The Impact of Problem-Solving Studios on Entrepreneurial Mindset of Engineering Students

Dimantha S. Kottawa Gamage
Mechanical & Industrial Engineering Department
Montana State University
Bozeman, USA
https://orcid.org/0000-0003-0552-7891

Durward K. Sobek II
Mechanical & Industrial Engineering Department
Montana State University
Bozeman, USA
dsobek@montana.edu

***Abstract*—This research-to-practice full paper describes a study carried out to foster Entrepreneurial Mindset (EM) in industrial engineering undergraduate students. EM is a unique combination of attitudes, habits, and behaviors that, when integrated with technical skills, empowers individuals to creatively solve problems, innovate, and create value across different contexts. In fostering an EM, active learning emerges as highly impactful as it has proven to be significantly more effective than traditional teaching methods, especially in engineering education. Unlike passive learning techniques, active learning prompts students to interact, fostering cognitive engagement leading to a proactive stance toward problem-solving and innovation. The Problem-solving studio (PSS) was designed with the objective of teaching students engineering ways of thinking and analytical problem-solving skills. PSS stands out due to its semester-long partnerships among students, absence of guided inquiry, negotiated roles, public problem-solving, and interaction with near-peer mentors, creating a distinct active learning environment. With the intention of developing an EM, an adapted PSS approach was used to teach Systematic Layout Planning in a facilities design course that is part of the senior year curriculum of an industrial engineering program. This approach was implemented sequentially for two cohorts using case studies. Cohort A engaged in a single case study at the conclusion of the fourth module of the course. In the subsequent year, Cohort B undertook three linked case studies, one at the conclusion of each of the first three course modules. Attainment of EM was evaluated through a quantitative assessment for each case study using a rubric. Additionally, qualitative surveys were employed to collect post-case study feedback. The analysis involved descriptive statistics of the quantitative data and a thematic analysis of the qualitative feedback. Overall, the study demonstrated that employing a PSS approach to teach Systematic Layout Planning fostered the development of students' entrepreneurial mindset and facilitated its transferability to different scenarios. Additionally, a notable mindset shift was observed in students accustomed to traditional learning methods. Lastly, based on the practices and artifacts utilized during the course and student comments on potential improvement, the authors discuss implications for engineering educators through success factors integral to fostering EM in industrial engineering students.**

***Index Terms*—Industrial Engineering, Undergraduate Education, Entrepreneurial Mindset, Problem-Solving Studio**

I. Introduction

Even though many students claim to understand engineering concepts, they encounter difficulties when confronted with open-ended problems [1]. One contributing factor is that many novice engineering students lack the skills to tackle engineering problems effectively as they resort to a rote problem-solving approach, wherein they 1) identify known and unknown variables outlined in the problem statement, 2) search for a formula or equation incorporating these variables, and 3) input the values into the formula to compute a solution [2]. While this method may help solve straightforward, well-defined problems, it often proves ineffective when addressing complex problems [3].

One approach to helping students gain more proficiency in solving complex, open-ended, and ill-structured problems is to cultivate an entrepreneurial mindset (EM) which encompasses a distinct blend of attitudes, habits, and behaviors. According to the Kern Entrepreneurial Engineering Network (KEEN), EM empowers individuals to creatively solve problems, innovate, and generate value across diverse environments [4]. Inculcating this mindset cannot be achieved solely through curriculum changes; instead, changes must be made in how the curriculum is delivered [5]. The Problem-solving studio (PSS) is a learning environment that was designed for teaching engineering ways of thinking and analytical problem-solving skills conducive to cultivating an EM. PSS is unique for its semester-long student collaborations, lack of guided inquiry, flexible roles, public problem-solving activities, and engagement with near-peer mentors, which collectively create a distinctive active learning environment [3].

To foster an EM in senior industrial engineering students, an adapted PSS approach was utilized for teaching Systematic Layout Planning (SLP) in a facilities design course. The objective of this course was to improve students' technical knowledge of SLP to design facility layouts for increased productivity and space utilization [6], while enhancing their EM skills to deal with ill-structured, complex, real-world layout planning scenarios. Traditionally, the co-author taught SLP through assigned readings, PowerPoint-supported lectures, and homework exercises to practice the various steps of SLP. However, due to dissatisfaction with student performance in SLP, the co-author decided to experiment with the PSS approach.

