HNUE JOURNAL OF SCIENCE
Educational Sciences 2024, Volume 69, Issue 5B, pp. 168-178
This paper is available online at http://hnuejs.edu.vn/es
DOI: 10.18173/2354-1075.2024-0145

APPLYING TECHNOLOGY TO ONLINE MATHEMATICS EDUCATION IN THE DIGITAL ERA

Tran Thanh Binh*, Bui Thi Thom and Dang Tung Long
Mathlish Company Limited, Hanoi city, Vietnam
*Corresponding author: Tran Thanh Binh, e-mail: tranbinhmathlish@gmail.com

Received May 18, 2024. Revised November 10, 2024. Accepted December 27, 2024.

Abstract. In the context of technological and educational advancement, the integration of technology and online platforms has yielded significant impacts on online pedagogical methodologies. This report presents the application of the online teaching software Classin, which has elicited positive and innovative changes in Mathlish's online math classes. By harnessing Classin's interactive features, Mathlish educators created an engaging and student-centered learning environment. The report emphasizes the integration of features and inspiration from televised educational programs into Mathlish's online math classes, aiming to provide captivating learning experiences for students. Furthermore, the report examines how Classin's real-time feedback mechanisms enhance personalized learning and global connectivity. Ultimately, the harmonious integration of Classin's features into the instructional process within Mathlish's online math classes underscores the essential role of technology in the online education model, thereby equipping learners with vital skills in the digital age.

Keywords: online learning, educational technology, personalized learning, student engagement, adaptive instruction.

1. Introduction

In the current era of rapid technological advancement, the global landscape of education is undergoing a profound transformation. Recent studies have demonstrated that digital technologies are reshaping educational paradigms [1], particularly in STEM fields [2]. The adoption of virtual learning environments has become increasingly significant [3], with research showing substantial impacts on educational delivery and outcomes. This transformation is particularly evident in mathematics education, where digital tools and platforms have shown promising results [4], [5].

Mathlish Education builds upon established frameworks in technology-enhanced learning [6], providing innovative online mathematics education for students of various age groups. Research has shown that age-appropriate digital interventions [7] and interactive technologies [8] significantly impact learning outcomes. Studies by Le and Vu [9] have demonstrated that real-time feedback in online mathematics courses can enhance student engagement and understanding, supporting Mathlish's approach to digital mathematics instruction.

The utilization of Classin as a modern online instructional software aligns with contemporary research on effective digital learning platforms [10]. Nguyen et al.'s study specifically demonstrated Classin's effectiveness in teaching algebra online in Vietnamese contexts. The

importance of interactive whiteboards and collaborative tools [11], [12] supports Mathlish's integration of diverse technological features. Research by Miller and Glover [8] emphasizes that the flexible adaptation of technology for specific educational objectives is crucial for successful implementation.

Studies have consistently shown that online mathematics instruction can be particularly effective when properly implemented [13], [14]. The integration of real-time feedback systems [15] and interactive learning environments [16] has been demonstrated to enhance student engagement and achievement. Through platforms like Classin, research has documented the benefits of synchronized learning experiences and collaborative digital environments [17], [18].

The foundation of this exploration rests on a meticulous survey of over 1000 participants, building upon established methodologies in educational research [19]. This approach aligns with analytical frameworks for online learning environments [20] while introducing new insights into mathematics education. The survey methodology follows validated practices for online educational research [21], ensuring robust data collection and analysis.

This study contributes to the existing body of knowledge by examining how specialized platforms can enhance mathematics education through personalized learning approaches [22] and gamified elements [23], [24]. By integrating findings from virtual manipulatives research [25] and adaptive learning technologies [6], this report provides valuable insights into the evolving landscape of digital mathematics education.

2. Content

2.1. The role of technology in online education

The application of technology in education has been extensively studied, revealing its transformative potential in enhancing engagement, comprehension, and accessibility. Research highlights the integration of Learning Management Systems (LMS) as a cornerstone of modern online education.

