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Post-Pandemic Conceptual Study on Virtual Learning Method (VLM) in Chemical Engineering-Related Courses

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ABSTRACT
Virtual learning in chemical engineering employs digital technologies and online platforms, including virtual classrooms, simulations, and collaborative tools, to deliver educational content and interactive experiences. This approach offers flexibility in time and location, enabling students to access course materials, simulations, and projects, fostering an understanding of

chemical engineering principles. It replicates traditional learning while providing remote engagement and assessments, ensuring specific learning goals are met. In the wake of the global pandemic, this paper explores the conceptual shift to virtual learning in chemical engineering. In considering the relationship between technology and education, evaluating the advantages and constraints of virtual learning approaches is crucial. Although technology has undeniable potential to improve accessibility and student involvement, it is vital to ensure that its implementation aligns with the specific needs and educational goals of chemical engineering. The study examines benefits, challenges, and student experiences during this transition, shedding light on efficacy, engagement impact, and perceptions regarding complex subjects like chemical engineering. By analyzing the literature review and integrating it into the conceptual learning method, the paper offers insights into the post-pandemic education landscape, informing educators and institutions about the viability of virtual learning approaches and providing suggestions for enhancing their implementation in chemical engineering curricula.

Keywords: chemical engineering, distance learning, pandemic, hybrid learning, blended learning

INTRODUCTION

Chemical engineering has long been a pillar of scientific and technical progress, playing a crucial part in tackling some of the most serious issues facing the world, from environmental preservation to the creation of sustainable energy. The evolving and diversifying demands placed on chemical engineers require an equivalent evolution in the educational approaches employed to train the future generation of professionals in the field. In the current era defined by rapid technological advancement and the digital transformation of various sectors, the incorporation of virtual learning approaches into chemical engineering education is now recognized as a prospective pathway for increasing the efficiency, availability, and significance of educational engagement (Sundaram & Ramesh, 2022; Asgari et al., 2021; Lockman & Schirmer, 2020). In light of the post-pandemic situation, the field of education has experienced a significant transformation, with traditional in-person instruction being replaced by remote and online learning. Chemical engineering, a discipline that traditionally relied heavily on in-person laboratory experiments and face-to-face (F2F) interactions, has had to adapt to the new normal. As a result, virtual learning methods (VLM) have emerged as a valuable solution for delivering chemical engineering courses in the post-pandemic world.

The conventional method of classroom-based education, although beneficial, frequently has difficulties in keeping up with the constantly evolving field of chemical engineering (Marquez et al., 2023). A perspective on the synergistic potential of artificial intelligence and product-based learning strategies in biobased materials education suggests that Virtual Learning Methods (VLMs), which use a wide range of digital tools and platforms, could help close this gap by putting students in more active, immersive, and flexible learning environments.

The primary objective of this conceptual paper is to examine the various dimensions of virtual learning within the framework of chemical engineering education. Thus, it aims to clarify the transformative potential of virtual learning and the broad spectrum of potential it provides to students, educators, and the broader discipline of chemical engineering. In subsequent sections, we will address the most crucial parts of virtual learning, such as peer-to-peer (P2P) collaborative learning, hybrid learning methods (HLM) and flipped classrooms. We aim to provide a comprehensive understanding of the benefits and challenges associated with using virtual learning environments in chemical engineering. We will explore how these methodologies impact pedagogical approaches, curriculum development, and the professional growth of future chemical engineers. It is essential that we carefully assess both the advantages and disadvantages of VLM as we navigate the intersection between technology and education. While technology certainly has the potential to enhance accessibility and engagement, it is critical to ensure that it is aligned with the chemical engineering discipline's unique requirements and learning objectives. Furthermore, concerns about equal access, digital literacy, and the safeguarding of hands-on laboratory experiences must be considered.