The PSS approach was implemented sequentially for two cohorts using real world case studies. The students had to initially acquire technical knowledge on SLP and Engineering Design Process (EDP). EDP is a systematic problem-solving process in technology and engineering [7], which can be effectively applied to implement SLP in a systematic manner [8]. Subsequently, students demonstrated their learning by applying knowledge of SLP and EDP to address facility layout design problems in case studies. Cohort A completed a single case study at the end of the fourth module of the course. The following year, Cohort B received three interconnected case studies, with one case study concluding each of the first three modules of the course. The achievement of EM was assessed quantitatively for each case study using a rubric that measured adherence to the EDP. Additionally, qualitative surveys were used to gather post-case study feedback on student experience. Figure 1 illustrates the implementation of the PSS approach.

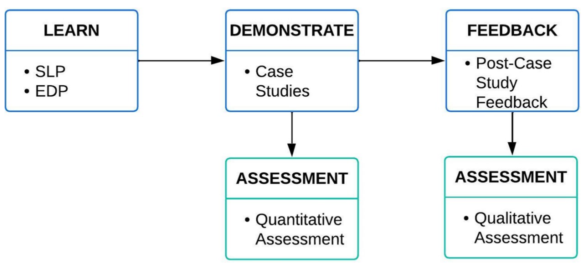

Fig. 1. Implementation of the adapted PSS Approach

This paper compares the results of classroom research projects across the two years to achieve the following objectives:

1) Assess the effectiveness of an adapted PSS approach in developing an EM.
2) Investigate the transferability of the EM cultivated through the adapted PSS approach.
3) Identify key success factors for instilling EM in industrial engineering students.

The next section presents a literature review that explains the theoretical background of this study and provides insights on how the theoretical framework supports achieving the objectives of this study. Subsequent sections discuss the research setting, methods used, analysis approach, results, and conclusions.

II. Literature Review

An entrepreneurial mindset (EM) involves the innovative search for opportunities and facilitates actions to exploit these opportunities, which improves the status quo and benefits individuals, sustains the competitiveness of economic organizations, and fosters environments conducive to human flourishing [4], [9]–[11]. This happens through the integration of EM with existing technical skills, which empowers individuals to solve problems, innovate, and create value [4]. People with an EM perceive needs, problems, and challenges as opportunities and develop creative solutions to address them [12]. Therefore, a crucial element of EM involves developing the metacognitive capacity to address open-ended problems effectively. Given the pivotal role of problem-solving in both professional settings and everyday life, it should be a focal point in education as well. The Accreditation Board for Engineering and Technology (ABET) lists the abilities to identify, formulate, and solve engineering problems as crucial learning outcomes for engineering programs. The National Council of Supervisors of Mathematics stated that the primary purpose of studying mathematics is to learn how to solve problems [13]. Problem-based learning (PBL) is an active learning instructional method that emphasizes the central role of problems in the learning process and actively involves students in their own learning [13], [14]. Proponents of PBL believe that problem solving should be at the core of curricula. According to [15], PBL students consistently apply basic science knowledge and transfer problem-solving skills to real-world professional or personal situations more effectively. Since both EM and PBL prioritize the development of skills that enable individuals to tackle complex, real-world challenges effectively, EM aligns well with PBL [11].

PBL methodologies have been implemented in several engineering programs [16]. PBL commences with students facing an open-ended, complex real-world problem, collaborating in teams to identify learning requirements and devise a feasible solution, with instructors assuming the role of facilitators rather than being the primary providers of information [17]. This fosters the growth of an EM, which may help students face real world scenarios more effectively.

The problem-solving studio (PSS) is a specific PBL technique. The objective of a PSS is to teach students about the process of solving engineering problems while achieving the content-related learning objectives of the class [3]. PSS was first implemented in 2008 in a biomedical engineering department as an experimental approach for teaching an entry-level course. Students involved in the PSS exhibited the capacity to apply knowledge acquired from the course to various facets of their lives and developed professional skills that could enhance their collaboration abilities in future workplaces [18]. Unique features of a PSS include:

- Working on open-ended problems which are more complex and less structured than textbook problems.
- Using dynamic scaffolding (instructional support) to provide students with an appropriate level of challenge.
- Using a two-person participant structure to support student learning.
- Sustaining engagement through a shared problem-solving space, just-in-time coaching and situated feedback.