One study by Kim and her co-workers demonstrated the benefits of LMS platforms in mathematics education [21]. The researchers found that LMS equipped with multimedia resources and asynchronous learning capabilities significantly improve student outcomes compared to traditional methods. The LMS allows for the integration of dynamic, interactive content that caters to diverse learning preferences, leading to enhanced student engagement and comprehension of mathematical concepts.

Additionally, the integration of interactive whiteboards has been shown to have significant pedagogical benefits. Miller and Glover emphasize the ability of these digital tools to facilitate dynamic visualization of complex mathematical concepts, fostering deeper student understanding [8]. The interactive nature of the whiteboards enabled teachers to engage students in more active, hands-on learning, moving beyond passive information transmission.

Furthermore, the use of virtual manipulatives has been identified as a crucial component of online math education. Reimer and Moyer found that these digital tools for manipulating mathematical concepts enhance students' spatial reasoning and problem-solving skills, surpassing traditional pen-and-paper approaches [5]. By providing students with the ability to interact with and explore mathematical representations in a virtual environment, virtual manipulatives address the need for hands-on, experiential learning in the online setting.

These findings underscore the importance of leveraging a variety of digital tools and technologies to provide engaging, interactive, and accessible learning experiences for students in the field of online mathematics education. The integration of LMS, interactive whiteboards, and

virtual manipulatives has the potential to transform the way mathematics is taught and learned, catering to diverse learning styles and promoting deeper conceptual understanding.

2.2. Personalized learning through real-time feedback

The advent of real-time feedback mechanisms has introduced new dimensions to personalized learning in online mathematics education. Researchers have explored the potential of these technologies to enhance student learning outcomes.

One study conducted by Nguyen and his collaborators in 2019 investigates the use of real-time feedback in online math courses [10]. The researchers concluded that providing immediate responses to student inputs significantly improves their comprehension and retention rates. By receiving immediate feedback on their performance and understanding, the surveyed students were able to address misunderstandings and consolidate their learning more effectively. This real-time interaction facilitated a more personalized learning experience, catering to the unique needs and pacing of each student.

Furthermore, Le led a team exploring the impact of adaptive learning technologies in online mathematics education [6]. These researchers highlight the ability of adaptive systems to tailor the educational experience to individual student needs, thereby maximizing learning efficiency. Adaptive technologies use data-driven algorithms to continuously assess student progress and adjust the content, difficulty level, and instructional strategies accordingly. This personalized approach ensures that students receive the appropriate level of challenge and support, maintaining their engagement and fostering their mastery of mathematical concepts.

These studies align with the analytics-driven approach to education proposed by Siemens and Long [20]. This framework emphasizes the use of data to inform instructional strategies and create responsive learning environments. By incorporating real-time feedback and adaptive technologies, educators can leverage data-driven insights to promptly identify and address student challenges, ultimately enhancing their overall learning experience and outcomes.

The integration of real-time feedback and adaptive learning technologies in online mathematics education represents a significant shift towards personalized, data-driven instruction. These advancements have the potential to transform the way students engage with and master mathematical content, catering to their individual learning needs and preferences. As the field of educational technology continues to evolve, the application of these innovative approaches can contribute to the ongoing efforts to improve the quality and accessibility of online mathematics education.

2.3. Gamification and student engagement

Gamification has emerged as a powerful tool for enhancing student engagement in online mathematics education. Research has shown that the incorporation of game-based elements can have a significant impact on student motivation and learning outcomes.

A study conducted by Pham [26] demonstrates that incorporating game-based elements into mathematics instruction significantly enhances student motivation and participation. By introducing elements such as scoring systems, leaderboards, and interactive challenges, the researchers were able to create a more immersive and engaging learning environment. This gamified approach taps into students' intrinsic desires for competition, achievement, and exploration, leading to increased levels of active engagement and persistence in the learning process.

Similarly, Tran and some researchers [27] found that gamified learning environments promote active involvement and collaborative problem-solving in online mathematics education.

