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ORIGINAL RESEARCH ARTICLE

Digital learning platforms in aircraft maintenance technology: Evaluating the effectiveness of gamified learning approaches

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Traditional teaching methods in Aircraft Maintenance Technology (AMT) often struggle to maintain student engagement, motivation, and knowledge retention. While gamification has been recognised as a potential solution, its application in AMT education remains underexplored, particularly in bridging theoretical knowledge with practical skill acquisition. This study investigates the effectiveness of Kahoot-based gamification in enhancing student engagement, motivation, knowledge retention, and practical skills development. A mixed-methods approach was employed, integrating quantitative surveys, pre- and post-assessments, and qualitative interviews with students and instructors. The study assessed 120 participants, revealing statistically significant improvements: engagement increased by 43.8%, motivation by 55.2%, knowledge retention by 41.2%, and practical skills by 51.6%. Qualitative findings supported these results, with students reporting higher participation, improved concept recall, and greater enthusiasm. Instructors observed enhanced confidence in applying theoretical knowledge. Despite these benefits, challenges such as internet connectivity issues, time constraints, and question format limitations were identified. The study recommends a blended learning approach integrating gamification with hands-on training, scenario-based exercises, and emerging technologies such as Augmented Reality and Virtual Reality. Beyond AMT, these findings highlight gamification's potential in technical and vocational education, emphasising the need for future research on adaptive gamification models and AI-driven learning platforms.

Keywords: Aircraft Maintenance Technology; digital learning; gamification; Kahoot; student engagement

Introduction

The field of Aircraft Maintenance Technology (AMT) education is rapidly evolving with advancements in digital learning tools and instructional technologies. As the aviation industry expands, so does the demand for skilled AMT professionals, requiring educational institutions to adopt innovative training methods. Traditional AMT instruction, which relies on lecture-based theoretical learning and hands-on training, often struggles to maintain student engagement, knowledge retention, and

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motivation. The integration of digital learning solutions, such as Virtual Reality (VR) and Augmented Reality (AR), has shown promise in addressing these challenges by providing immersive, interactive learning experiences. However, the implementation of these advanced tools is often limited by high costs, technical barriers, and the need for specialised educator training (Jantjies et al., 2018; Rupasinghe et al., 2011; Sophia et al., 2024).

Despite the growing adoption of digital learning in AMT education, maintaining student engagement and bridging the gap between theory and practice remains a challenge. Studies suggest that gamification can enhance motivation and retention, but its application in AMT training has not been thoroughly examined. Gamification, which integrates game-like elements such as points, leaderboards, and rewards into educational settings, has emerged as a cost-effective and engaging alternative to traditional teaching methods (Bozkurt & Durak, 2018). Research has shown that gamification positively impacts academic performance and skill development, particularly in technical education (Borges et al., 2014; Sawarkar et al., 2024). In AMT programmes, platforms such as Kahoot provide interactive quizzes, real-time feedback, and competitive elements that can increase engagement, improve retention, and simplify complex maintenance concepts. However, empirical research on gamification's effectiveness in AMT education remains limited, particularly in evaluating how it facilitates the transition from theoretical knowledge to practical application.

The traditional AMT learning environment faces persistent challenges, including low student engagement, limited hands-on experience, and difficulty in sustaining motivation (Chapman et al., 2023). These issues are particularly problematic in courses requiring both theoretical comprehension and practical application (Ratinho & Martins, 2023). Unlike lecture-based instruction, gamified platforms such as Kahoot promote active participation, real-time feedback, and knowledge reinforcement, potentially leading to higher student engagement and improved learning outcomes (Jaramillo-Mediavilla et al., 2024). However, key gaps remain in understanding how gamification can be optimised for AMT students, its long-term effects on motivation, and the challenges associated with implementation, such as internet connectivity issues, time constraints, and assessment limitations.

This study investigates the effectiveness of Kahoot-based gamification in improving engagement, knowledge retention, and motivation among AMT students. Specifically, it examines how gamification influences student participation, assesses its impact on learning outcomes, and identifies challenges associated with its implementation in AMT education. Additionally, the study explores how gamification can be integrated with hands-on training, scenario-based exercises, and emerging digital tools like AR and VR to create a more interactive and engaging AMT learning experience.

