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Evaluating the knowledge ability of students by inquiry-based learning technique

Wesam Salah Alaloul[1], Khalid Mhmoud Alzu'bi[2], Muhammad Ali Musarat[3,4]
[1]Department of Civil and Environmental Engineering, United Arab Emirates University, Al Ain, United Arab Emirates
[2]Department of Civil and Environmental Engineering, Al-Huson University College, Al-Balqa Applied University, Irbid, Jordan
[3]Department of Civil and Environmental Engineering, Universiti Teknologi PETRONAS, Seri Iskandar, Malaysia
[4]Faculty of Civil and Mechanical Engineering, Riga Technical University, Riga, Latvia

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ABSTRACT

Inquiry-based learning (IBL) as an instructional approach has been popular amongst science, technology, engineering, mathematics disciplines, but the practice specifically in engineering education deserves further exploration. This study explores the impact of IBL on student engagement and learning within an engineering project management course. Using a case-study methodology, engineering students engaged in real-world problem-solving activities and provided feedback through a questionnaire assessing lecturer deliverables and IBL effectiveness. For this study, a questionnaire approach was adopted comprised of 34 questions compressed under two main groups. The distribution was made among engineering students of various disciplines. The descriptive and reliability analysis of the responses revealed that IBL positively influenced students' engagement and problem-solving abilities, fostering a collaborative learning environment. However, students noted a high workload associated with IBL tasks, suggesting the need for careful assignment structuring. Overall, the study highlights IBL's potential to enrich engineering education by aligning learning outcomes with industry demands, recommending that future implementations consider workload optimization to maintain balance. This research contributes to understanding effective pedagogical approaches in engineering, promoting student-centered learning that prepares students for professional challenges.

Corresponding Author:

Khalid Mhmoud Alzu'bi
Department of Civil and Environmental Engineering, Al-Huson University College
Al-Balqa Applied University
21510, Irbid, Jordan
Email: alzoubi_khalid@bau.edu.jo

1. INTRODUCTION

Inquiry-based learning (IBL) is an active learning approach that has emerged as a powerful educational approach that promotes active engagement, critical thinking, and problem-solving skills among students [1], [2]. This pedagogical method encourages learners to explore real-world challenges, ask questions, and seek solutions through investigation and analysis [2], [3]. In the realm of engineering project management, the application of IBL holds significant promise for enhancing students' understanding of complex project management concepts and practices. Engineering education plays a pivotal role in preparing students for the dynamic and multifaceted field of project management. By integrating IBL into the learning process, educators can provide students with opportunities to develop essential skills, such as decision-making, teamwork, and communication within the context of real engineering projects [4], [5].

The implementation of IBL across various educational contexts is marked by its emphasis on student-centered exploration and discovery. Generally, IBL is implemented by structuring learning experiences around open-ended questions, real-world problems, or authentic tasks that prompt students to actively engage with course material [6].

To effectively integrate IBL into engineering curricula, instructors must design learning experiences that align with the specific goals and objectives of engineering programs. This may involve selecting appropriate engineering problems or projects that are relevant, authentic, and engaging for students. Furthermore, instructors must provide scaffolding and support to help students navigate the inquiry process, particularly in fields where foundational knowledge and technical skills are essential [4], [7].

IBL activities have been shown to improve student's learning in various subjects, including physics and mechanics of materials [8]–[10]. Several studies have demonstrated the effectiveness of IBL in enhancing students' understanding and performance in these areas [8], [11], [12]. Recently, there has been a growing emphasis on active learning approaches in engineering education, with IBL emerging as a prominent pedagogical strategy. IBL shifts the focus from passive reception of knowledge to active exploration, inquiry, and discovery, aligning closely with the demands of the contemporary engineering profession [8], [13]. By engaging students in authentic, problem-centered learning experiences, IBL aims to develop problem-solving abilities, critical thinking skills, and a deeper understanding of engineering principles [5], [8], [9]. However, the successful implementation of IBL in engineering education is not without its challenges. Issues such as faculty resistance, resource constraints, and the need for appropriate assessment strategies pose significant hurdles to widespread adoption. Moreover, as technology continues to reshape the educational landscape, there is a need to explore how emerging digital tools and learning environments can enhance the effectiveness of IBL in engineering curricula [14]–[16].

IBL can be categorized into several types based on the level of structure and guidance provided to students during the inquiry process. These types include structured inquiry, guided inquiry, and open inquiry [17], [18]. Numerous studies have explored the implementation of IBL in engineering education, consistently highlighting its positive impact on student engagement and performance. For instance, Luo *et al.* [8] examined the implementation of guided inquiry methods in an undergraduate engineering course over a four-week period. Despite challenges posed by the COVID-19 pandemic, which affected the implementation process, the findings revealed mixed reactions among students. While some students expressed reluctance towards the activities, perceiving them as stressful and time-consuming, others embraced them positively. Students appreciated the collaborative learning environment fostered by the inquiry-based approach, which encouraged teamwork and peer interaction. Despite occasional struggles with independent work and a lack of prior guidance, students found the inquiry-based activities beneficial for enhancing their understanding of engineering concepts. Overall, the study highlights both the challenges and benefits of integrating IBL into engineering education, emphasizing the importance of supportive and collaborative learning environments in facilitating student engagement and learning.