The researchers noted that the game-based elements transformed the learning experience from passive reception to active exploration. The students were more inclined to work together, share strategies, and collectively solve mathematical problems, fostering a sense of community and promoting deeper conceptual understanding.

The integration of gamification in online mathematics education represents a significant shift towards engaging, personalized, and data-driven instruction. As the field of educational technology continues to evolve, the application of these innovative approaches can contribute to the ongoing efforts to improve the quality and accessibility of online mathematics learning.

2.4. The evolution of online math education

Recent studies have highlighted the evolving nature of online math education, with a focus on incorporating cutting-edge technologies to enhance learning outcomes. These advancements align with global trends in education, where technology serves not only as a tool but as an integral component of the learning process.

Research has emphasized the role of artificial intelligence (AI) in personalizing instruction and providing targeted interventions. Nguyen et al. [3] explore the potential of AI-driven platforms to adapt the learning experience to the unique needs and preferences of individual students. By leveraging machine learning algorithms, these systems can continuously monitor student progress, identify areas of difficulty, and deliver personalized content, feedback, and support. This AI-powered approach to online mathematics education has the potential to dramatically improve learning outcomes by ensuring that each student receives the appropriate level of challenge and scaffolding.

Alongside the integration of AI, researchers have also explored the potential of augmented reality (AR) in creating immersive educational experiences. A team led by Wu [1] investigated the use of AR in the teaching of abstract mathematical concepts. By superimposing digital visualizations and interactive elements onto the physical environment, AR can help students better understand and engage with complex ideas. This technology-enabled approach to mathematics instruction can be particularly beneficial in the online setting, where the lack of physical manipulatives and hands-on activities can pose a challenge.

These advancements in online mathematics education, including the incorporation of AI-driven personalization and AR-enhanced visualizations, represent a holistic approach to addressing the challenges and opportunities of remote learning. By seamlessly integrating cutting-edge technologies into the learning process, educators can create more engaging, responsive, and accessible online environments that cater to the diverse needs of students.

2.5. Challenges and future directions

Despite the promising potential of technology in education, challenges persist. Issues such as digital equity, teacher training, and the need for robust infrastructure continue to impede widespread adoption. Paterson and his colleagues in 2019 emphasized the importance of professional development for educators to effectively integrate technology into their teaching practices [18]. Moreover, the need for high-quality, culturally relevant digital content remains a pressing concern, particularly in diverse educational contexts.

Future research should focus on addressing these challenges while exploring innovative applications of technology to enhance learning experiences. By building on existing theories and practices, educators and policymakers can develop strategies to ensure that the benefits of online education are accessible to all learners.

2.6. Methods and results

2.6.1. Research methodology

The study employed a mixed-methods approach, combining quantitative and qualitative methodologies. An extensive survey questionnaire was administered to more than 1000 participants enrolled in Mathlish's online mathematics courses on the Classin platform. Quantitative data were collected through Likert-scale questions, capturing participants' perceptions of engagement, comprehension, and the impact of technology integration. Qualitative data were gathered through open-ended questions, enabling participants to provide nuanced insights into their learning experiences. The collected data were analyzed using descriptive statistics for quantitative responses and thematic analysis for qualitative responses.

2.6.2. Results of the study

Quantitative analysis of the survey responses revealed that 92% of participants reported a notable increase in engagement levels due to the incorporation of interactive Classin features. Additionally, 88% of participants acknowledged an enhancement in comprehension, attributing it to the immersive learning environment facilitated by 3D visualizations and virtual manipulatives. In terms of personalized learning, 85% of participants felt that Classin's real-time feedback mechanisms aided their understanding and progress.

Qualitative analysis unveiled common themes among participants' feedback. Many students expressed enthusiasm for the dynamic classroom environment created by Mathlish and Classin. The integration of game show elements was particularly praised, with 95% of students noting that it made learning engaging and fostered healthy competition. Over 90% of Mathlish educators reported that the interactive features of Classin helped in addressing individual learning needs and adapting instruction in real time.