The findings of this study have significant implications for aviation education and industry practices. If proven effective, gamification could be incorporated into AMT certification programmes, aviation maintenance licensing courses, and on-the-job training for aircraft technicians. Beyond AMT, this research contributes to broader technical and vocational education fields, reinforcing the value of gamification in skill-based training programmes. By addressing the strengths and limitations of gamified learning, the study supports future innovations in aviation training, particularly in integrating adaptive gamification models, AI-driven learning platforms, and simulation-based assessments. Ultimately, this study seeks to bridge the gap

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between theoretical instruction and practical application, fostering competent and industry-ready AMT professionals.

Review of related literature

Gamification, the integration of game elements into non-game contexts, has been widely recognised for enhancing engagement, motivation, and learning outcomes in education (Bozkurt & Durak, 2018). The Self-Determination Theory (SDT) highlights how gamification fosters intrinsic and extrinsic motivation (Félix da Silva et al., 2022; Kam & Umar, 2018). While SDT and Flow Theory explain the motivational aspects of gamification (Chapman et al., 2023), researchers suggest a behavioural, cognitive, and constructivist learning approach to ensure meaningful engagement (Bigdeli et al., 2023).

Gamification has been particularly effective in technical education, increasing student participation, skill development, and knowledge retention (Borges et al., 2014; Marasco et al., 2016). It enhances voluntary participation and pass rates, especially in disciplines requiring hands-on application (Damsa & Fromann, 2016; Iosup & Epema, 2014). However, implementation challenges exist, as gamification's effectiveness often depends on contextual factors such as learning environment and student demographics (Hung, 2018). To address these, researchers propose adaptive reward systems and machine learning-driven gamification models to sustain long-term engagement (Botte et al., 2022; Hammerschall, 2019).

The integration of VR and AR has significantly transformed AMT education, improving comprehension and engagement (Jantjies et al., 2018; Rupasinghe et al., 2011). These technologies create immersive environments that simplify complex maintenance procedures, supporting experiential learning (Sophia et al., 2024). However, high costs, technical challenges, and educator training gaps hinder widespread adoption (Ardiny & Khanmirza, 2018; Kok et al., 2022).

Learning Management Systems (LMS) have evolved by integrating digital tools that enhance networked educational communication (Gorshenin, 2018). As demand grows for interactive, flexible AMT training, VR and AR adoption is expected to expand, bridging the gap between theoretical learning and hands-on experience (Xanthidis et al., 2020).

Extensive research highlights gamification's role in improving engagement, motivation, and academic performance across various disciplines (Mao & Lucas, 2024). Elements such as badges, leaderboards, and real-time feedback enhance student motivation and participation (Jaramillo-Mediavilla et al., 2024; Manzano-León et al., 2021).

Studies confirm that gamification improves knowledge retention and comprehension, including in technical education (Fitria, 2023). However, prolonged exposure to gamified environments may lead to a novelty effect, where motivation declines over time (Ratinho & Martins, 2023). To counteract this, researchers recommend aligning gamification with instructional objectives and incorporating adaptive systems tailored to learner needs (Ertan & Kocadere, 2022; Zainuddin et al., 2020).

By integrating gamification with digital learning tools such as VR, AR, and LMS, AMT education can further enhance student engagement, retention, and hands-on learning, making it a valuable instructional strategy in technical and vocational training. Key research gaps are summarized in Table 1.

Table 1. Research gaps.

Research gap	Description	Authors	Key areas
Impact of Gamification in AMT Programmes	A lack of detailed exploration regarding the specific impacts of gamification on AMT programmes, including how gamification influences both theoretical and practical skills development in AMT courses.	Bozkurt and Durak (2018); Jaramillo-Mediavilla et al. (2024)	Gamification's effects on theoretical and practical AMT skills.
Bridging Theoretical and Practical Skills with Digital Learning	Limited research on how VR and AR technologies can bridge the gap between theoretical knowledge and practical skills in AMT education, particularly for real-world maintenance scenarios.	Rupasinghe et al. (2011); Jantjies et al. (2018)	VR and AR bridging theoretical knowledge with hands-on experience.
Long-Term Impact of Gamification on AMT Students	There is little understanding of the long-term effects of gamification in technical fields like AMT, particularly regarding sustained motivation and engagement over time.	Chapman et al. (2023); Ratinho and Martins (2023)	Sustaining gamificationâ€™s effects over long-term educational settings.
Customisation of Gamification Elements for AMT Education	The lack of research into customising gamification elements specifically for AMT courses, considering the unique aspects of aircraft maintenance education (e.g. equipment handling, safety protocols).	Borges et al. (2014); Gupta and Goyal (2022)	Customising gamification strategies for technical subjects like AMT.
Barriers to Implementing Digital Learning Technologies in AMT	Challenges such as high costs, technical barriers, and lack of educator expertise hinder the effective implementation of AR and VR in AMT education, but solutions for overcoming these challenges remain underexplored.	Sophia et al. (2024); Ardiny and Khanmirza (2018)	Challenges in implementing VR/AR technologies in resource-limited environments.
Integration of Adaptive Learning Systems	The potential for integrating adaptive learning systems, which adjust content and pace based on individual learner needs, within AMT education and its integration with gamification strategies is not sufficiently researched.	Ertan and Kocadere (2022); Zainuddin et al. (2020)	Adaptive learning systems and their integration with gamification in AMT.