PSS differs from other active learning methods in several ways. Unlike Informal Cooperative Learning, which often involves short, unstructured interactions in lecture-style rooms, PSS features extended engagements. Unlike Formal Cooperative Learning, where roles are assigned and rotated, PSS allows students to negotiate their roles and collaborate on complex problems rather than rotating through pre-defined tasks. In contrast to Process Oriented Guided Inquiry Learning (POGIL), which relies on structured worksheets, PSS focuses on open-ended problem-solving without guided worksheets. Scale-up methods involve shorter class periods, while PSS uses long, continuous sessions for collaborative problem-solving. Additionally, Laboratory Courses are distinguished by their focus on following specific experimental procedures and individual lab notebooks, whereas PSS emphasizes collaborative problem-solving in a shared space. Overall, PSS combines elements from various cooperative learning approaches but remains unique due to its specific methods and components [3]. Finally, Peer Assisted Learning (PAL), which is an established teaching and learning method in medical education that involves students teaching their peers, leveraging their shared experiences to enhance understanding and foster mutual benefits, while PSS focus on solving open-ended, complex problems collaboratively [19].

The PSS approach was employed in this study to encourage students' EM by having them tackle facility layout problems utilizing an EDP that includes SLP steps [8]. The EDP has been described in numerous variations by engineering education researchers [20]–[25]. Despite their differences, these descriptions typically involve detailed and distinct stages. Generally, the EDP consists of design activities aimed at thoroughly defining a problem, generating ideas for its solution, and refining those ideas into high-quality solutions [7].

EDP is a methodical approach to solving problems in the fields of technology and engineering and can be used in PBL [7], [26]. In a study involving undergraduate engineering students, it was noted that during a design activity, the students instinctively incorporated elements of EM into their reflections. This observation highlights the interrelationship between the EDP and EM, illustrating how each aspect influences the other [27]. As such, following an EDP promotes EM.

III. Methodology

The current study was carried out for two cohorts, Cohort A and Cohort B in adjacent years. Each class consisted of five modules. The course follows a standard format of three credits, comprising three 50-minute class sessions per week throughout the 15-week semester and utilizes the facilities planning textbook [8].

For cohort A, a single case study was developed and implemented based on a prior client-based student project involving a wood furniture production facility. However, since concepts scaffold through the course, the students had to apply the learnings of the two prior modules to develop solutions. Working in pairs, students interacted with the instructor, who assumed the role of the client, to obtain necessary data and discuss the requirements of the case study. A flipped classroom strategy was implemented, whereby students first engaged with course content on SLP and EDP through materials uploaded to the learning management system, including readings from the textbook, online lecture videos, and online discussion forums. Classroom sessions were then utilized by the instructor to do practice problems, answer questions or work on case studies. To build on and improve upon prior offering, the case study initially introduced to cohort B was expanded and divided into three segments. Additionally, following feedback from cohort B students, more resources were allocated towards coaching students, and the weighting of grades for the case studies was increased. A summary of the case study allocation for each Cohort can be found in Table I.

A. Assessment Approach

Three instruments were used to gather information on the success of the PSS approach which are,

- Memos to the client outlining recommendations based on analysis of the case data
- Critical Incident Questionnaire (CIQ)
- Capstone Survey

The deliverable of each case study was a memo to the client outlining the students' recommendations plus any associated deliverables (e.g., layout drawings). The memo was used to understand the development of an entrepreneurial mindset. This was done by assessing the demonstration of specific objectives directly related to the EDP. Those are:

- Identifying and gathering information and data,
- Compiling and synthesizing information/data collected,
- Understanding and defining a problem in terms of stakeholder value,
- Generating alternative solutions,
- Evaluating alternative solutions in terms of stakeholder value,
- Collaboration and coordination among fellow team members and group problem-solving, and
- Communication with stakeholders.

A rubric was developed with three competency levels for each objective (Level I being non-achievement, Level II being partial achievement and Level III being complete achievement of objective) and used to evaluate the memos. At the end of each case study, students reflected upon their experience and gave feedback using a CIQ administered through the online learning management system. The CIQ is an effective qualitative tool to solicit reflection at critical junctures during the process of learning that can lead to transformative development of both students and teachers [28]. Each CIQ consisted of five open-ended, qualitative questions. These questions prompted students to reflect on a "critical event" that occurred, i.e., the case study. The CIQ responses were useful for understanding challenges students faced and the benefits they accrued during each case study.

