Enhancing Student Engagement in Mechanical Foundation Courses through Blended Learning at Guangzhou Vocational College of Technology & Business

(Meningkatkan Penglibatan Pelajar dalam Kursus Asas Mekanikal melalui Pembelajaran Teradun di Kolej Vokasional Teknologi & Perniagaan Guangzhou)

HUSHUJUAN, NURAZIDAWATI MOHD ARSAD & MOHAMAD NIZAM NAZARUDIN

ABSTRACT

The COVID-19 pandemic accelerated the adoption of online education, challenging traditional teaching methods in mechanical engineering courses. This study aimed to enhance student engagement and learning outcomes through a blended learning model at Guangzhou Vocational College of Technology and Business. Thirty second-year students participated in a 16-week study involving two cycles of blended learning. The methodology included pre-tests, questionnaires, and learning assessments to establish baseline data, followed by targeted improvements based on initial findings. Results showed significant increases in behavioral, cognitive, and emotional participation across both cycles. For example, the mean score for behavioral participation rose from 2.50 (SD = 0.45) in the pre-test to 3.41 (SD = 0.49) in Cycle 2. Additionally, academic performance improved, with the number of students failing to decrease from 10 in the pre-test to 1 by Cycle 2, and the average score rising from 65.53 to 76.43. These findings suggest that blended learning effectively enhances engagement and academic outcomes. Future research should explore further integration of technology to sustain and expand these improvements.

Keywords *Blended Learning, Mechanical foundational course, Intelligent mobile, learning platform*

ABSTRAK

Pandemik COVID-19 telah mempercepatkan penerimaan pendidikan dalam talian, mencabar kaedah pengajaran tradisional dalam kursus kejuruteraan mekanikal. Kajian ini bertujuan untuk meningkatkan penglibatan pelajar dan hasil pembelajaran melalui model pembelajaran teradun di Guangzhou Vocational College of Technology and Business. Tiga puluh pelajar tahun kedua terlibat dalam kajian selama 16 minggu yang melibatkan dua kitaran pembelajaran teradun. Metodologi kajian termasuk ujian pra, soal selidik, dan penilaian pembelajaran untuk menetapkan data asas, diikuti dengan penambahbaikan yang disasarkan berdasarkan penemuan awal. Hasil kajian menunjukkan peningkatan ketara dalam penglibatan tingkah laku, kognitif, dan emosi dalam kedua-dua kitaran. Sebagai contoh, skor min untuk penglibatan tingkah laku meningkat daripada 2.50 (SD = 0.45) dalam ujian pra kepada 3.41 (SD = 0.49) dalam Kitaran 2. Selain itu, prestasi akademik juga menunjukkan peningkatan, dengan bilangan pelajar yang gagal menurun daripada 10 dalam ujian pra kepada 1 dalam Kitaran 2, dan skor purata meningkat daripada 65.53 kepada 76.43. Penemuan ini mencadangkan bahawa pembelajaran teradun secara efektif meningkatkan penglibatan dan hasil akademik pelajar. Penyelidikan masa depan harus meneroka integrasi teknologi yang lebih lanjut untuk mengekalkan dan mengembangkan penambahbaikan

Kata kunci: *Pembelajaran Teradun, Kursus Asas Mekanikal, Platform Pembelajaran, Peranti Mudah Alih Pintar*

INTRODUCTION

The shocking emergence of the COVID-19 virus in the education system all over the world has fast-forwarded education online and taught from home or any other remote corner of the world (Tarkar, 2020). Mechanical foundational courses also cannot escape this new normal in education and therefore need to embrace these progressive methods of imparting knowledge to ensure that students continue to be offered the best circumstances in which to learn in case the situation changes one way or another (McNeilly et al., 2020). Many mechanical engineering courses are important to help students develop technical skills in their area of specialization in diversified fields. Though ordinary approaches such as one-way transmission of knowledge by using lectures are still efficient in implementing the curriculum knowledge, they are not as efficient in keeping the students actively intrigued and curious (Dietrich & Evans, 2022). One of the major challenges that mechanical engineering instructors face is the ability to keep their students engaged in class.