PEER-TO-PEER (P2P) COLLABORATIVE LEARNING

P2P collaborative learning is one such method that has gained significant attention in recent years (Lokhat, 2022; Ballesteros et al., 2021; Chandra & Palvia, 2021). This method has emerged as a powerful tool for facilitating effective and engaging learning experiences among students and professionals alike. A P2P Collaborative Learning could be conducted in many ways, for example, in flipped classrooms, group projects, online discussions, and peer mentoring. These methods allow students to engage in the learning process actively, develop critical thinking skills, and learn from one another in a collaborative and supportive environment. This type of active learning has gained popularity in recent years as educators recognize that traditional lecture-style teaching may not fully meet the diverse needs and preferences of students. One of the methods that has emerged for active learning is peer instruction or peer-assisted learning. These P2P methods would enable the sharing of learning resources and foster collaboration within online communities. The use of P2P technologies in learning environments offers numerous benefits (Krishan & Al-rsa'i, 2023; Chuan, 2020). Firstly, this method facilitates the widespread distribution of learning objects, hence enhancing students' accessibility to a variety of educational resources (Qin et al., 2020; Cifrian et al., 2020; Al-Abri et al., 2017). Incorporating this approach not only facilitates the acquisition of knowledge but also fosters a collective spirit among students engaged in the learning process (Jamieson & Shaw, 2020). Furthermore, P2P collaborative learning can enhance the efficiency and scalability of an online or F2F learning environment. Additionally, P2P technologies enable mobile and versatile learning experiences, allowing users to access educational content anytime and anywhere. Moreover, P2P collaborative learning platforms can facilitate group cognition processes in problem-solving environments.

Encouraging P2P interactions and enabling students to share their knowledge, insights, and perspectives also promote teamwork and critical thinking skills. This method was also beneficial for facilitating group projects and problem-solving sessions to tackle complex chemical engineering challenges and reinforce their understanding of chemical engineering-related courses. Such collaboration not only helps students learn from one another but also provides a sense of community and engagement, which can be lacking in remote learning environments. However, achieving quality assurance on a P2P network is not the same as it would be in a traditional learning system where content is centrally managed and controlled since P2P relies on the participation and contributions of individual users to share learning content.

HYBRID LEARNING METHOD (HLM)

HLM is a versatile approach to education that combines the benefits of both in-person and online learning to create a flexible educational experience. The use of HLM, or the Hybrid Learning Model, is also recognized as an effective approach in blended learning methodologies (Rao, 2019; Hrastinski, 2019). With HLM, students have the opportunity to engage in F2F interactions with lecturers and peers while also taking advantage of the flexibility and convenience offered by online learning platforms. The HLM aims to provide a well-rounded and adaptive learning experience, catering to the individual needs and preferences of students. In a post-pandemic context, this method allows social distancing while still providing in-person interactions, which are crucial for laboratory work and hands-on experiments in chemical engineering. By incorporating advanced video conferencing tools, virtual labs, and collaborative online platforms, institutions can enhance student engagement, promote active participation, and foster a dynamic learning environment where students receive a well-rounded education combining in-person and remote learning benefits.

Developing a HLM that integrates the strengths of traditional classroom instruction with online education requires thorough implementation and meticulous preparation (Suartama et al., 2019). This method shall begin by clearly defining the learning objectives and outcomes for each course or module. Consider what knowledge and skills students should gain from in-person sessions versus online components. In this method, theoretical aspects of chemical engineering can be taught online, allowing students to access lectures and course materials at their own pace. Meanwhile, practical laboratory sessions, hands-on experiments, and collaborative group work can be conducted in person. This approach maximizes flexibility while ensuring students receive essential hands-on experience, which is often crucial in chemical engineering.

Curriculum mapping involves defining learning goals, deciding which content best suits online and in-person instruction, sequencing topics, and aligning assessments. This strategy ensures a structured and logical approach to hybrid learning in chemical engineering, optimizing the balance between virtual and physical components. Next, choose the right tools and platforms to support online learning. Ensure that these technologies are user-friendly and compatible with the needs of chemical engineering courses, such as virtual laboratory software, simulation tools, video conferencing platforms, and learning management systems (LMS).

The assessment strategies should be carefully designed to align with the HLM (Medina, 2018; Suartama et al., 2019). This includes utilizing diverse assessment methods such as online quizzes, written assignments, virtual lab reports, and in-person exams. These assessments should be structured to accurately measure students' comprehension of both theoretical and practical aspects of chemical engineering, ensuring a comprehensive evaluation of their knowledge and skills. Finally, to enhance the effectiveness of hybrid learning in chemical engineering, it is essential to create engaging online content or gamification that encourages active participation (Md Zaki & Kadri, 2020). This includes using interactive features like quizzes, discussion boards, peer reviews, and collaborative online projects. Additionally, multimedia elements such as videos, simulations, and animations can be used to enhance the learning process.