In addition to the memo and CIQ, a survey was distributed to the students of Cohort B at the completion of their senior capstone project class the following semester. In the senior capstone project class, the students work in teams on a real-world project with an actual client. Survey responses were analyzed to understand the level of impact the SLP class had on developing an EM to tackle complex, open-ended problems as demonstrated in their capstone projects. Analysis also helped identify potential improvements to the PSS approach to teach SLP.

B. Analysis Approach

Data from the summative assessments of each case study memo was analyzed using inferential and descriptive sta-

TABLE I
SUMMARY OF CASE STUDY ALLOCATION

Module	Cohort A	Cohort B
1	N/A	Wood Furniture Production Case Study – Part A
2	N/A	Wood Furniture Production Case Study – Part B
3	N/A	Wood Furniture Production Case Study – Part C
4	Wood Furniture Production Case Study	N/A

tistical methods. The post case study feedback from CIQs were analyzed using qualitative methods. The capstone survey was analyzed using both descriptive statistics and qualitative analysis. A summary of statistical methods utilized is shown in Table II.

In Cohort A, the class consisted of 24 students. For Cohort B, there were 22 students for the first case study and 24 students for subsequent ones. Consequently, this translated into either 11 or 12 pairs of students, and hence the same number of memos. Therefore, the sample sizes for the proportions test were either 77 (11 pairs * 7 EDP objectives) or 84 (12 pairs * 7 EDP objectives). All the students who participated in the case studies responded to the CIQ's. 21 students responded to the capstone survey.

For research objective 1, which aims to assess the effectiveness of an adapted PSS approach in fostering an EM, the convergence variant of the triangulation design was employed for the analysis. The triangulation design is widely recognized as the most popular approach in mixed-method studies [29]. It aims to leverage the unique strengths and address the distinct limitations of both quantitative methods, such as large sample sizes and trend analysis for generalization, and qualitative methods, which offer detailed insights with a smaller sample size and in-depth examination [30]. In the convergence variant of the triangulation design, both quantitative and qualitative data pertaining to the same phenomenon are collected and analyzed independently. Subsequently, during the interpretation phase, the researcher converges the different results by comparing and contrasting them [29]. Initially, the quantitative data from the case studies are analyzed by comparing the overall Level III achievement of EDP objectives within Cohort B and between Cohort A and Cohort B. This is followed by an analysis of Level I, II, and III achievements for EDP objectives within each case study and an assessment of Level III achievement for each EDP objective across all case studies. Next, the qualitative data from the CIQ are analyzed independently to explore student experiences and perceptions. Finally, the quantitative and qualitative findings converged, which involves comparing, contrasting and interpreting the results from both data types.

For research objective 2, which aims to investigate the transferability of the EM cultivated through the adapted PSS approach, quantitative data from the capstone survey was utilized. For research objective 3, which seeks to identify key success factors for instilling EM in industrial engineering students, all the information captured from this study combined with the observations made by the instructor during the semesters was utilized.

IV. Results & Discussion

A. Objective 1: Assess the effectiveness of an adapted PSS approach in fostering an EM

Table III presents a summary of two-sample proportions tests conducted on the case study data. The cohort is denoted by A and B, where the numerical value (1, 2, or 3) represents the case study number, and P indicates proportion. For the comparison between cohorts A and B, at a significance level of 5%, the null hypothesis is rejected for proportion comparisons of A1-B3 and fails to be rejected for A1-B1. This suggests that the proportion of Level III attainment for EDP objectives is higher in B3 compared to A1 and equal in A1 compared to B1. In the comparison between case studies within Cohort B, at a significance level of 5%, the null hypothesis is rejected for proportion comparisons of B1-B2 and B2-B3. This implies that the proportion of Level III attainment for EDP objectives is higher in B3 compared to B2 and higher in B1 compared to B2. It is interesting to note the uncharacteristic dip in Level III attainment in B2.

Figure 2 summarizes the percentage achievement of Level I, II and III for each case study memo. As shown in the graphs, the proportion of Level III objectives increased from Cohort A (29.8%) to Cohort B (47.6%). Also, the proportion of Level I objectives decreased from Cohort A (21.4%) to Cohort B (8.3%). Within Cohort B, the proportion of Level I objectives decreased from 19.5% to 8.3% across the four modules and the achievement of Level III objectives increased from 40.3% to 47.6%. However, it is interesting to observe a decrease in Level II and III objective achievements alongside an increase in Level I objective achievement in B2.