In another study, Qi *et al.* [2] investigated the efficacy of structured inquiry-based learning activities (IBLAs) as pre-training materials for a mechanics of materials class. Using descriptive analysis and statistical hypothesis tests, the researchers evaluated the impact of IBLAs on student learning outcomes compared to traditional reading assignments. The findings revealed that IBLAs had a significantly stronger positive effect on students' academic performance in topics where they were employed, as evidenced by delayed tests such as quizzes, midterms, and final exams. Similarly, Adorno [19] explores the effectiveness of guided and open inquiry approaches in bio-signal processing training. The results suggested that self-directed learning activities enhanced students' enthusiasm and engagement in engineering investigations, ultimately contributing to improved academic achievements and the adoption of more effective learning approaches. Moreover, in Ghadi and Mammucari [20], an active laboratory learning experience for chemical engineering students was facilitated using hypothesis testing. The effectiveness of this approach was evaluated through a combination of students' reflections, summative assessment results, and observations from the teaching team. Furthermore, the study integrated pre-lab and post-lab student surveys, along with interviews with the teaching team, to gather comprehensive feedback on the learning experience. There are several challenges and opportunities for the implementation of IBL in engineering education. Figure 1 summarizes the opportunities, challenges, and implication forms of IBL in engineering education. IBL promotes a learner-centered environment that empowers students to take ownership of their learning process [21]. By engaging in authentic project scenarios and collaborative problem-solving activities, students are better equipped to develop critical thinking abilities, creativity, and adaptability qualities that are highly valued in the modern engineering workforce [22], [23].

Incorporating IBL into an engineering project management course can significantly enrich the learning experience and better prepare students for the complexities of managing engineering projects. By immersing students in inquiry-driven investigations, educators can instill a sense of curiosity, resilience, and continuous learning that are fundamental for success in the dynamic field of project management. Hence, this study aims to assess the impact of IBL on engineering students to observe the improvement brought to their learning. Implementing IBL in an engineering project management course holds significant importance in fostering the development of essential skills and competencies among students. By incorporating structured, guided, or open inquiry approaches within the course curriculum, students are exposed to real-world challenges and scenarios, enhancing their problem-solving abilities, critical thinking skills, and teamwork capacities.

The primary objective of this study was to evaluate the effectiveness of IBL in enhancing students' knowledge acquisition and overall learning experience within the context of engineering education. By investigating students' perceptions of IBL, this research aimed to provide insights into the potential benefits and challenges associated with implementing this teaching approach. The study is relevant because it addresses the need for innovative and effective teaching methodologies in higher education. IBL has gained increasing attention as a student-centered approach, but its impact on engineering students, specifically in the context of project management, remains under-explored. This research contributes to the existing body of knowledge by shedding light on the potential benefits and challenges of implementing IBL in this field. Accordingly, this study is trying to answer the question: how does IBL impact engineering students' learning experiences and outcomes within a project management course?