FLIPPED CLASSROOM MODELS (FLM)

Integrating the flipped classroom model (FLM) into a chemical engineering course presents an innovative method for instruction, encouraging active participation from students and enhancing their comprehension of intricate principles (Munir et al., 2018; Hwang et al., 2015). FLM, also known as inverted classrooms, is a pedagogical approach that flips the traditional structure of a classroom. Instead of receiving direct instruction during class time, students are assigned pre-recorded lectures or reading materials to review beforehand. This allows for more efficient use of class time, as students come prepared with prior knowledge and can engage in higher-level activities such as problem-solving, group discussions, and hands-on experiments (Lawter & Garnjost, 2023).

The flipped classroom model (FLM) offers numerous benefits for both students and instructors. FLM fosters a more engaging learning environment, promoting active learning and critical thinking. By shifting the focus from passive reception of information to active application, students are better able to retain and understand complex concepts. This approach also provides opportunities for personalized learning, as instructors can offer more targeted support during class activities. Additionally, it encourages collaboration among students, as they work together on projects and problem-solving tasks, enhancing their teamwork and communication skills. This method has shown to improve student motivation and performance, making it a valuable tool in modern education. In a post-pandemic context, this method reduces the time spent in close proximity in classrooms, making it safer for students and instructors. It also allows students to learn at their own pace and revisit materials as needed. This approach encourages self-directed learning and can be enhanced with online quizzes, discussion forums, and collaborative projects to ensure active engagement and knowledge retention.

In the context of chemical engineering, the flipped classroom model has several advantages (Akçayır & Akçayır, 2018; Halili & Zainuddin, 2015). First, it allows students to learn foundational theory at their own pace, ensuring that everyone arrives in class with a basic understanding of the subject matter. This paves the way for more meaningful discussions, problem-solving exercises, and laboratory work during in-person sessions. Additionally, the flipped classroom fosters active engagement, encourages critical analysis, and facilitates student collaboration (Joy et al., 2023). Lapitan Jr et al. (2023) reported positive perceptions of students toward collaborative learning via a flipped classroom approach in an undergraduate chemical engineering course at the University of Santo Tomas. Students can collaborate to tackle challenging problems, simulate experiments, and explore practical case studies to enhance their understanding of the subject matter. In addition, lecturers can provide immediate feedback and address student queries during F2F sessions, enhancing the learning experience. In addition to maximizing class time, the flipped classroom approach also encourages a dynamic and cooperative learning atmosphere. This effectively equips chemical engineering students with the skills needed to thrive in an ever-changing industry.

PRELIMINARY FINDINGS

The survey was conducted with 50 respondents, all students enrolled in the Separation Processes course, to understand their acceptance and preferences regarding various learning methods, including virtual, face-to-face, peer-to-peer, hybrid, and flipped learning. The questionnaire, distributed online for convenience, asked students to rate their acceptance of virtual learning on a scale from strongly disagree to strongly agree and to indicate their preferred learning method. The primary objective of this preliminary survey was to gather insights into the students' perceptions and acceptance of different learning methods to identify the most effective strategies and understand potential challenges. The expectation was to gain a clear understanding of students' preferences, refine teaching strategies, address challenges, and inform future research in engineering education. By analyzing the survey results, educators aim to create a more effective, student-centered learning environment that leverages the strengths of various teaching methods to enhance student engagement and learning outcomes.