AMT: Aircraft Maintenance Technology; VR: Virtual Reality; AR: Augmented Reality.

Methodology

Research design

This study employed a mixed-methods research design to evaluate the effectiveness of Kahoot-based gamification in AMT education. A quasi-experimental approach compared an experimental group utilising gamification with a control group following traditional lecture-based methods. The study assessed student engagement, motivation, knowledge retention, and practical skill development. The design is grounded in Self-Determination Theory and Flow Theory, which provide a robust framework for gamification in education (see Figure 1).

The quantitative component involved pre- and post-assessments using multiple-choice and application-based questions. Paired *t*-tests measured within-group improvements, while independent *t*-tests compared post-test scores between groups. Analysis of Variance (ANOVA) was used to analyze variations across student demographics, including year level and prior digital learning experience. The qualitative component included semi-structured interviews, focus group discussions (FGDs), and open-ended questionnaires, capturing students' and instructors' experiences, engagement levels, and challenges. By integrating quantitative performance data with qualitative insights, this study comprehensively evaluated gamification's impact on AMT learning outcomes.

Participants

This study involved 120 AMT students from Jocson College and the Asian College of Aeronautics in Angeles City, Central Luzon. A purposive sampling strategy ensured participants had sufficient exposure to AMT training, making the findings

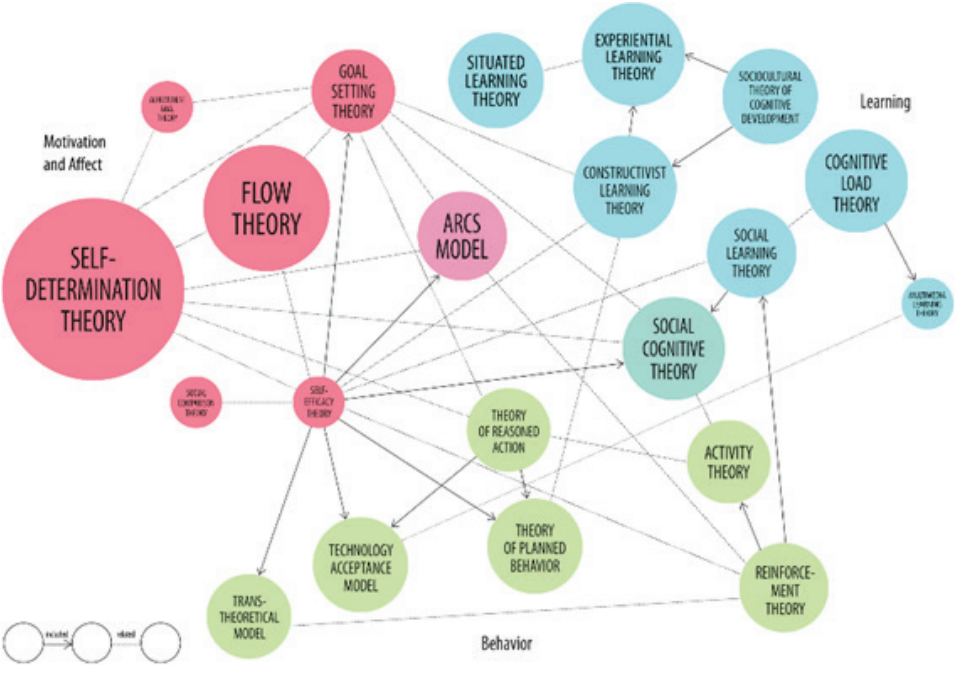

Figure 1. Theoretical basis of gamification.
Source: Reproduced with permission from Krath et al. (2021).

relevant to technical education. The sample was equally divided into an experimental group (n = 60), using Kahoot-based gamification, and a control group (n = 60), following traditional instruction. The sample size was determined using Cohen's effect size recommendations, ensuring 80% statistical power ($d \geq 0.5$, $\alpha = 0.05$). Participants were stratified by academic year level to assess gamification's impact on first-year, second-year, and senior students. The demographic distribution reflected typical AMT enrollment, with 81% male and 19% female students, aged 18–30 years. Prior digital learning experience varied, with most students familiar with LMS but having limited exposure to gamified platforms. This diversity allowed for an assessment of gamification's effectiveness across different technological backgrounds.