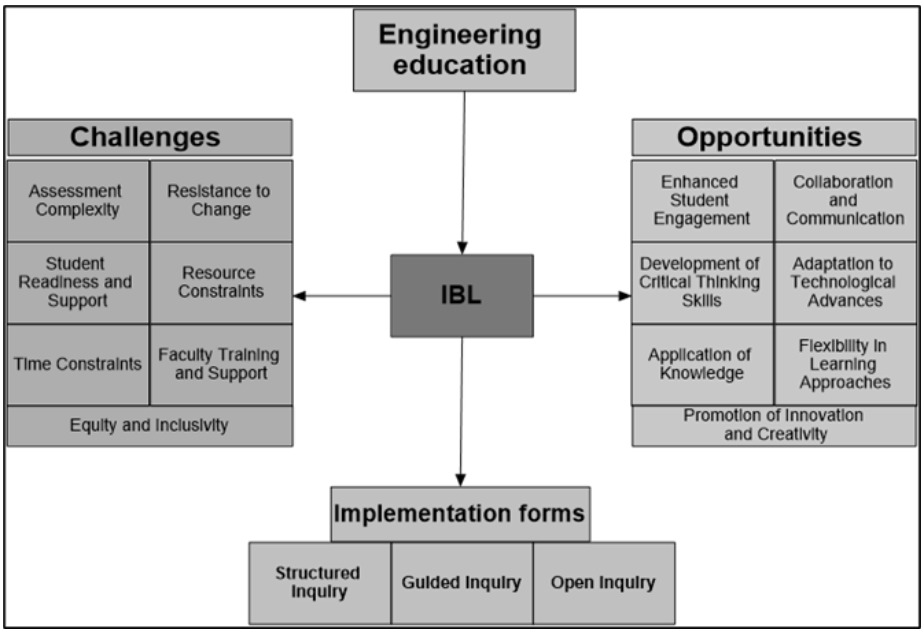

Figure 1. Implementation of IBL in engineering education

2. METHOD

The methodology of this study focuses on the assessment of the impact of IBL technique on engineering students' knowledge acquisition within a project management course. A case-study approach was employed involving 100 students. A sample size of 100 students was deemed adequate following educational research guidelines, which suggest that sample sizes of 30-100 are sufficient for studies examining perceptions and effectiveness of teaching approaches in higher education [24]–[26]. Students tackled three real-world project management cases over three weeks. After that students' perceptions were gathered through questionnaires. Two types of main groups were identified in which further questions were set up. The first group of questions was related to "lecturer deliverables", comprised of 13 questions and the second group was about the "impact of IBL technique on course learning" comprised of 21 questions. The questionnaire was reviewed by educational experts to ensure face validity, aligning with standard practices in survey design. The reliability analysis yielded a Cronbach's alpha of 0.980 for 34 items questionnaire, which is considered excellent for educational research. Once the feedback was collected, statistical analysis was performed comprised of Reliability analysis and descriptive analysis [27], [28].

3. RESULTS

Assessing IBL involves evaluating not only students' understanding of content knowledge but also their ability to engage in critical thinking, problem-solving, and inquiry skills [21], [29]. Traditional assessment methods such as tests and quizzes may not adequately capture the depth of learning and skills developed through IBL. Instead, a variety of assessment strategies are employed to assess students' progress and proficiency in IBL. Rubrics and checklists are often used to assess the quality of students' inquiry processes, including their ability to formulate research questions, design experiments, collect and analyze data, and communicate findings effectively [30], [31]. Formative assessment techniques such as peer and self-assessment can also be valuable in IBL, allowing students to reflect on their learning progress and provide feedback to peers. Furthermore, authentic assessments that simulate real-world challenges or scenarios provide opportunities for students to apply their learning in context and demonstrate their ability to solve complex problems. Overall, assessing IBL involves a multifaceted approach that emphasizes not only content mastery but also higher-order thinking skills, metacognition, and collaboration. The following subsections show the respondents profile and the analysis of the collected data to evaluate the knowledge ability of students by IBL techniques.

3.1. Respondents profile

The students of various engineering disciplines were targeted to provide feedback. Age, gender, degree program, and CGPA were the basic questions that were asked of the respondents, the details can be seen in Figure 2. It can be observed that the majority of respondents were males and the highest response rate was from chemical engineering students.

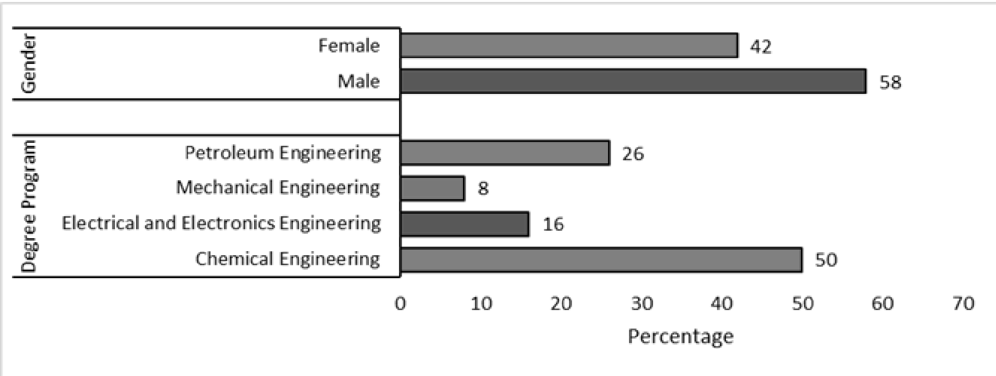

Figure 2. Respondents profile

3.2. Reliability analysis

The reliability analysis conducted through Cronbach's alpha achieved a score of 0.980, indicating high internal consistency [27], [28]. This result suggests that students' responses to the IBL-related questions were stable and reflected consistent perceptions across different items. Such a high level of reliability underscores the effectiveness of the questionnaire in capturing reliable data on student engagement and learning. The details are mentioned in Table 1.

Table 1. Reliability analysis

	Case processing summary	N	%
Cases	Valid	100	100.0
	Excluded	0	0.0
	Total	100	100.0
	Reliability statistics		
Cronbach's alpha		0.980	
N of items		34	

3.3. Descriptive analysis

The descriptive analysis highlights key findings related to both lecturer deliverables and IBL's impact. Notably, students rated aspects like effective use of class time and the lecturer's supportiveness highly, underscoring the value placed on interactive and clear teaching practices. The following subsections show in details the key findings related to the first group of questions "lecturer deliverables", and the second group of questions "impact of IBL technique on course learning".