This has been particularly true due to the rise in educational expectations, as it becomes increasingly important to adopt a more student-centered, creative, and communicative approach (Khodadad, 2023). The blended learning model strikes the perfect balance between achieving what face-to-face teaching does while utilizing both the flexibility inherent in using online material and the activity created by constant interaction. This approach is intended for learners' engagement with content in different ways and different purposes, with the acknowledgment of students' heterogeneity (Singh et al., 2021). Educational technology becomes a significant solution to those teaching drawbacks when incorporating technology, especially blended learning on smart mobile devices. In so doing, this approach draws from the best of both worlds, where the face-to-face traditional model is complimented by the flexibility and interactivity brought about by the use of online resources, especially in meeting the dynamics of learning needs by students (Paechter & Maier, 2010).

This paper begins with an overview of the current state of the literature on blended learning, with a particular emphasis on the challenges and opportunities of blending blended learning with smart mobile learning platforms. Following this, a teaching reform project for Guangzhou Vocational College of Technology and Business is described concerning the project methodology, data collection, and main conclusions. Last, the paper points out the issues faced during the conduct of the project, an analysis of which, along with suggestions for the enhancement of blended learning on the SMLPs, are presented at the end of the paper. Therefore, this research aims to enhance the quality of practice teaching in mechanical engineering education by systematically addressing these factors.

LITERATURE REVIEW

In the last few years, blended learning has received considerable interest as an innovative delivery mode in the literature on instruction. A large number of papers have been dedicated to the use and efficacy of mixed learning in different fields. Blended learning has been studied in terms of how it affects students' academic achievement on one hand. For example, Al-Qatawneh et al. (2020) were concerned with the effects of blended learning on performance in Arabic language teaching and learning, emphasizing the role of students' perceptions of this kind of learning. The findings of this study can be quite useful for improving the quality of Arabic as a foreign language. Likewise, in their study, 'A Guide to Student Engagement', Barkley & Major (2020) outlined strategies for engagement, focusing on strategies to engage students and offering a very direct, step-by-step, handbook-type approach to making blended learning more effective.

Also, some works describe the results of the comparison between the result-oriented blended learning approach and traditional forms of teaching. Another paper comparing the effectiveness of blended learning to traditional learning was conducted by Bazelais and Doleck (2018), where the authors enrolled in a university mechanics course to compare blended learning to traditional learning, and the results show that the former provides more effective ways of improving the learning outcomes of students. Bonk and Graham, with their colleagues (2012), reviewed many designs and frameworks about blended learning across contexts and provided global, comprehensive help and knowledge for blended learning practitioners and researchers. Blended learning influences students' learning outcomes, motivation, and autonomy, according to the study's findings. According to Berga et al. (2021), in a quasi-experimental study, the authors evaluated the effects of using blended learning on student performance and participation in an undergraduate nursing health assessment course. The study reveals that blended learning increases enormously the students' motivation and level of autonomy. In the same way, Chiu's (2021) study, which was based on self-determination theory, concluded that the application of various digital tools in a blended learning environment does lead to an improvement in the level of motivation and autonomy present among students.

Further, Min and Yu's (2023) systematic review of the critical success factors of blended learning outlined the

following influencers: characteristics of learners and teachers, curriculum and course content and aims, institutional accreditation to organizational goals and objectives, information and communication technology support, and the learning environment. All these aspects have an impact on the successful application of blended learning; thus, they provide the necessary prerequisites for further development and improvement of the mentioned instructional model. The introduction and implementation of new technologies, as well as the use of mobile technologies, mobile learning, and educational games in teaching processes, have made the learning process more liberalized, diversified, innovative, and interactive.

Indeed, in their perspective, intelligent mobile learning platforms that are responsive to students' requirements and learning aptitudes are said to exert a significant influence on learning results and learning style preferences by Adinda and Mohib (2020). In their research, Bidarra and Sousa (2020) pointed out the advantages of the mobile learning approach for the integration of resources, opportunities for real-time student interactions, and monitoring of performance. Dahri et al. (2022) observed that when conducted for teacher training, mobile learning has a positive impact and improves the achievements of teachers and their attitude towards mobile learning-based training. Other research has looked at the effectiveness of technologies in classroom settings. Here, educational robots that were studied by Chaldi and Mantzanidou (2021) demonstrated that their usage creates a favorable environment to shape the interest of preschool children in science and engineering. Another study by Ristanto et al. (2022) supported the notion that digital games enable students to grasp lessons.