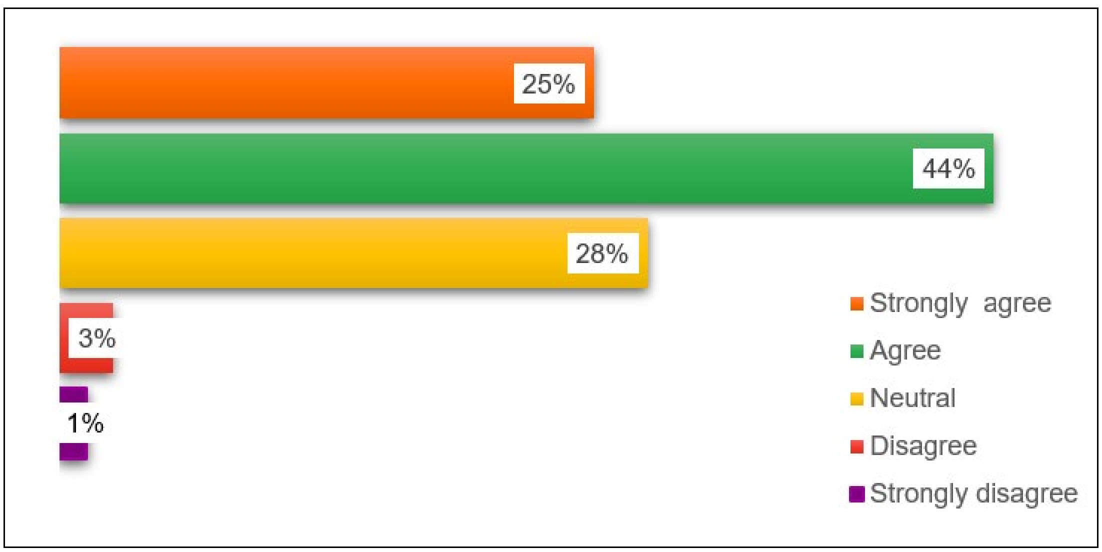

Figure 1. The acceptance of VLM among students registered Separation Processes

Figure 1 illustrates the acceptance of virtual learning methods among students, with the following distribution: 44% agree, 25% strongly agree, 28% neutral, 3% disagree, and 1% strongly disagree. This data reveals that a substantial majority, 69%, have a positive view towards virtual learning, highlighting its growing acceptance and perceived benefits, such as flexibility and accessibility. However, the 28% neutral response indicates a considerable portion of students who are either uncertain about its effectiveness or have mixed feelings. The small percentage of disagreement (4%) suggests that while virtual learning is generally well-received, there are still some students who face challenges or prefer traditional methods. These findings are consistent with broader trends in educational research, which show that while digital learning platforms offer significant advantages, they also require continuous improvements to fully address the diverse needs and preferences of all students.

To further enhance the acceptance of virtual learning methods among students, it is crucial to address the underlying factors contributing to the 28% neutral and 4% disagreement responses. One recommendation is to improve the quality and accessibility of digital resources and technological infrastructure, ensuring that all students have reliable access to the necessary tools and platforms. Additionally, providing comprehensive training and support for both students and educators can help in overcoming initial hesitations and technical challenges. Incorporating interactive and engaging elements, such as virtual labs, simulations, and collaborative projects, can also make virtual learning more appealing and effective. Furthermore, gathering continuous feedback from students to understand their specific concerns and preferences can lead to targeted improvements, making virtual learning more personalized and effective. By addressing these aspects, educational institutions can increase the acceptance and effectiveness of virtual learning methods, ultimately enhancing the overall learning experience.