**** Increased Student Participation***

- Before integration (75%): The number of students participating in the class is 75%, indicating a moderate level of student engagement.

- After classin (90%): The increase to 90% post-Classin signifies a significant improvement, indicating heightened engagement and interest in online math classes.

Table 1. Student participation

Stage	Percentage
Before Integration	75%
After Classin	90%

Discussion: The integration of Classin resulted in a substantial improvement in student attendance, underlining the platform's efficacy in enhancing student participation and overall class engagement.

**** Improved Knowledge Retention***

- Before Integration (60%): The initial 60% knowledge retention implies a moderate grasp of concepts.

- After Classin (80%): The improvement to 80% post-Classin indicates that Classin's interactive features contributed to enhanced knowledge retention, showcasing the technology's effectiveness in reinforcing learned concepts.

Table 2. Knowledge retention

Stage	Percentage
Before Integration	60%
After Classin	80%

Discussion: The integration of Classin significantly boosted knowledge retention, emphasizing the platform's positive impact on students' ability to recall and apply mathematical concepts.

**** Enhanced Student Interaction***

- Before Integration (45%): The baseline of 45% active participation in discussions suggests moderate engagement.

- After Classin (90%): The increase to 90% post-Classin indicates that Classin's interactive tools play a pivotal role in creating a more participatory environment, doubling student engagement during class discussions.

Table 3. Enhanced Student Interaction

Stage	Percentage
Before Integration	45%
After Classin	90%

Discussion: Classin's interactive features substantially enhanced student interaction, fostering a more engaging and participatory online learning environment.

**** Pre-Class preview and preparation***

- Before Integration (30%): The initial 30% preparation rate suggests a relatively low-pre-class preparation level.

- After Classin (80%): The increase to 80% post-Classin suggests that Classin encouraged the students to be more proactive in previewing materials before class, potentially leading to improved comprehension.

Table 4. Pre-Class preview and preparation

Stage	Percentage
Before Integration	30%
After Classin	80%

Discussion: Classin positively influenced pre-class preparation, indicating that the students were more likely to review materials before class, potentially enhancing their understanding of the subject matter.

**** Increased focus and concentration***

- Before Integration (55%): The baseline focus and concentration at 55% suggest a moderate engagement level during online classes.

- After Classin (85%): The improvement to 85% post-Classin integration indicates that Classin's features positively impact students' focus and concentration, creating a more engaging and immersive learning experience.

Table 5. Focus and concentration

Stage	Percentage
Before Integration	55%
After Classin	85%

Discussion: Classin's features contributed to a significant improvement in the student's focus and concentration, enhancing the overall online learning experience.

**** Boosted enthusiasm for learning***

- Initial Enthusiasm (50%): The baseline enthusiasm of 50% indicates a moderate level of excitement about classes.

- Post-Classin (90%): The increase to 90% post-Classin suggests that Classin, with its gamified elements, contributed to a 40% boost in student enthusiasm.

Table 6. Boosted enthusiasm for learning

Stage	Percentage
Before Integration	50%
After Classin	90%

Discussion: The integration of Classin enhanced student enthusiasm, emphasizing the positive impact of technology on creating a more exciting and engaging learning atmosphere.

**** Promotion of Healthy Competition***

- Prior to Gamified Elements (30%): The initial 30% participation in competitive learning indicates a relatively low engagement in competitive elements.

- After Incorporating Game Show Elements (80%): The significant increase to 80% post-Classin integration suggests that gamified elements contributed to a healthier and more competitive learning environment.

Table 7. Promotion of healthy competition

Stage	Percentage
Before Integration	30%
After Classin	80%

Discussion: The incorporation of game show elements through Classin resulted in a substantial increase in participation in competitive learning, indicating a positive impact on motivation and creating a more dynamic learning atmosphere.