As elaborated by Maharjan et al., the incorporation of ICT in math teachers' practice enhances the meaning of learning. According to Mayhuay and Cruz's (2023), the effectiveness of mobile applications in enhancing learners' learning processes was evident among secondary learners. The innovative concept of Juraev (2022) stressed the necessity of the integration of educational technology with cloud technology so that a better teaching experience can be offered. Last but not least, Karakose et al. (2022) also stressed the prominence of digital technology in facilitating an understanding of the students' use of digital media and summarizing the corresponding strategies meant to be applied. These studies demonstrate the potential of blended learning and digital tools in teaching and learning, with implications and suggestions for improvement in various learning environments.

RESEARCH HYPOTHESIS

H1: Students who participate in blended learning experiences will exhibit higher levels of engagement compared to those in traditional, solely face-to-face instructional settings.

H2: Students who participate in the blended learning experience will demonstrate higher levels of learning outcomes compared to the traditional, purely face-to-face teaching environment.

METHODOLOGY

The respondents comprised 30 second-year students of the urban railway applications specialty at Guangzhou Vocational College of Technology and Business. To achieve maximal clarity in the experiment while keeping it optimally scientific, we first outlined the purpose of the experiment to the subjects. The study therefore carried out a pre-test that entailed class observations, the administration of questionnaires, and learning achievement tests to obtain baseline data against which future comparisons can be made. In this study, the students followed a blended learning model over a 16-week period, where two study cycles were completed. In the first cycle, the Learning Pass was used to deliver pre-class content so that it supported students' understanding that was augmented by face-to-face teaching. After the completion of this cycle, a new set of questionnaires and learning assessments for data collection were conducted (Refer to Figure 1).
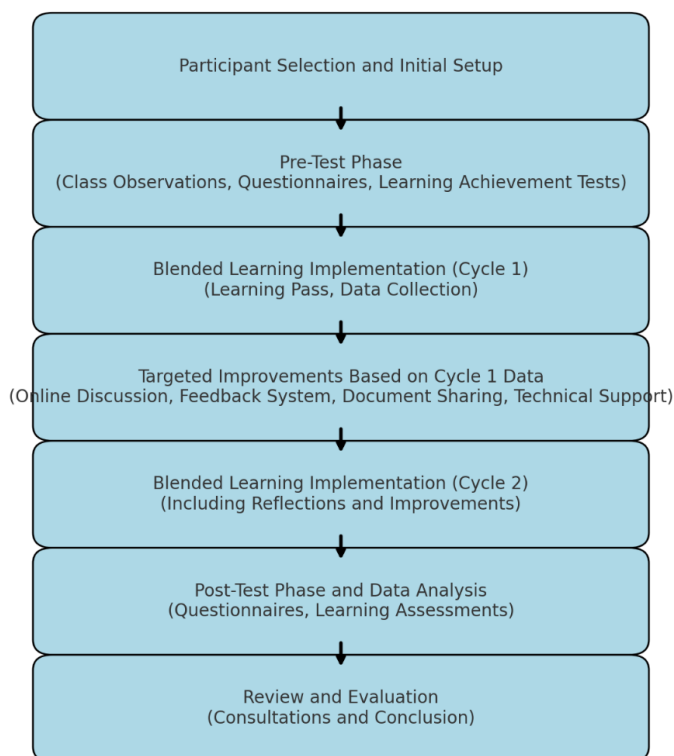

FIGURE 1. Research Frameworks

Some of these complexities within the process of blended learning, as recognized from the first cycle data, include: In turn, we have designed and instituted several targeted improvement initiatives with roots in prior results. Initially, an online discussion module was adopted to enable students to discuss topics, foster critical thinking, and encourage classroom participation. Second, an online feedback system was also incorporated into classroom sessions to complement the strategy of blended learning to boost the quality, pertinentness, and efficiency of teaching. Thirdly, we created a platform module that would enable a student to upload documents on their own and share documents with other students. This was done with the view of promoting independent learning as well as communication among students. Further, full technical consultation and advice were given on the learning platform to help students and teachers in case of technical challenges they experienced in the utilization of the platform to enhance the teaching process.