Table IV shows the proportion of student pairs who demonstrated Level III attainment of each EDP objective for the two Cohorts. In comparing A1 and B3, the percentage of Level III achievement of five out of seven objectives was larger for Cohort B than Cohort A. From B1 to B3 within Cohort B, the percentage of Level III achievement improved for four out of seven objectives. It is noticeable that there is a significant dip in the Level III achievement in B2, specifically for EDP objectives 2, 3, 4 and 5.

The thematic analysis of Cohort A CIQ highlights various aspects of student experience. Students generally felt engaged with the real-world application of knowledge, although they found the amount and quality of data lacking and inconsistent.

TABLE II
SUMMARY OF STATISTICAL METHODS

Instrument	Statistical Analysis	Explanation
Case studies	Two-Sample Proportions Test	Compare the proportions of Level III achievement across all EDP objectives for all student pairs between different case studies
	Quantitative Data Summarization	Percentage achievement of Level III for each EDP objective for each case study
	Quantitative Data Summarization	Percentage achievement of Level I, II and III for each case study
CIQs	Thematic Analysis	Identification of themes in the student reflection on critical incidents during each case study
Capstone Survey	Thematic Analysis	Identification of themes the student reflection on how the SLP PSSs can be enhanced to better prepare students for open ended problem solving in capstone projects
	Quantitative Data Summarization	Average ratings of the effectiveness of the PSSs in preparing students to apply each EDP objective during the capstone projects

TABLE III
SUMMARY OF TWO-SAMPLE PROPORTIONS TEST

*indicates significant at P-value=0.1, **indicates significant at P-value=0.05

	Cohort A to B Comparison		Within Cohort B Comparison	
	A1 – B1	A1 – B3	B1 – B2	B2 – B3
Null Hypothesis (H_0)	P_{A1} - P_{B1} = 0	P_{A1} - P_{B3} = 0	P_{B1} - P_{B2} = 0	P_{B2} - P_{B3} = 0
Alternative Hypothesis (H_a)	P_{A1} - P_{B1} <0	P_{A1} - P_{B3} <0	P_{B1} - P_{B2} >0	P_{B2} - P_{B3} <0
P-value	0.081*	0.008**	0.012**	0.000**

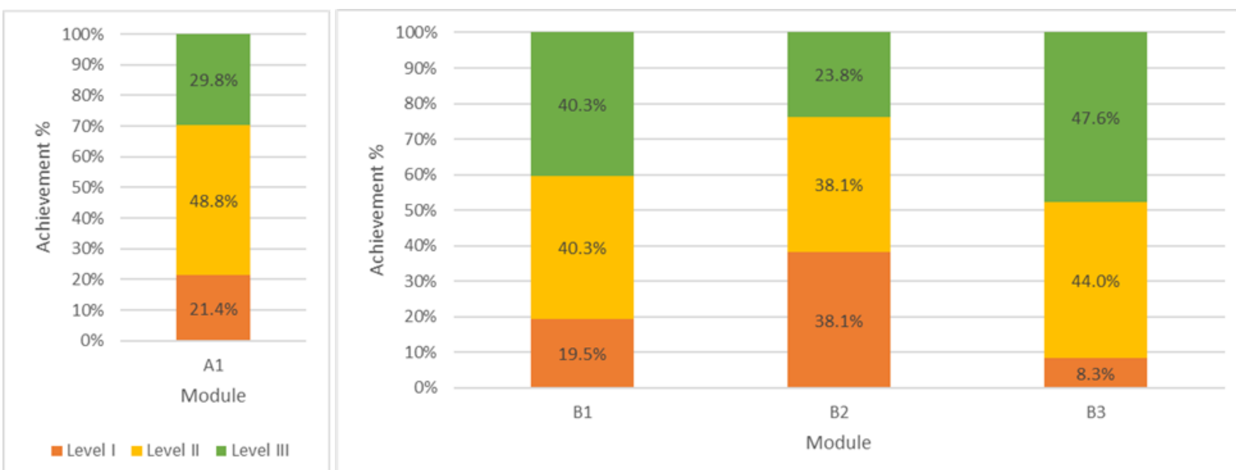

Fig. 2. Summary of EDP Objective Achievement

The class structure and material, particularly the case study, were perceived as demanding for little credit. While they valued instructor engagement in problem-solving, they felt disconnected during CAD tutorials. Group learning dynamics were mixed, with some finding peers helpful while others felt they lacked effort and communication skills. Students enjoyed working with technology but found it challenging due to insufficient instructions. Despite complexities and open-endedness in the case study, students felt engaged in various aspects but also experienced distance during decision-making processes.