3.3.1. Lecturer deliverables

As can be shown in Tables 2 and 3, the first group of questions were related to lecturer deliverables which comprised 13 sub-questions. The students were asked to give feedback based on the Likert scale which was 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree. The descriptive analysis was performed that covers minimum, maximum, mean, standard deviation, Skewness and Kurtosis values. It can be observed that the minimum value lies as 1, while the maximum value is 5. The highest mean value was observed for the questions "explains the topic well helps to understand it in a better way" and "uses class time effectively to educate the students" with a score of 4.5400, followed by the questions "the lecturer applied the target language and thinking style properly" and "Encourages collaboration and involvement among the students" with a score of 4.5200. The third-ranked questions were "The lecturer allowed all students to engage in activities and conversations related to inquiry-based technique", "Offers information in a number of ways so that it gets delivered in a better way" and "implements the rules equally and consistently among the students" with a score of 4.5000. Further details can be found in Table 4.

Table 2. List of questions related to lecturer deliverables

No	Question	Code
1	The lecturer had a certain course plan	L1
2	The lecturer applied the target language and thinking style properly	L2
3	The lecturer allowed all students to engage in activities and conversations related to inquiry-based technique	L3
4	Clearly describes the course's objectives, prerequisites, and grading structure	L4
5	Explains the topic well helps to understand it in a better way	L5
6	Recognizes and acknowledges my efforts during the course	L6
7	Is friendly and eager to help me whenever I needed	L7
8	Uses class time effectively to educate the students	L8
9	Encourages collaboration and involvement among the students	L9
10	Offers information in a number of ways so that it gets delivered in a better way	L10
11	Promotes and embraces diverse ideas to educate the students	L11
12	Implements the rules equally and consistently among the students	L12
13	Makes the class engaging and relevant to the topic	L13

Table 3. List of questions related to impact of IBL technique on course learning

No	Question	Code
1	IBL was easy to understand in the project management course	I1
2	I had a clear idea about the IBL requirements in this course	I2
3	The IBL technique workload was too heavy to handle	I3
4	There was a lot of pressure on me to solve the IBL-related assignments	I4
5	IBL technique provided a platform to learn the course in our own way	I5
6	IBL technique improved by problem-solving skills	I6
7	IBL technique provided the platform to interact with the lecturer more efficiently	I7
8	IBL technique provided the platform to interact with teammates more efficiently	I8
9	IBL-related assignments were enjoyable to solve	I9
10	IBL technique guides to understanding the topic in a better way	I10
11	In comparison to conventional teaching techniques, IBL is much more effective in delivering the knowledge	I11
12	I enjoy learning and utilizing the IBL technique	I12
13	My learning process went well while following an IBL technique	I13
14	The IBL technique is an intriguing and novel learning tool for my project management course	I14
15	The IBL technique is more fascinating for me to learn	I15
16	Using the IBL technique, I became more engaged in learning activities	I16
17	My learning spirit increased after adopting the IBL technique	I17
18	I use the IBL approach to focus on project management topics in the classroom by questioning more	I18
19	I find it easier to comprehend project management principles utilizing an IBL technique	I19
20	Learning with my IBL technique can solve the exercise complexity	I20
21	Learning to use an IBL technique helps me grasp more rapidly	I21

3.3.2. Impact of IBL technique on course learning

The second group of questions were related to the Impact of IBL technique on course learning which comprised 21 sub-questions. The students were asked to give feedback based on the Likert scale which was 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree. The descriptive analysis was performed that covers minimum, maximum, mean, standard deviation, Skewness and Kurtosis values. It can be observed that the minimum value lies as 1, while the maximum value is 5. The highest mean value was observed for the question "IBL was easy to understand in the project management course" with a score of

4.3000, followed by the questions “IBL technique improved by problem-solving skills” and “IBL technique provided the platform to interact with teammates more efficiently” with a score of 4.2600. The third-ranked question was “the IBL technique is an intriguing and novel learning tool for my project management course” with a score of 4.2400. Further details can be found in Table 5.

Table 4. Descriptive analysis of lecturer deliverables

SN	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Dev.	Statistic	Std. Dev.
L1	3.00	5.00	4.4400	0.67491	-0.811	0.337	-0.432	0.662
L2	3.00	5.00	4.5200	0.64650	-1.021	0.337	-0.009	0.662
L3	3.00	5.00	4.5000	0.58029	-0.653	0.337	-0.523	0.662
L4	2.00	5.00	4.4200	0.78480	-1.439	0.337	1.945	0.662
L5	2.00	5.00	4.5400	0.67643	-1.593	0.337	2.936	0.662
L6	1.00	5.00	4.3600	0.82709	-1.673	0.337	4.163	0.662
L7	2.00	5.00	4.4200	0.78480	-1.439	0.337	1.945	0.662
L8	3.00	5.00	4.5400	0.64555	-1.103	0.337	0.149	0.662
L9	2.00	5.00	4.5200	0.67733	-1.512	0.337	2.708	0.662
L10	3.00	5.00	4.5000	0.64681	-0.943	0.337	-0.145	0.662
L11	3.00	5.00	4.4400	0.70450	-0.873	0.337	-0.463	0.662
L12	2.00	5.00	4.5000	0.67763	-1.435	0.337	2.510	0.662
L13	2.00	5.00	4.4600	0.67643	-1.292	0.337	2.195	0.662