The second research cycle was conducted with the inclusion of the reflections and improvements from the first cycle. At the end of this cycle, more questionnaires and learning assessments were administered to the students so that the overall outcome of the blended learning method could be assessed. The information given from all the questionnaires and learning assessments was then matched, interpreted, and integrated to make conclusions about the influence of the interventions. These results were then described in consultations to review the effectiveness of the blended learning model and identify areas for improvement.

FINDINGS

To facilitate group-based learning and monitor student engagement, we divided the 30 students into 6 groups, each consisting of 5 students. During class sessions, we closely observed and recorded the level of motivation exhibited by each group member, focusing on their attentiveness, note-taking, propensity to ask thoughtful questions, and active participation in discussions. The results of these observations are summarized in Table 1.

		Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Scale
Listen Attentively	Number of Students	2	3	4	4	2	3	18
Take notes	Number of Students	4	3	2	3	2	1	15
Actively questioning	Number of Students	0	1	1	0	0	1	3
Initiative replies	Number of Students	2	1	0	3	1	1	8
Participate in discuss	Number of Students	3	2	4	3	2	3	17

TABLE 1. Classroom observation table results

Table 2 provides a detailed summary of the minimum, maximum, mean, standard deviation, and median values for three dimensions of student participation (behavioral, cognitive, and emotional) across three phases: pre-test, cycle 1, and cycle 2.

Dimension		Minimum	Maximum	Mean	Standard Deviation	Median
Behavioral Participation	Pre-test	1.8000	3.6000	2.5032	0.4498	2.6000
	Cycle 1	2.0000	3.6000	2.9267	0.4502	3.0000
	Cycle 2	2.4000	4.2000	3.4133	0.4925	3.4133
Cognitive Participation	Pre-test	1.4000	3.8000	2.7548	0.5575	2.6000
	Cycle 1	2.2000	3.8000	2.9067	0.3704	3.0000
	Cycle 2	2.6000	4.2000	3.4200	0.4213	3.4200
Emotional Participation	Pre-test	1.6000	3.4000	3.8000	0.4569	2.4000
	Cycle 1	2.0000	3.8000	2.8667	0.4467	2.9000
	Cycle 2	2.8000	4.2000	3.4333	0.3407	3.4333

TABLE 2. Mean results for each dimension of the questionnaire

Based on Figure 2, behavioral participation mean value exhibited a notable increase, rising from 2.5032 in the pre-test phase to 2.9227 in Cycle 1, and further advancing to 3.4133 in Cycle 2. The slight variations in standard deviation indicate a consistent trend of improvement in behavioral participation throughout the cycles, suggesting that students became progressively more engaged in class activities over time. Cognitive participation also displayed a positive growth trajectory. The mean value increased from 2.7548 in the pre-test phase to 2.9067 in Cycle 1, and then significantly rose to 3.4200 in Cycle 2. The reduction in standard deviation from the pre-test to Cycle 1 suggests that students became more uniformly engaged in cognitive activities, reflecting a more consistent level of cognitive engagement across the group.

Emotional participation also made significant strides. The mean score rose from 2.4000 in the pre-test phase to 2.8667 in Cycle 1, and further increased to 3.4333 in Cycle 2. The relatively low and stable standard deviation throughout the cycles indicates that students consistently invested emotionally in the learning process, with a growing sense of persistence and stability in their emotional engagement. Overall, these results show that using the blended learning method made a big difference in all three areas of student participation. Throughout the study phases, there was more consistency and interest in the activities.
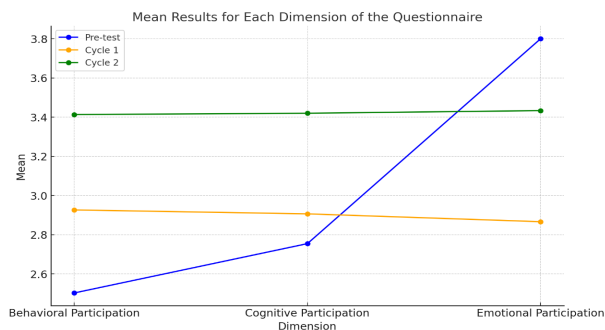
FIGURE 2. Mean results graph for each dimension of the questionnaire across the Pre-test, Cycle 1, and Cycle 2.