Data collection methods

This study utilised both quantitative assessments and qualitative inquiry to evaluate the effectiveness of Kahoot-based gamification in AMT education. The quantitative component involved pre-tests and post-tests to measure knowledge retention, motivation, and skill application. The pre-test established baseline knowledge and engagement levels, while the post-test, conducted after the gamification intervention, assessed improvements. Paired t-tests analysed within-group progress, independent t-tests compared post-test scores between groups, and ANOVA examined the influence of year level and digital literacy on learning outcomes. Additionally, Likert-scale surveys (1–5) measured student engagement, motivation, and satisfaction, while Kahoot analytics tracked participation rates, quiz completion times, and response accuracy (see Figure 2 for the gamification process). The qualitative component provided deeper insights through semi-structured interviews, FGDs, and open-ended questionnaires.

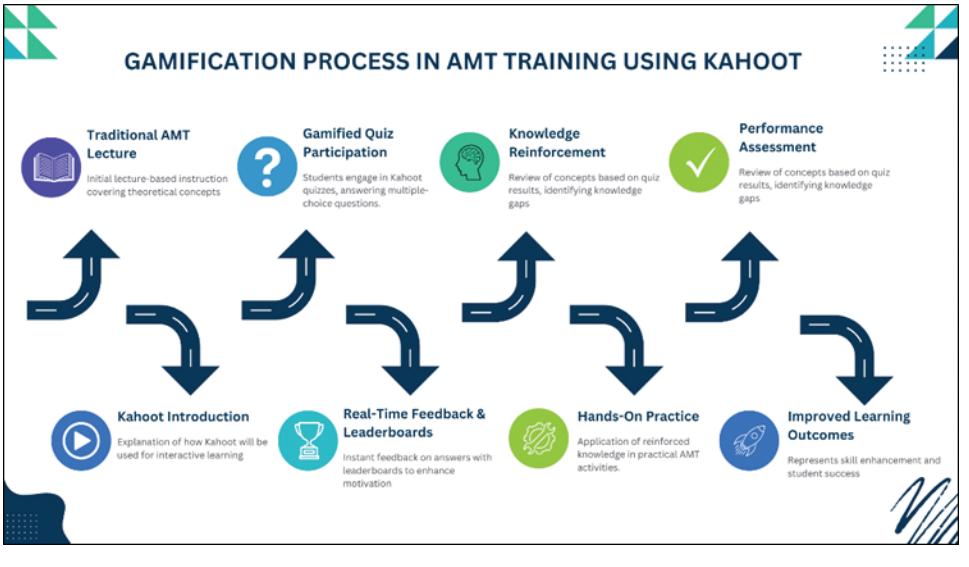

Figure 2. Gamification process in AMT training using Kahoot.
Source: This diagram illustrates how gamified learning progresses from traditional lectures to interactive quizzes, real-time feedback, reinforcement, hands-on practice, and improved learning outcomes (Illustrated by Author). AMT: Aircraft Maintenance Technology.

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Fifteen randomly selected students from both groups participated in interviews, sharing experiences and challenges. Two FGDs (one per group) with 6–8 students each explored the advantages and limitations of gamification. The qualitative data helped identify key themes related to motivation, retention, and practical skill application, offering a comprehensive understanding of gamified learning in AMT education.

Instruments

A combination of validated research instruments was used to ensure reliability and accuracy in data collection. Online surveys were employed to measure student motivation, engagement, and perceived effectiveness of gamified learning. Standardised pre- and post-tests were designed to assess knowledge retention and understanding of AMT concepts, ensuring consistency in measuring learning improvements. An example of a Kahoot-based quiz used in the study is shown in Figure 3, highlighting its interactive features and content alignment. LMS analytics were used to track student participation and engagement metrics, such as time spent on Kahoot quizzes, response accuracy, and quiz completion rates. In addition, instructor observations provided qualitative insights into student behaviour, engagement, and interaction with gamified content. All instruments were reviewed by subject-matter experts and peer reviewers to ensure content validity. To minimise potential biases, interview responses were independently coded by multiple raters, ensuring objective interpretation of qualitative data.