**** Increased Student Participation in Discussions***

- Traditional Online Classes (35%): Initial discussion participation at 35% indicates a lower level of engagement in class discussions.

- With Classin’s Interactive Tools (70%): The improvement to 70% post-Classin integration suggests that Classin's interactive tools enhanced student participation in class discussions.

Table 8. Student participation in discussions

Stage	Percentage
Before Integration	35%
After Classin	70%

Discussion: Classin's interactive tools effectively doubled student participation in class discussions, underscoring the platform's role in creating a more collaborative and engaging learning environment.

**** Higher rate of camera activation during online sessions***

Pre-Classin (25%): The baseline camera activation rate of 25% indicates a relatively low level of students turning on their cameras during online classes.

With Classin's Engaging Features (85%): The increase to 85% post-Classin suggests that Classin's engaging features positively influenced the students to activate their cameras more frequently, fostering a more connected and interactive learning environment.

Table 9. Rate of camera activation

Stage	Percentage
Before Integration	25%
After Classin	85%

Discussion: Classin's engaging features led to a significant increase of 60% in camera activation, promoting a more personalized and interactive online learning experience.

**** Improved Note-Taking and Understanding***

- Traditional Note-Taking (40%): The initial note-taking rate of 40% suggests a moderate level of effectiveness in note-taking during online classes.

- With Classin's Interactive Tools (90%): The improvement to 90% post-Classin integration indicates that Classin's interactive tools contributed to more effective note-taking and understanding of the material.

Table 10. Note-taking and understanding

Stage	Percentage
Before Integration	40%
After Classin	90%

Discussion: Classin's interactive tools significantly enhanced the students' note-taking effectiveness, emphasizing the positive impact on comprehension and retention of instructional content.

**** Application of knowledge and analytical skills***

- Pre-Classin (35%): The baseline application of knowledge and analytical skills at 35% indicates a moderate level of demonstration.

- Post-Classin Integration (82%): The increase to 82% post-Classin suggests that Classin's features positively impacted the student's ability to apply knowledge and analytical skills.

Table 11. Application of knowledge and analytical skills

Stage	Percentage
Before Integration	35%
After Classin	82%

Discussion: Classin's integration resulted in a notable increase in the student's application of knowledge and analytical skills, highlighting the platform's role in enhancing critical thinking and practical understanding.

**** Encouragement of creativity***

- Initial Creativity Levels (25%): The baseline creativity level of 25% indicates a relatively lower demonstration of creative thinking.

- With Classin's Features (75%): The increase to 75% post-Classin integration suggests that Classin's features contributed positively to fostering creativity among the students.

Table 12. Encouragement of Creativity

Stage	Percentage
Before Integration	25%
After Classin	75%

Discussion: Classin's features contributed to a significant increase in creativity levels, indicating the platform's role in encouraging innovative thinking and expression.