The thematic analysis of Cohort B CIQs reveals several key insights. Students appreciated the application of course learnings to real-world scenarios, though some found certain class materials challenging especially direct clustering algorithm (DCA) in module 2 (pertains to B2). While initially praising the class structure, some students later expressed dissatisfaction with assigned pairs. They valued the instructor's guidance but found clarity lacking in certain modules. Group learning dynamics were positive overall, fostering skill

TABLE IV
PERCENTAGE OF LEVEL III ACHIEVEMENT FOR EACH EDP OBJECTIVE

#	EDP Objectives	Cohort A	Cohort B		
		A1	B1	B2	B3
1	Identifying and gathering information and data	16.7%	45.5%	50.0%	41.7%
2	Compiling and synthesizing information/data collected	16.7%	27.3%	8.3%	33.3%
3	Understanding and defining a problem in terms of stakeholder value	25.0%	18.2%	0.0%	41.7%
4	Generating alternative solutions	66.7%	27.3%	0.0%	58.3%
5	Evaluating alternative solutions in terms of stakeholder value	25.0%	18.2%	0.0%	33.3%
6	Collaboration and coordination among fellow team members and group problem-solving	0.0%	90.9%	83.3%	83.3%
7	Communication with stakeholders	58.3%	54.5%	25.0%	41.7%

development in leadership, problem-solving, and teamwork. Students found case studies engaging but demanding. Students generally preferred in-person classes but acknowledged effective management of online components. Despite the effort required to be successful in the class, students recognized skill development and the supportive role of their teams.

The analysis of the data from the two cohorts, A and B, provides valuable insights into the effectiveness of the adapted PSS approach in fostering an EM in engineering students. During Cohort A, the case studies were given relatively low weightage, resulting in less effort from students, as evidenced by CIQ responses. However, adjustments were made in Cohort B, where case studies were given higher weightage. Despite these adjustments, the performance of A1 and B1 remained comparable. Additionally, since the PSS instructional method was new to students, there was an initial need for adaptation in how students approached the class, reflected in CIQ feedback. However, over time, negative comments decreased significantly, replaced by more positive ones.

The quantitative data presented above indicates an enhancement in EM from Cohort A to B, as well as within Cohort B. This suggests that the more time students spend in a PSS environment, the greater the improvement in their EM. However, it is important to address the decline in Level III and II objective achievement in B2, attributed to the failure to meet EDP objectives 2, 3, 4, and 5. Feedback from the CIQ indicates that students encountered difficulty understanding the concepts of DCA and this difficulty was reflected during the case study. This underscores the importance of dynamic scaffolding for instructing and highlights a potential area of improvement.

Moreover, the slight decrease in EDP objective 6 attainment in B3 may potentially be linked to student dissatisfaction with their partners towards the end of the semester, as indicated by the CIQs. This highlights another area for potential improvement in future class deliveries. Overall, this analysis clearly demonstrates the impact of the PSS approach in enhancing EDP objectives and consequently fostering EM.

B. Objective 2: Investigate the transferability of the EM cultivated through the adapted PSS approach

Table V presents the effectiveness of PSS in preparing students to achieve EDP objectives based on capstone survey feedback. Each objective is rated on a scale of 1 to 5, with 1 indicating the lowest and 5 indicating the highest level of preparation. Overall, 75% - 85% responses indicated a high-level preparation for achieving each EDP objective during the capstone project. Therefore, it is evident that the EM established through SLP PSSs in the prior semester was transferable to other real-world scenarios.

C. Objective 3: Identify key success factors for instilling EM in industrial engineering students

All the information captured from this study combined with the observations made by the instructor during the semesters revealed several success factors to successfully inculcate EM in industrial engineering students. These success factors could be used to enhance the PSS experience.