Table 5. Descriptive analysis of impact of IBL technique on course learning

SN	Minimum	Maximum	Mean	Std. Dev.	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Dev.	Statistic	Std. Dev.
I1	3.00	5.00	4.3000	0.76265	-0.575	0.337	-1.038	0.662
I2	2.00	5.00	4.2000	0.88063	-0.784	0.337	-0.318	0.662
I3	1.00	5.00	3.6400	1.22491	-0.443	0.337	-0.950	0.662
I4	1.00	5.00	3.7000	1.16496	-0.347	0.337	-1.042	0.662
I5	3.00	5.00	4.1400	0.75620	-0.241	0.337	-1.187	0.662
I6	3.00	5.00	4.2600	0.75078	-0.473	0.337	-1.061	0.662
I7	2.00	5.00	4.0600	0.84298	-0.329	0.337	-0.978	0.662
I8	3.00	5.00	4.2600	0.80331	-0.514	0.337	-1.255	0.662
I9	2.00	5.00	4.1400	0.85738	-0.481	0.337	-0.942	0.662
I10	2.00	5.00	4.1800	0.87342	-0.749	0.337	-0.316	0.662
I11	2.00	5.00	4.1200	0.82413	-0.458	0.337	-0.747	0.662
I12	1.00	5.00	4.1200	0.93982	-1.016	0.337	1.044	0.662
I13	2.00	5.00	4.1800	0.77433	-0.602	0.337	-0.196	0.662
I14	2.00	5.00	4.2400	0.82214	-0.709	0.337	-0.457	0.662
I15	2.00	5.00	4.1000	0.86307	-0.595	0.337	-0.449	0.662

4. DISCUSSION

4.1. Lecturer deliverables

The analysis of lecturer deliverables reveals critical insights into how students perceive their educational experiences. The high mean scores for questions regarding topic explanation and effective class time usage indicate that students value clarity and efficiency in teaching. An engaging teaching style that fosters a supportive learning environment is paramount, as evidenced by the positive results regarding the lecturer's friendly demeanor and readiness to assist students (L7). Moreover, items focusing on collaboration and the use of diverse instructional methods (L9 and L10) suggest that students appreciate opportunities for active participation and the incorporation of varied perspectives during discussions. This aligns with current educational theories advocating for constructivist approaches, where knowledge is co-constructed among students and instructors.

The results point to the potential transformation of pedagogical practices within the course. For instance, understanding that students place value on engagement and acknowledgment of their efforts may lead lecturers to refine their approaches, integrating more interactive elements such as hands-on projects, real-world applications of theoretical concepts, or gamification to further enhance motivation and retention of knowledge. A focus on delivering content through multiple modalities (L10) is particularly significant in catering to diverse learning styles. By utilizing technology, such as multimedia presentations, discussion forums, and interactive platforms, instructors can create a richer learning environment that accommodates various student preferences, thereby enhancing the overall learning experience.

4.2. Reflecting on the impact of IBL technique on course learning

Turning to the IBL technique, the findings are equally significant. The overall positive perceptions, particularly regarding the ease of understanding (I1) and the effect of IBL on problem-solving skills (I6), underline the effectiveness of this pedagogical approach in fostering deeper learning. These findings indicate that students felt empowered to take ownership of their learning, a core tenet of IBL. The high appreciation for IBL's capacity to facilitate interaction with both lecturers (I7) and peers (I8) underscores the technique's role in building a collaborative learning atmosphere. This collaborative aspect not only aids comprehension but enhances critical thinking and communication skills. Encouraging students to engage in dialogue, share thoughts, and collaboratively tackle complex problems can result in a more enriching educational experience. However, it is essential to acknowledge the responses indicating concerns, such as the perceived heavy workload associated with IBL (I3) and the pressure experienced during assignments (I4). While IBL can foster a dynamic learning environment, the implementation of such techniques must be balanced with manageable workloads to prevent student overwhelm. Educators should carefully design assignments that are stimulating but also realistic in scope to maintain student engagement and prevent burnout.

4.3. Comparative analysis

The findings that students perceive IBL as beneficial for problem-solving align with substantial prior research across STEM fields that demonstrates IBL's positive impact on critical thinking and skill acquisition. Marshall and Horton [32] observed that IBL significantly enhances higher-order thinking, including problem-solving, among science and mathematics students, compared to traditional methods. Similarly, Aditomo *et al.* [33] noted that IBL encourages deeper cognitive engagement, fostering students' abilities to question, analyze, and apply knowledge. Previous studies [4], [10] further suggest that IBL environments enhance resilience and autonomy in problem-solving, a crucial skill for engineering and applied sciences. For instance, Kolmos *et al.* [4] found that engineering students exposed to IBL showed improvements in handling complex, real-world problems, which are essential in professional practice. Furthermore, Wale and Bishaw [12] reported that IBL improved students' analytical thinking and helped them approach scientific challenges more independently.