To assess students' comprehension of foundational mechanical courses, an academic test was administered, with the results presented in Table 3. In the pre-test phase, 10 students did not meet the passing threshold.

TABLE 3. Comparison of pre-test, cycle 1, and cycle 2 test results

Sample Size	Fail (0-59)	Pass (60-69)	Moderate (70-79)	Good (80-89)	Excellent (90-100)
Pre-test	30	10	10	7	3	0
Cycle 1	30	5	12	10	2	1
Cycle 2	30	1	7	9	9	4

In terms of achievement distribution, 56.67% of the students achieved either a passing or intermediate level, while only three students performed well, resulting in an overall average score of 65.53 points. This outcome indicates a relatively low level of academic achievement during the pre-test period. Following the first learning cycle, a marked improvement was observed. The number of students failing to pass the test significantly decreased to five, and two students attained a satisfactory level of academic performance. The highest score increased to 90 points, and the overall average score rose to 69.2 points, reflecting an improvement of 3.67 points from the pre-test.

During the second learning cycle, further advancements were evident. The number of students failing the test dropped to just one, while the number of students achieving outstanding performance significantly increased to nine. Additionally, four more students reached an outstanding level. At this stage, the average score further improved to 76.433 points, indicating that the majority of students had attained an intermediate level of academic performance. This progression in performance across the study cycles suggests that the student's learning capabilities have been significantly enhanced as a result of the successive learning interventions, demonstrating the effectiveness of the blended learning approach (Refer to Figure 3)
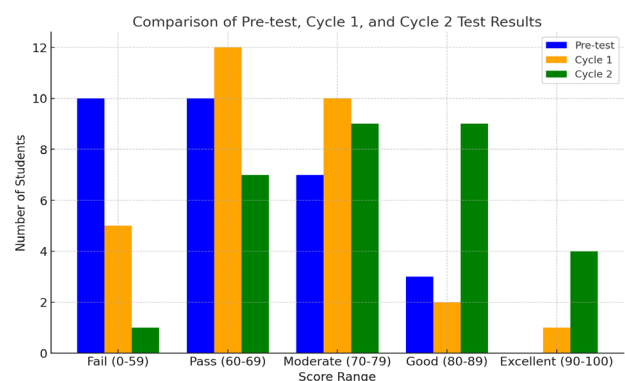
FIGURE 3: Comparison of Pre-test, Cycle 1, and Cycle 2 Test Results

DISCUSSION

Through comprehensive data analysis, we identified significant advancements across all measured dimensions. The findings of this study indicate that the improvement strategies implemented after the first stage of the educational process positively influenced students' motivation and engagement. We observed that students became notably more involved in class, adopting a more proactive approach to learning. This increased level of participation was associated with a greater focus on comprehending the material and active involvement in discussions. The study corroborates the notion that interactive and participatory teaching methods are effective in enhancing students' sense of involvement and academic performance (Pavlou & Castro-Varela, 2024).

In terms of cognitive engagement, students demonstrated considerable progress. They not only actively participated in learning activities, but also engaged in more profound and critical thinking about the material. This shift is likely linked to the diversification of teaching methods and the provision of a rich array of educational resources (Barber, 2020). Cognitive engagement is a critical aspect of effective learning, as it directly reflects the degree to which students are invested in mastering and understanding the content (Wallace-Spurgin, 2020). The data also indicated a gradual increase in students' interest and enthusiasm for learning. As students' emotional engagement intensified, so did their comprehension and understanding of the material (Strevens, 2024). Emotional engagement, which encompasses students' attitudes, interests, and values toward learning, plays a crucial role in achieving sustained academic success (Hofstein & Mamlok-Naaman, 2011).

The notable improvement in student achievement throughout the learning cycles can be attributed to several key components of the blended learning approach:

1. Integration of Online Discussion Modules and Feedback Mechanisms
   This strategy enhanced the interactivity of learning, thereby deepening students' understanding of the material (Castillo-Montoya, 2017). Online discussions and feedback mechanisms foster collaborative learning environments, which have been shown to improve learning outcomes.