1) Coaching: Since the problems are complex and open ended, the instructor needs to allocate sufficient time for coaching students. Coaching not only entails answering questions but also guiding students to ask the correct questions, make accurate assumptions and think about different approaches.

2) Facilitate Active Learning: We believe in a two-person participation structure for the PSS. However, a separate extended group of students engaging in discussions pertaining to technical knowledge or open-ended problems improves their understanding and increases their soft skills by engaging with a team. Soft skills are also necessary in problem solving, which is the core aspect of EM. Therefore, different methods and artifacts can be utilized to maximize student engagement (i.e., discussion boards, study groups).

3) Two-way Communication: The structure of the PSS can be frustrating for students since it is different from traditional learning methods. Therefore, the instructor needs to communicate expectations clearly for every activity. Also, an environment needs to be created so that the students can clarify

TABLE V
EFFECTIVENESS OF SLP PSSS IN PREPARING STUDENTS TO ACHIEVE EACH EDP OBJECTIVE

#	EDP Objectives	Cohort A	Cohort B		
		A1	**B1**	**B2**	**B3**
1	Identifying and gathering information and data	16.7%	45.5%	50.0%	41.7%
2	Compiling and synthesizing information/data collected	16.7%	27.3%	8.3%	33.3%
3	Understanding and defining a problem in terms of stakeholder value	25.0%	18.2%	0.0%	41.7%
4	Generating alternative solutions	66.7%	27.3%	0.0%	58.3%
5	Evaluating alternative solutions in terms of stakeholder value	25.0%	18.2%	0.0%	33.3%
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7	Communication with stakeholders	58.3%	54.5%	25.0%	41.7%

expectations. We believe that this is an important aspect of dynamic scaffolding to ensure that the students are operating in their zone of proximal development (ZPD).

4) Evaluation and Feedback: Evaluation and feedback for the students on both technical knowledge gain and development of EM is important. Also, evaluation should be used as a way for identifying the current state of the class.

5) Current State Monitoring: To provide dynamic scaffolding, the instructor should monitor the learning and progress of the overall cohort and individuals using multiple methods and artifacts (i.e., CIQ, survey, student performance). This should happen consistently during the semester so that the instructor can make real-time changes to the approach to ensure the students are operating in their ZPD.

6) Real World Case Studies: Open-ended and complex problems could be designed in many ways. We believe that one of the best ways is to develop a real-world case study because students gain exposure to a realistic scenario with its associated uncertainties and complexity.

7) Content Flexibility: Each cohort is bound to be different in terms of the understanding of the material and approach taken to solve problems, especially in an open-ended problem-solving environment. Hence, teaching for every cohort should be customized to that group which requires schedule flexibility with time allocated for coaching and just-in-time teaching based on the information gathered using the current state monitoring.

D. Limitations

One of the limitations of this study is that the research involved two distinct cohorts, which introduces the risk of cohort-specific variability affecting the results. This variability may impact the generalizability of the findings, suggesting that results could differ with other groups. Another limitation is the limited validity and reliability testing of the rubric and questionnaire used for evaluation, which potentially impacts the robustness of the findings. Addressing these limitations in future research will be important for validating and enhancing the credibility and applicability of the study's findings.

V. CONCLUSIONS & FUTURE WORK

The findings from this study indicate that using a PSS approach to teach SLP not only fostered the development of students' EM but also facilitated its transferability to different scenarios. Even though there were certain EDP objectives where the achievement deteriorated through the modules, achievement of majority of the EDP objectives increased across cohorts and through the modules.

Furthermore, the authors introduced seven success factors that could be used to inculcate EM through the PSS. Successful implementation of these factors would also achieve the unique features of a PSS mentioned by [3]. Finally, a mindset shift in the students who were used to traditional learning approaches could be seen towards the end of the class. The students realized that developing problem skills to deal with ill-structured and open-ended problems is important since it more closely resembles actual working environment.

For the upcoming semesters, it is imperative to prioritize ongoing monitoring of student progress and providing dynamic scaffolding as needed. This involves regularly assessing the current state of student understanding and adjusting instructional strategies accordingly to address any areas of difficulty. Additionally, exploring methods such as team member rotation to enhance student dynamics within pairs warrants further investigation.It is also essential to expand the use of the PSS approach to other engineering courses to help assess its broader applicability and effectiveness.

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