However, while these benefits are clear, research also highlights the challenge of increased cognitive load associated with IBL, as students must navigate complex tasks with limited guidance. Luo *et al.* [8] found that, while engineering students appreciated the skills gained through IBL, many reported feelings overwhelmed by its demands. Qi *et al.* [2] similarly noted that independent inquiry processes in IBL often require substantial effort and time, potentially increasing student anxiety. Several studies [20], [34], [35] also revealed that students experience heightened cognitive load when working with open-ended IBL assignments, particularly when these tasks lack clear instructions. Pedaste *et al.* [17] identified that different types of IBL, such as open and guided inquiry, vary in complexity and can lead to cognitive overload if not structured effectively. Finally, Sirojiddinovna [14] emphasized that, despite IBL's potential for improving engagement and understanding, instructors must design tasks that balance student autonomy with manageable workloads to prevent burnout. Together, these studies underscore the importance of structuring IBL assignments thoughtfully to balance the benefits of active engagement and skill-building with realistic workload expectations.

4.4. Study contributions

Practically, this study suggests that while IBL is beneficial for engagement, educators should consider assignment scope and pacing to prevent cognitive overload, especially in complex fields like project management. Theoretically, this study supports constructivist learning theories, demonstrating that IBL fosters a deeper, more collaborative learning environment. This approach aligns well with the needs of engineering education, where active learning is paramount. While methodologically, this research contributes by offering a framework for reliably measuring student perceptions of IBL in engineering, paving the way for similar studies in other technical disciplines.

5. CONCLUSION

This study aims to evaluate the impact of the IBL technique on engineering students. For this purpose, a questionnaire was established comprised of two main groups, the first group of questions was related to "lecturer deliverables", which includes 13 questions and the second group was the "impact of IBL technique on course learning" includes 21 questions. The analysis of lecturer deliverables and the impact of IBL techniques provide crucial insights into students' perceptions of their educational experiences. The generally favorable feedback suggests that both teaching effectiveness and innovative pedagogical strategies contribute positively to student engagement and learning outcomes. Moving forward, educators are encouraged to adopt a reflective approach to their teaching practices, incorporating student feedback and research findings to continuously adapt and enhance the learning environment. This process will ultimately foster a more student-centered educational framework that values individual learning paths and collaborative engagement, preparing students effectively for their future endeavors. The significance of the results lies in their ability to validate effective teaching practices, promote student-centered learning, highlight areas for improvement, inform educational curriculum development, and influence institutional policies related to teaching and learning. By recognizing these implications, educators and institutions can enhance the overall educational experience, improve student outcomes, and ultimately contribute to the development of a more effective and engaging learning environment.

The data from this study paves the way for further research into the long-term effects of IBL on student success beyond immediate course outcomes. Future inquiries might examine whether students who experience IBL techniques in their courses exhibit improved retention rates, higher levels of critical thinking in upper-level courses, or greater satisfaction in their academic careers. Additionally, exploring demographic variables—such as age, prior educational experiences, and learning preferences could yield insights into how different student populations interact with IBL and traditional lecture formats. This demographic analysis could further inform the development of tailored educational strategies that maximize student success across diverse learner groups.

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Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Wesam Salah Alaloul	✓			✓			✓			✓		✓	✓	✓
Khalid Mhmoud Alzu'bi	✓	✓	✓		✓	✓		✓	✓		✓			
Muhammad Ali Musarat	✓	✓	✓		✓	✓		✓	✓		✓			

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

The authors confirm that the data supporting the findings of this study are available within the article.

REFERENCES

[1] M. Blum, *Teaching and learning approaches*. Cham: Springer, 2022, doi: 10.1007/978-3-030-91471-4_2.

[2] H. Qi, C. Chen, R. E. Vallejo, T. K. Oshiro, E. Z. Y. Yu, and I. Fiorini, "Improving students' learning through inquiry-based learning activities as pre-training for mechanics of materials classes," in *2023 ASEE Annual Conference & Exposition*, 2023, pp. 1–19, doi: 10.18260/1-2--43594.

[3] Z. Berie, D. Damtie, and Y. N. Bogale, "Inquiry-based learning in science education: a content analysis of research papers in Ethiopia (2010–2021)," *Education Research International*, vol. 2022, no. 1, pp. 1–10, Jul. 2022, doi: 10.1155/2022/6329643.

[4] A. Kolmos, P. Bøgelund, and J. E. Holgaard, "Inquiry and learning in engineering," in *International Handbook of Inquiry and Learning*, 1st ed., R. G. Duncan and C. Chinn, Eds., New York: Routledge, 2021, pp. 345–357.

[5] I. Guler, S. Cutler, and S. E. Zappe, "Work in progress: inquiry-based learning in transportation engineering," in *2020 ASEE Virtual Annual Conference Content Access*, 2020, pp. 1–10, doi: 10.18260/1-2--35653.

[6] R. W. C. Lui, P. T. Y. Lee, and K. Y. Fung, "Inquiry based learning with Kanban game," in *2019 IEEE 11th International Conference on Engineering Education (ICEED)*, Nov. 2019, pp. 108–112, doi: 10.1109/ICEED47294.2019.8994957.