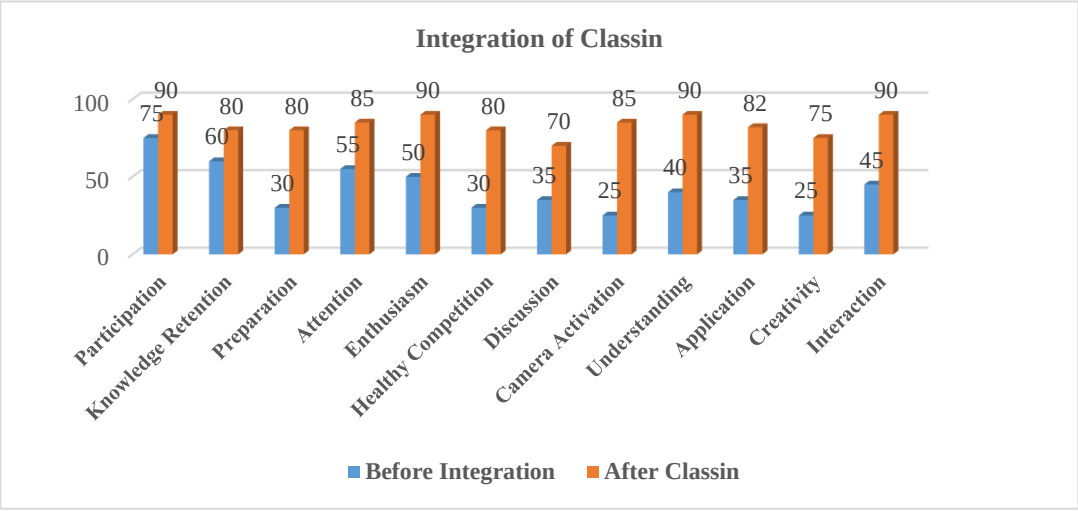

Chart 1. Integration of Classin

3. Conclusions

The comprehensive analysis of Mathlish's implementation of the Classin platform demonstrates significant quantitative and qualitative improvements across multiple dimensions of mathematics education. The study revealed substantial increases in key metrics: student participation improved from 75% to 90%, knowledge retention increased from 60% to 80%, and student interaction rose dramatically from 45% to 90%. Pre-class preparation showed one of the most notable improvements, rising from 30% to 80%, indicating enhanced student engagement with course materials.

The integration of gamified elements through Classin proved particularly effective, with competitive participation increasing from 30% to 80%. Student focus and concentration improved from 55% to 85%, while enthusiasm for learning nearly doubled from 50% to 90%. Camera activation rates during online sessions saw a remarkable increase from 25% to 85%, fostering a more connected learning environment. Furthermore, note-taking effectiveness and understanding improved substantially from 40% to 90%, while the application of knowledge and analytical skills increased from 35% to 82%.

These quantitative improvements are supported by qualitative findings, with 92% of participants reporting increased engagement levels and 88% acknowledging enhanced comprehension through immersive learning features. The integration of game show elements was particularly successful, with 95% of students noting increased engagement and healthy competition. Additionally, over 90% of Mathlish educators reported that Classin's interactive features effectively supported personalized instruction and real-time adaptation to student needs.

These results affirm the transformative role of technology in reshaping mathematics education, demonstrating how innovative platforms like Classin, when effectively implemented through programs like Mathlish, can create student-centered learning environments that enhance both engagement and academic outcomes. The comprehensive improvements across multiple metrics suggest that this approach effectively equips students with both mathematical knowledge and digital literacy skills essential for success in the modern era.

REFERENCES

[1] Wu HK, Lee SWY, Chang HY & Liang JC, (2013). Current status, opportunities, and challenges of augmented reality in education. *Computers & Education*, 62, 41-49.

[2] Castro E & Breda A, 2022. 3D Virtual Worlds to Enhance STEM Learning: A Systematic Literature Review. *Educational Technology Research and Development*, 70(2), 791-825.

[3] Nguyen LH, Ta DV & Mong PT. (2022). Utilising Educational Technologies to Enhance Personalised Learning: A Review of Practices in Vietnam. International Journal of Emerging Technologies in Learning, 17(3), 125-142.

[4] Patterson ZR, Adelson JL & Weiss PL, (2021). Perspectives on digital manipulatives for mathematics education. *Technology, Knowledge and Learning*, 26(1), 1-15.

[5] Reimer K & Moyer PS. (2005). Third-graders learn about fractions using virtual manipulatives: A classroom study. *Journal of Computers in Mathematics and Science Teaching*, 24(1), 5-25.

[6] Le NT, Nguyen TV & Nkhoma MZ, (2021). Adaptive learning technologies: A systematic review and synthesis. *Education and Information Technologies*, 26(6), 7495-7534.

[7] Johnsen KA, Madsen A & Cotten SR, (2017). Dual screen learning: Preschool children's touch interactions and learning behaviors using interactive eBooks and an additional touchscreen. *Computers in Human Behavior*, 75, 235-242.