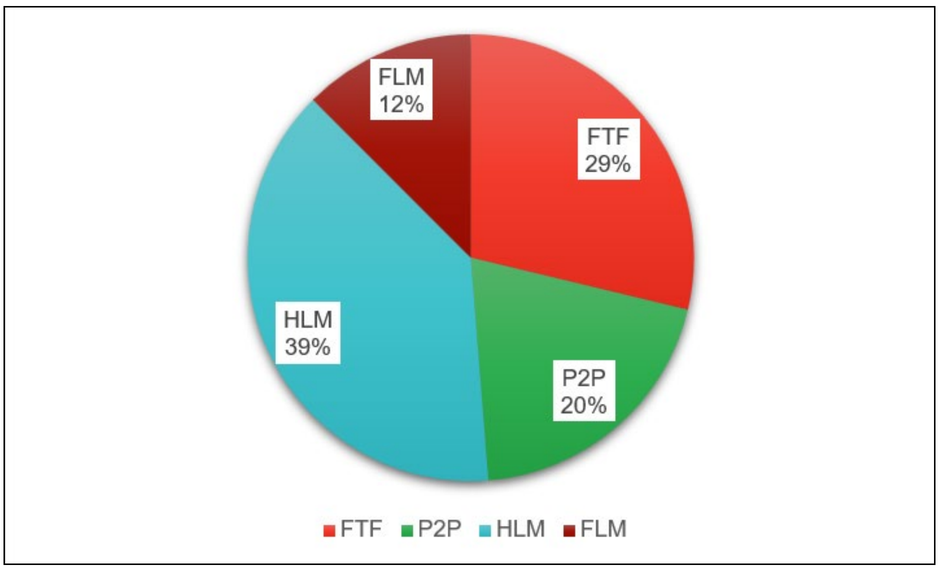

Figure 2. Preference of learning method among students registered Separation Processes

The distribution of learning methods among students is shown in Figure 2. There are 29% Face-to-Face (FTF), 20% Peer-to-Peer (P2P), 39% Hybrid Learning Method (HLM), and 12% Flipped Learning Method (FLM). The significant preference for HLM (39%) suggests that combining online and in-person learning is seen as the most effective approach, likely due to its flexibility and enhanced engagement. The traditional FTF method, still favored by 29% of students, underscores the importance of direct, personal interaction in education. P2P learning at 20% highlights the value of collaborative learning and peer support. Meanwhile, the lower adoption of FLM (12%) indicates that while innovative, this method may face challenges such as requiring significant student preparation and possible technical issues. These insights align with existing educational research, which emphasizes the transformative potential of blended and hybrid learning approaches in catering to diverse student needs and improving educational outcomes.

In addition to understanding the distribution of learning method preferences, it is essential to consider the underlying reasons behind these preferences. The significant inclination towards the Hybrid Learning Method (HLM) at 39% can be attributed to its ability to provide the best of both worlds by integrating the structured environment of face-to-face learning with the flexibility and resource richness of online learning. This hybrid approach allows students to benefit from immediate feedback and personal interaction during in-person sessions, while also enabling self-paced learning and access to a wider range of resources through online platforms. On the other hand, the lower preference for the Flipped Learning Method (FLM), despite its innovative approach, suggests that students might struggle with the increased responsibility for pre-class preparation and potential technical difficulties. Addressing these challenges through improved technological infrastructure and providing additional support and guidance for students can help in maximizing the benefits of FLM. Furthermore, the data highlights the importance of continuous evaluation and adaptation of teaching methods to align with student needs and preferences, ultimately enhancing the overall learning experience and educational outcomes.

CONCLUSION

In conclusion, this conceptual paper examines the incorporation of virtual learning in chemical engineering education to improve student learning experiences and support educators, as well as explore the promising realm of virtual learning in chemical engineering education. By integrating traditional teaching methods with innovative virtual approaches, graduates can develop crucial skills and knowledge necessary for a dynamic global environment. By examining the potential of these methods to enrich the learning experiences of students and empower educators, we aspire to contribute to the ongoing discourse on the evolution of pedagogy within our discipline. Ultimately, the synthesis of traditional pedagogical practices with innovative virtual learning approaches has the potential to shape the future of chemical engineering education, empowering graduates with the skills and knowledge needed to tackle the complex challenges of our rapidly changing world.

The preliminary results from our study on the acceptance of Virtual Learning Methods (VLM) among students registered in Separation Processes courses reveal significant insights. A substantial majority, 69%, have a positive view towards virtual learning, highlighting its growing acceptance and perceived benefits, such as flexibility and accessibility. This positive reception underscores the potential of VLM to enhance the educational experience. However, the 28% neutral response indicates a considerable portion of students who are either uncertain about its effectiveness or have mixed feelings. This suggests that while many students appreciate the benefits of virtual learning, there remains a need to address concerns and enhance these methods to fully engage all learners.

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Authors' Contributions

Syafiza Abd Hashib carried out the field work, and overlook the writeup of the whole article. **Fauziah Marpani** wrote the paper concept. **Nurul Asyikin Md Zaki** and **Aidora Abdullah** prepared the literature review and carried out the overlook of the whole article.

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