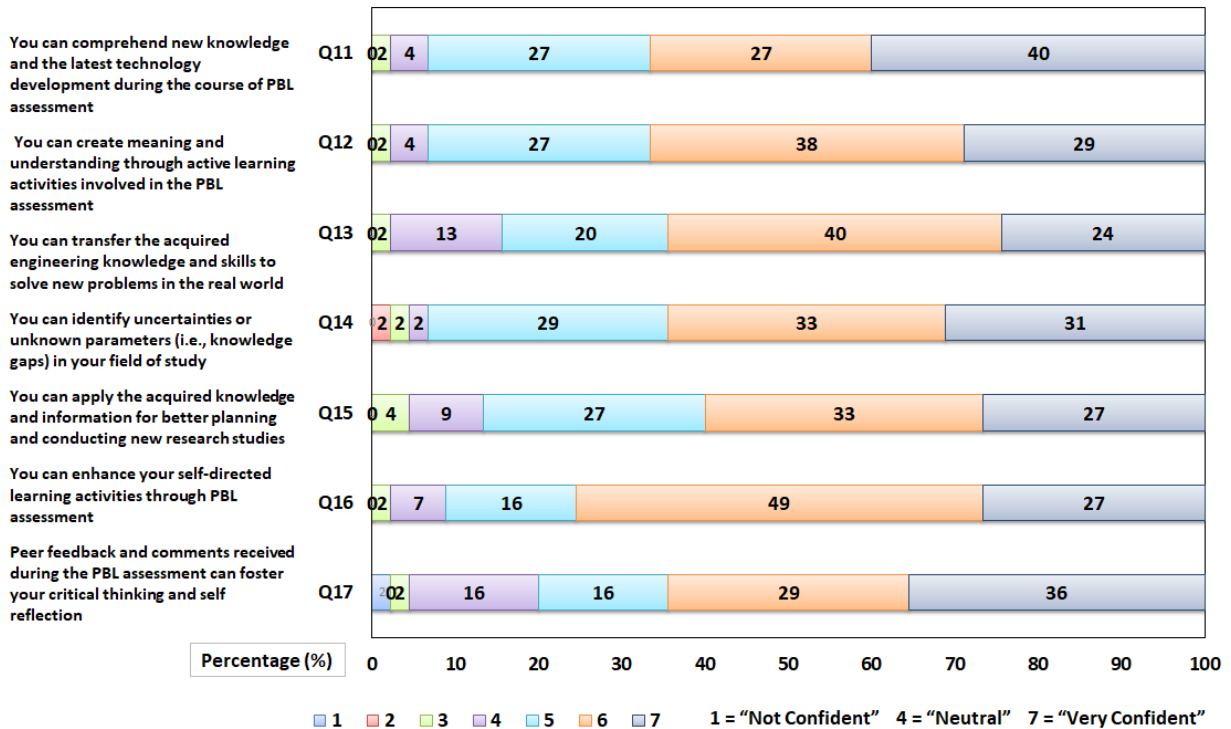


Figure 3. Students' self-assessment of learning enhancement through PBL assessment.

remediation plan, while it was hard to organize our thoughts at the earlier stage of the project. However, through brainstorming, we got the right logic! Our minds were trained!"

"I have a different educational background. So, this subject was very difficult for me to understand. But my teammates helped me a lot, not only for the learning in class but also to perform the PBL assessment together."

Another significant aspect of the PBL learning scheme is developing transferable knowledge and problem-solving skills in new situations (Bates, 2019). Students' self-assessment in the survey (Q-13) indicated that approximately 84% of students articulated various degrees of confidence when asked "You can transfer the acquired engineering knowledge and skills to solve new problems in the real world". The remaining students (16%) were neutral on this viewpoint and might need further supervision and motivation to improve their confidence level. Additionally, over 93% of students manifested high confidence about identifying uncertainties or unknown parameters (i.e., knowledge gaps) in their field of study (Q-14), substantiating PBL's efficacy in stimulating students' connective learning behavior. Further, this study investigated students' self-evaluation of their research ability and self-directed learning, considering their adoption of constructive and connective learning. Impressively, around 91% expressed confidence in

applying the acquired knowledge and information for better planning and conducting new research studies, while 87% of students were confident that the PBL assessment was beneficial in enhancing their self-directed learning activities. These findings and observations are encouraging and stipulate that the PBL assessment was conducive to instilling a research mindset among students by facilitating their active engagement in self-directed learning.

CONCLUSIONS

Observations in this study reveal that postgraduate students embraced the PLE&N and PBL approaches with enthusiasm, recognizing their efficacy in enhancing the quality of their learning experiences. Remarkably, students exhibited a commendable propensity for self-directed learning and the cultivation of robust research competence, signifying a pivotal aspect of their academic development. Consequently, students articulated a high agreement on the usefulness of the PLE&N and PBL approaches, as revealed by the survey and the interview. However, it is pivotal to craft a learning environment that synergizes with these progressive student-centered pedagogies, one that catalyzes interactions, collaborative engagement, and an ardor for research pursuits. This research highlighted that incorporating cutting-edge pedagogical approaches such as PLE&N and PBL into the

conventional lecture-based curriculum could enhance self-directed learning and research attributes among postgraduate students. This integration aptly enhances the proclivity for self-directed learning and the cultivation of research attributes in post-graduate students, heralding a promising trajectory for the higher education landscape. From a broader perspective, the present study champions the merits of modern pedagogical paradigms, advocating their role as catalysts for empowering students and steering academia towards a dynamic and student-centric future.

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