2. Diversified Learning Resources
   By providing pre-class videos and interactive lessons, the approach catered to students with varying learning styles, offering a personalized learning experience. This approach aligns with the principles of Universal Design for Learning (UDL), which advocates for multiple means of representation, engagement, and expression to support diverse learners (Roski, Walkowiak, & Nehring, 2021).

3. Regular assessment and feedback
   Regular assessments and feedback enabled teachers to promptly identify students' learning challenges and provide timely interventions. Continuous assessment and feedback are fundamental components of formative assessment practices, which support student learning progress and the adaptation of teaching strategies (Nayak, Punja, & Suryavanshi, 2020).

4. Comprehensive technical support
   Ensuring that students could effectively use the learning platform contributed to a more seamless and efficient learning experience. Technical support is critical for the successful implementation of blended learning environments (Alamri, Watson, & Watson, 2021).

These elements collectively contributed to the improved learning outcomes observed in the study, reinforcing the effectiveness of the blended learning approach in enhancing student engagement and academic achievement.

CONCLUSION

Across the two learning cycles, it became clear that the implementation of blended learning methods significantly enhanced students' academic performance and engagement. These positive results emphasize the effectiveness of targeted instructional interventions and the integration of resources in fostering overall student engagement, which is crucial for improving learning outcomes. The findings from this study provide valuable insights for the application of similar teaching practices in other courses, underscoring the importance and impact of blended learning models in contemporary education. Firstly, the combination of online resources with face-to-face instruction created a more dynamic and interactive learning environment. Students benefited from the flexibility of accessing course materials online, allowing them to review content at their own pace and convenience, thereby accommodating diverse learning needs. Secondly, the introduction of online discussions and collaborative activities significantly enhanced interaction among students. This not only deepened their understanding of the course content but also cultivated a sense of community and shared learning experiences, contributing to a more engaged and cohesive learning cohort.

Furthermore, the use of intelligent mobile learning platforms offered students personalized learning experiences, catering to a variety of learning styles. The availability of resources on these platforms facilitated continuous learning beyond the traditional classroom, enabling students to engage with the material more consistently and effectively. These findings reinforce the value of blended learning approaches in modern education, demonstrating their ability to enhance student engagement, foster collaboration, and support personalized learning experiences.

REFERENCES

Adinda, D., & Mohib, N. 2020. Teaching and instructional design approaches to enhance students' self-directed learning in blended learning environments. *Electronic Journal of E-Learning, 18*(2), 162-174.

Alamri, H. A., Watson, S., & Watson, W. 2021. Learning technology models that support personalization within blended learning environments in higher education. *TechTrends, 65*(1), 62-78.

Al-Qatawneh, S., Eltahir, M. E., & Alsalhi, N. R. 2020. The effect of blended learning on the achievement of HDE students in the methods of teaching Arabic language course and their attitudes towards its use at Ajman University: A case study. *Education and Information Technologies, 25,* 2101–2127. https://doi.org/10.1007/s10639-019-10046-w

Arulogun, O. T., Akande, O. N., Akindele, A. T., & Badmus, T. A. 2020. Survey dataset on open and distance learning students' intention to use social media and emerging technologies for online facilitation. *Data in Brief, 31*(1), 1-8.

Barber, R. 2020. The impact of the diversification of ALL services on the practices of learning advisors. *Journal of Academic Language and Learning, 14*(2), 77-94.

Barianos, A. K., Papadakis, A., & Vidakis, N. 2022. Content manager for serious games: Theoretical framework and digital platform. *Advances in Mobile Learning Educational Research, 2*(1), 251-262.

Barkley, E. F., & Major, C. H. 2020. *Student engagement techniques: A handbook for college faculty.* John Wiley & Sons.

Bazelais, P., & Doleck, T. 2018. Blended learning and traditional learning: A comparative study of college mechanics courses. *Education and Information Technologies, 23,* 2889–2900. https://doi.org/10.1007/s10639-018-9748-9

Berga, K. A., Vadnais, E., Nelson, J., Johnston, S., & Olaiya, B. 2021. Blended learning versus face-to-face learning in an undergraduate nursing health assessment course: A quasi-experimental study. *Nurse Education Today, 96,* 104622.