[7] A. W. Lazonder and R. Harmsen, “Meta-analysis of inquiry-based learning,” *Review of Educational Research*, vol. 86, no. 3, pp. 681–718, Sep. 2016, doi: 10.3102/0034654315627366.
[8] T. Luo, K. Arcaute, and P. S. Muljana, “Integrating inquiry-based learning into engineering education: a case study,” *Innovations in Education and Teaching International*, vol. 60, no. 6, pp. 836–847, Nov. 2023, doi: 10.1080/14703297.2022.2130393.
[9] T. Jungmann, “Inquiry-based learning in the engineering sciences,” in *Inquiry-Based Learning – Undergraduate Research: The German Multidisciplinary Experience*, H. A. Mieg, Ed., Cham: Springer International Publishing, 2019, pp. 205–215, doi: 10.1007/978-3-030-14223-0_19.
[10] M. A. Firman, C. Ertikanto, and A. Abdurrahman, “Description of meta-analysis of inquiry-based learning of science in improving students’ inquiry skills,” *Journal of Physics: Conference Series*, vol. 1157, p. 022018, Feb. 2019, doi: 10.1088/1742-6596/1157/2/022018.
[11] H. Järvisalo, J. Korhonen, and P. Silventoinen, “From seminar presentations to inquiry-based learning – developing an advanced electronics course,” in *2020 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE)*, Dec. 2020, pp. 626–629, doi: 10.1109/TALE48869.2020.9368435.
[12] B. D. Wale and K. S. Bishaw, “Effects of using inquiry-based learning on EFL students’ critical thinking skills,” *Asian-Pacific Journal of Second and Foreign Language Education*, vol. 5, no. 1, p. 9, Dec. 2020, doi: 10.1186/s40862-020-00090-2.
[13] K. Maaß and M. Artigue, “Implementation of inquiry-based learning in day-to-day teaching: a synthesis,” *ZDM*, vol. 45, no. 6, pp. 779–795, Nov. 2013, doi: 10.1007/s11858-013-0528-0.
[14] H. D. Sirojiddinovna, “Inquiry-based learning: exploring methods that encourage students to ask questions and actively seek answers,” *International Journal So‘ngi Ilmiy Tadqiqotlar Nazariyasi*, vol. 7, no. 1, pp. 143–148, 2024.
[15] T. Kaçar, R. Terzi, İ. Arıkan, and A. C. Kırıkçı, “The effect of inquiry-based learning on academic success: a meta-analysis study,” *International Journal of Education and Literacy Studies*, vol. 9, no. 2, pp. 15–23, May 2021, doi: 10.7575/aiac.ijels.v.9n.2p.15.
[16] J.-L. Dorier and F. J. García, “Challenges and opportunities for the implementation of inquiry-based learning in day-to-day teaching,” *ZDM*, vol. 45, no. 6, pp. 837–849, Nov. 2013, doi: 10.1007/s11858-013-0512-8.
[17] M. Pedaste *et al.*, “Phases of inquiry-based learning: definitions and the inquiry cycle,” *Educational Research Review*, vol. 14, pp. 47–61, Feb. 2015, doi: 10.1016/j.edurev.2015.02.003.
[18] C. P. Constantinou, O. E. Tsivitanidou, and E. Rybska, “What is inquiry-based science teaching and learning?” in *Professional Development for Inquiry-Based Science Teaching and Learning*, O. E. Tsivitanidou, P. Gray, E. Rybska, L. Louca, and C. P. Constantinou, Eds., Cham: Springer International Publishing, 2018, pp. 1–23, doi: 10.1007/978-3-319-91406-0_1.
[19] D. P. Adorno, “Inquiry-based environments for bio-signal processing training in engineering education,” *International Journal of Mechanical Engineering Education*, vol. 50, no. 3, pp. 629–647, 2022, doi: 10.1177/03064190211026207.
[20] A. E. Ghadi and R. Mammucari, “An active laboratory learning experience for chemical engineering students facilitated by hypothesis testing,” *9th Research in Engineering Education Symposium and 32nd Australasian Association for Engineering Education Conference, REES AAEE 2021: Engineering Education Research Capability Development*, 2021, pp. 560–567, doi: 10.52202/066488-0062.
[21] M. Duran and I. Dökme, “The effect of the inquiry-based learning approach on student’s critical-thinking skills,” *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 12, no. 12, pp. 2887–2908, 2016, doi: 10.12973/eurasia.2016.02311a.
[22] L. C. J. C. Bruhl, J. L. Klosky, T. Mainwaring, and J. P. Hanus, “Accelerating the development of engineering judgment in students through inquiry-based learning activities,” in *2017 ASEE Annual Conference & Exposition*, 2017, pp. 1–18, doi: 10.18260/1-2--27532.
[23] J. E. Auerbach, A. Concordel, P. M. Kornatowski, and D. Floreano, “Inquiry-based learning with RoboGen: an open-source software and hardware platform for robotics and artificial intelligence,” *IEEE Transactions on Learning Technologies*, vol. 12, no. 3, pp. 356–369, Jul. 2019, doi: 10.1109/TLT.2018.2833111.
[24] J. W. Creswell and J. D. Creswell, *Research design: qualitative, quantitative, and mixed methods approaches*, 4th ed. Thousand Oaks, CA: SAGE Publications, Inc., 2017.
[25] H. Robin, “What sample size is ‘enough’ in internet survey research,” *Interpersonal Computing and Technology: An electronic journal for the 21st century*, vol. 6, no. 3–4, pp. 1–12, 1998.
[26] R. V. Krejcie and D. W. Morgan, “Determining sample size for research activities,” *Educational and Psychological Measurement*, vol. 30, no. 3, pp. 607–610, Sep. 1970, doi: 10.1177/001316447003000308.
[27] K. S. Taber, “The use of Cronbach’s alpha when developing and reporting research instruments in science education,” *Research in Science Education*, vol. 48, no. 6, pp. 1273–1296, Dec. 2018, doi: 10.1007/s11165-016-9602-2.
[28] R. F. DeVellis and C. T. Thorpe, *Scale development: theory and application*, 5th ed. Thousand Oaks, CA: SAGE Publications, Inc., 2021.
[29] P. Levy and R. Petrulis, “How do first-year university students experience inquiry and research, and what are the implications for the practice of inquiry-based learning?” *Studies in Higher Education*, vol. 37, no. 1, pp. 85–101, Feb. 2012, doi: 10.1080/03075079.2010.499166.
[30] G. V. Madhuri, V. S. S. Kantamreddi, and L. N. S. P. Goteti, “Promoting higher order thinking skills using inquiry-based learning,” *European Journal of Engineering Education*, vol. 37, no. 2, pp. 117–123, May 2012, doi: 10.1080/03043797.2012.661701.
[31] O. A. Acar and A. Tuncdogan, “Using the inquiry-based learning approach to enhance student innovativeness: a conceptual model,” *Teaching in Higher Education*, vol. 24, no. 7, pp. 895–909, Oct. 2019, doi: 10.1080/13562517.2018.1516636.
[32] J. C. Marshall and R. M. Horton, “The relationship of teacher-facilitated, inquiry-based instruction to student higher-order thinking,” *School Science and Mathematics*, vol. 111, no. 3, pp. 93–101, Mar. 2011, doi: 10.1111/j.1949-8594.2010.00066.x.
[33] A. Aditomo, P. Goodyear, A.-M. Bliuc, and R. A. Ellis, “Inquiry-based learning in higher education: principal forms, educational objectives, and disciplinary variations,” *Studies in Higher Education*, vol. 38, no. 9, pp. 1239–1258, Nov. 2013, doi: 10.1080/03075079.2011.616584.
[34] Z. Bayram, Ö. Ö. Oskay, E. Erdem, S. D. Özgür, and Ş. Şen, “Effect of inquiry based learning method on students’ motivation,” *Procedia - Social and Behavioral Sciences*, vol. 106, pp. 988–996, Dec. 2013, doi: 10.1016/j.sbspro.2013.12.112.
[35] W. S. Alaloul and A. H. Qureshi, “E-learning versus face-to-face civil and environmental engineering education: a case study of the COVID-19 pandemic,” in *E3S Web of Conferences*, Apr. 2022, p. 05007, doi: 10.1051/e3sconf/202234705007.