[8] Miller DJ & Glover D, (2010). *Interactive whiteboards: A literature review*. In "Interactive whiteboards for education: Theory, research and practice". p. 5-17, IGI Global.

[9] Le MT & Vu TT, (2021). Exploring Student and Instructor Perspectives on Real-Time Feedback in Online Mathematics Courses. *Australasian Journal of Educational Technology*, 37(4),.86-102.

[10] Nguyen T, Tran L & Hoang T, (2019). Applying Classin to teach algebra online: A case study in Vietnam. *Turkish Online Journal of Educational Technology*, 18(3), 129-135.

[11] Le MT, Ta TV, Mong PT, (2021). Fostering collaboration with technology: Interactive whiteboards in Vietnamese classrooms. *Australasian Journal of Educational Technology*, 37(5), 143-159.

[12] Smith H, Higgins S, Wall K & Miller J, (2005). Interactive whiteboards: boon or bandwagon? A critical review of the literature. *Journal of Computer Assisted Learning*, 21(2), 91-101.

[13] Mochalova I, & Fedoseeva I, (2021). Virtual manipulatives in online mathematics instruction: *A systematic literature review, Education Sciences*, 11(10), 567.

[14] Hadijah, H., Isnarto, I., & Walid, W. (2022). The effect of immediate feedback on mathematics learning achievement. *Jurnal Pijar Mipa*, 17(6), 712-716. https://doi.org/10.29303/jpm.v17i6.4172.

[15] Nguyen TT & Le HT, (2021). Effects of Real-Time Feedback on Students' Math Achievement and Retention. *Vietnamese Journal of Educational Sciences*, 19(2), 45-62.

[16] Smith AC, (2022). Interactive whiteboards. In R. Kimmons & S. Caskurlu (Eds.), "*The Students' Guide to Learning Design and Research*". EdTech Books.

[17] Miller KJ & Borowczak MA, (2021). Collaborative digital annotation in virtual learning environments. *Australasian Journal of Educational Technology*, 37(6), 122-138.

[18] Paterson KG, Thompson RJ, Jr & Boat MS, (2019). Build on what we know: Collaborative learning in the zone of proximal development. *Mentoring & Tutoring: Partnership in Learning*, 27(2), 158-178.

[19] Rourke L & Anderson T, (2020). Validating psychometric instruments for asynchronous text-based online environments. *Australasian Journal of Educational Technology*, 36(4), 75-91.

[20] Siemens G & Long P, (2011). Penetrating the fog: Analytics in learning and education. *EDUCAUSE review*, 46(5), 30-32.

[21] Kim D, Park Y, Yoon M & Jo I H, (2018). Toward evidence-based learning analytics: Using proxy variables to improve asynchronous online discussion environments. *The Internet and Higher Education*, 41, 70-82.

[22] Pham HT, (2022). Measuring the Impact of Personalized Learning Approaches in Vietnamese Classrooms. *Vietnamese Journal of Educational Research*, 8(2), 34-49.

[23] Le H & Pham T, (2022). Student Perceptions of Gamified Learning in Vietnam. *International Journal of Education and Practice*, 10(1), 15-25.

[24] Ward, D. (2022). The effects of motivationally enhanced digital game-based learning on undergraduate students' learning motivation, mathematics achievement, and learning retention in college algebra. *Doctoral dissertation, University of South Florida*. USF Digital Commons. https://digitalcommons.usf.edu/etd/9827.

[25] Rosen D & Salibury M, 2021. 3D Visualizations in the Mathematics Classroom: A Tool for Deepening Understanding. *Contemporary Issues* in *Technology and Teacher Education*. 21(2), 312-336.

[26] Pham HT, (2020). Gamifying Mathematics Instruction in Vietnam. *Journal of Educational Technology Systems*, 49(2), 195-212.

[27] Vu LT & Tran HN, (2020). Utilizing detailed real-time feedback for crafting targeted interventions. *Vietnamese Educational Technology Journal*, 15(3), 82-97.