Bidarra, J., & Sousa, N. 2020. Implementing mobile learning within personal learning environments: A study of two online courses. *International Review of Research in Open and Distance Learning, 21*(4), 182-198. https://doi.org/10.19173/irrodl.v21i4.4891

Bond, M. 2020. Facilitating student engagement through the flipped learning approach in K-12: A systematic review. *Computers & Education, 151,* 103819.

Bonk, C. J., & Graham, C. R. 2012. *The handbook of blended learning: Global perspectives, local designs.* John Wiley & Sons.

Castillo-Montoya, M. 2017. Deepening understanding of prior knowledge: What diverse first-generation college students in the US can teach us. *Teaching in Higher Education, 22*(5), 587-603.

Chaldi, D., & Mantzanidou, G. 2021. Educational robotics and STEAM in early childhood education. *Advances in Mobile Learning Educational Research, 1*(2), 72-81.

Chen, J. 2022. Effectiveness of blended learning to develop learner autonomy in a Chinese university translation course. *Education and Information Technologies, 27*(9), 12337-12361.

Chiu, T. K. 2021. Digital support for student engagement in blended learning based on self-determination theory. *Computers in Human Behavior, 124,* 106909.

Dahri, N. A., Vighio, M. S., Alismaiel, O. A., & Al-Rahmi, W. M. 2022. Assessing the impact of mobile-based training on teachers' achievement and usage attitude. *International Journal of Interactive Mobile Technologies, 16*(9), 107-129.

Dietrich, H., & Evans, T. 2022. Traditional lectures versus active learning--a false dichotomy? *arXiv preprint arXiv:2206.12144.*

Drolia, M., Papadakis, S., Sifaki, E., & Kalogiannakis, M. 2022. Mobile learning applications for refugees: A systematic literature review. *Education Sciences, 12*(2), 96.

Dziuban, C., Hartman, J., Moskal, P., Sorg, S., & Truman, B. 2004. Three ALN modalities: New structures for online learning. *EDUCAUSE Quarterly, 27*(4), 61-67.

Evans, J. C., Yip, H., Chan, K., Armatas, C., & Tse, A. 2020. Blended learning in higher education: Professional development in a Hong Kong university. *Higher Education Research & Development, 39*(4), 643-656.

Flanigan, A. E., & Babchuk, W. A. 2020. Digital distraction in the classroom: Exploring instructor perceptions and reactions. *Teaching in Higher Education, 27,* 352–370.

Garris, C. P., & Fleck, B. 2022. Student evaluations of transitioned-online courses during the COVID-19 pandemic. *Scholarship of Teaching and Learning in Psychology, 8,* 119–139.

Garrison, D. R., & Vaughan, N. D. 2008. *Blended learning in higher education: Framework, principles, and guidelines.* Jossey-Bass.

Hofstein, A., & Mamlok-Naaman, R. 2011. High-school students' attitudes toward and interest in learning chemistry. *Educación Química, 22*(2), 90-102.

Jang, H., Reeve, J., & Deci, E. L. 2010. Engaging students in learning activities: It is not autonomy support or structure but autonomy support and structure. *Journal of Educational Psychology, 102*(3), 588–600.

Juraev, T. 2022. Problems of integration of pedagogical software with cloud technologies (example of m-learn). *Central Asian Journal of Education and Computer Sciences (CAJECS), 1*(1), 58-63.

Karakose, T., Tülübaş, T., & Papadakis, S. 2022. Revealing the intellectual structure and evolution of digital addiction research: An integrated bibliometric and

science mapping approach. *International Journal of Environmental Research and Public Health, 19*(22), 14883.

Khodadad, D. 2023. Creating a supportive and effective learning environment for engineering students: Pedagogical strategies, engagement, and enhanced outcomes. *International Journal of Engineering Pedagogy, 13*(8).

Maharjan, M., Dahal, N., & Pant, B. P. 2022. ICTs into mathematical instructions for meaningful teaching and learning. *Advances in Mobile Learning Educational Research, 2*(2), 341-350.