BIOGRAPHIES OF AUTHORS

Wesam Salah Alaloul research interests lie in construction management and automation, BIM and digital twin technology, construction materials, and lifecycle cost assessment. Additionally, he is a certified PMP and a trainer for construction costing and sustainability issues. Currently, he is associate professor at the civil engineering University of Technology Petronas, with 20 years of experience in both industry and academia and served as a member of various evaluation committees for development and research project. He has also published numerous research papers in international conferences and reputable journals. He can be contacted at email: wesam.alaloul@uaeu.ac.ae.

Khalid Mhmoud Alzu'bi is a lecturer at Al Balqa Applied University–Jordan. His research interests lie in construction management, automated monitoring, productivity monitoring, computer vision, and construction materials. He can be contacted at email: alzoubi_khalid@bau.edu.jo.

Muhammad Ali Musarat is a civil engineering researcher specializing in construction engineering, digital construction technologies, and sustainable infrastructure. He is currently a researcher at Riga Technical University, Latvia, where his work focuses on digital twin technologies, AI-based computer vision, and real-time infrastructure monitoring systems. He earned his PhD in Civil Engineering (Construction Engineering & Management) from Universiti Teknologi PETRONAS, Malaysia. His research interests include AI-driven predictive modeling, structural health monitoring, building information modeling (BIM), robotics for infrastructure inspection, and sustainable construction materials. Dr. Musarat also serves on editorial boards of leading international journals and has held academic and research positions across Europe, Asia, and the Middle East. He can be contacted at email: muhammad-ali.musarat@rtu.lv.