Mayhuay, E., & Cruz, D. La. 2023. Mobile application to improve the learning of secondary school students: Literature review. *Advances in Mobile Learning Educational Research, 3*(1), 586-595. https://doi.org/10.25082/AMLER.2023.01.00

McNeilly, S. A., Pakala, K., & Plumlee, D. 2020. Revolutionizing the mechanical engineering undergraduate curriculum.

Min, W. H., & Yu, Z. G. 2023. A systematic review of critical success factors in blended learning. *Education Sciences, 13,* 469.

Nayak, K. R., Punja, D., & Suryavanshi, C. 2020. Impact of readiness assurance process and faculty feedback on individual application exercises: A model for continuous assessment in physiology. *Advances in Physiology Education, 44*(4), 509-515.

Nikolopoulou, K. 2023. Self-regulated and mobile-mediated learning in blended tertiary education environments: Student insights from a pilot study. *Sustainability, 15*(16), 12284.

Ouimet, J. A., & Smallwood, B. 2005. CLASSE-The class level survey of student engagement. *Assessment Update, 17*(6), 13–15.

Paechter, M., & Maier, B. 2010. Online or face-to-face? Students' experiences and preferences in e-learning. *The Internet and Higher Education, 13*(4), 292-297.

Parsons, J., & Taylor, L. 2011. Improving student engagement. *Current Issues in Education, 14*(1).

Pavlou, V., & Castro-Varela, A. 2024. E-learning canvases: Navigating the confluence of online arts education and sustainable pedagogies in teacher education. *Sustainability, 16*(5), 1741. https://doi.org/10.3390/su16051741

Ristanto, R. H., Kristiani, E., & Lisanti, E. 2022. Flipped classroom-digital game-based learning (FC-DGBL): Enhancing genetics conceptual understanding of students in bilingual programme. *Journal of Turkish Science Education, 19*(1), 328-348.

Roblyer, M. D., & Wiencke, W. R. 2004. Exploring the interaction equation: Validating a rubric to assess and encourage interaction in distance courses. *Journal of Asynchronous Learning Networks, 8*(4), 25–37.

Roski, M., Walkowiak, M., & Nehring, A. 2021. Universal design for learning: The more, the better? *Education Sciences, 11*(4), 164.

Singh, J., Steele, K., & Singh, L. 2021. Combining the best of online and face-to-face learning: Hybrid and blended learning approach for COVID-19, post vaccine, & post-pandemic world. *Journal of Educational Technology Systems, 50*(2), 140-171.

Strevens, M. 2024. Grasp and scientific understanding: A recognition account. *Philosophical Studies, 181*(4), 741-762.

Tarkar, P. 2020. Impact of COVID-19 pandemic on education system. *International Journal of Advanced Science and Technology, 29*(9), 3812-3814.

Vaughan, N. D., Cleveland-Innes, M., & Garrison, D. R. 2013. *Teaching in blended learning environments: Creating and sustaining communities of inquiry.* Athabasca University Press.

Wallace-Spurgin, M. 2020. Implementing technology: Measuring student cognitive engagement. *International Journal of Technology in Education, 3*(1), 24-38.

Wong, Z. Y., & Liem, G. A. D. 2022. Student engagement: Current state of the construct, conceptual refinement, and future research directions. *Educational Psychology Review, 34*(1), 107-138.

Yazıcı Arıcı, E., Keskin, H. K., Papadakis, S., & Kalogiannakis, M. 2022. Evaluation of children's discourses regarding imaginary companion: The case of Türkiye. *Sustainability, 14*(24), 16608.

Yong, L., Ya, Z., & Fuan, W. 2021. Research process, themes and issues of online learning participation in China: A review of selected research 2000~2020. *Advances in Education.* https://doi.org/10.12677/ae.2021.114211

HuShujuan
Faculty of Education, Universiti Kebangsaan Malaysia, Selangor, Malaysia
P129511@siswa.ukm.edu.my

Nurazidawati Mohd Arsad
Faculty of Education, Universiti Kebangsaan Malaysia, Selangor, Malaysia
azidarsad@ukm.edu.my

Mohamad Nizam Nazarudin
Faculty of Education, Universiti Kebangsaan Malaysia, Selangor, Malaysia
mohdnizam@ukm.edu.my

Corresponding Author: Mohamad Nizam Nazarudin