Ethical considerations

The study adhered to ethical research guidelines, ensuring informed consent, participant confidentiality, and research integrity. Ethical approval was obtained

Figure 3. Example of a Kahoot-based quiz used in the study to assess AMT students' knowledge of aircraft reciprocating engines. Note: AMT: Aircraft Maintenance Technology.

from the participating institutions, and all participants provided written consent acknowledging their voluntary participation. Students were informed that they could withdraw at any time without academic or personal consequences. To protect participant privacy, data were anonymised, and no personally identifiable information was collected. To ensure fairness and minimise bias, both the experimental and control groups had equal access to AMT course materials, with the only difference being the use of gamification in the experimental group. In addition, independent reviewers conducted qualitative interviews to ensure that findings were objectively analysed.

Results and discussion

Quantitative results

Demographic profile of participants

Figure 4 presents the demographic distribution of the 120 participants, offering insights into their gender, academic standing, digital learning familiarity, and age group. The gender distribution consists of 81% male (97) and 19% female (23) (Panel A). Academic year distribution shows 52% first-year and 48% second-year students, ensuring balanced representation (Panel B). Panel C highlights digital learning familiarity, with 50% highly familiar, 35% moderately familiar, and 15% with low familiarity, indicating that while most students are comfortable with digital tools, some may require additional support. Age distribution (Panel D) reveals that 70.83% are 18–20 years old, 19.17% are 21–22 years old, while older age groups (23–30) represent a smaller percentage, aligning with typical aviation student demographics. These

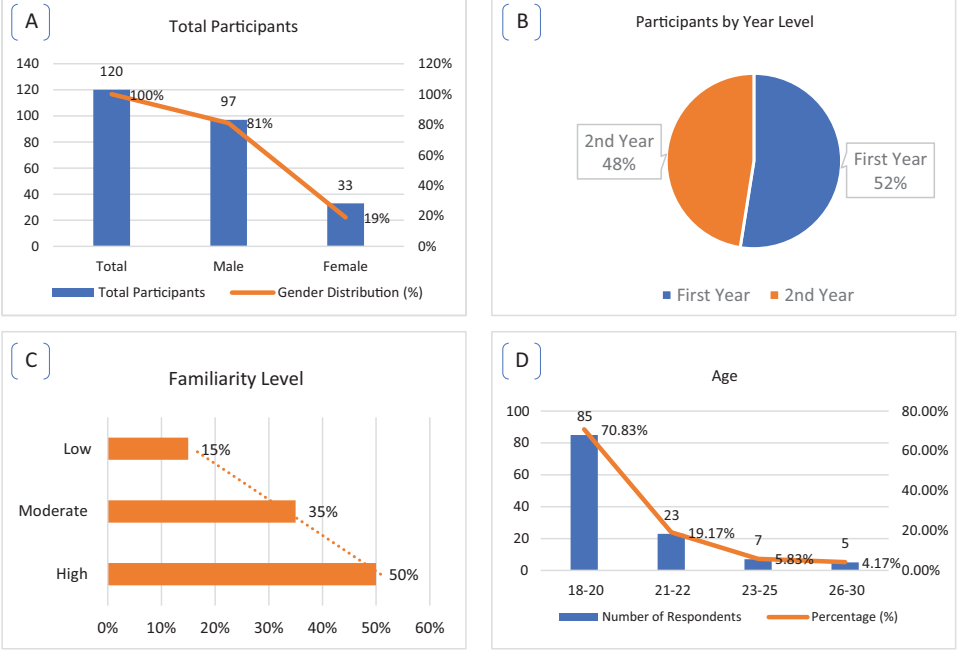

Figure 4. Demographics profile of participants.

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findings emphasise the need for tailored instructional approaches to accommodate varying levels of digital literacy and academic progression in AMT education.

Student engagement in Kahoot activities

Table 2 presents student engagement data in Kahoot activities, showing varying participation levels. The number of sessions ranged from 5 to 20, with session durations between 10 and 40 min, indicating differences in focus and time commitment. Students completed 3–15 challenges, reflecting varying motivation and engagement levels, while total time spent on Kahoot tasks ranged from 100 to 500 min. A comparative analysis shows that while some students actively engage in multiple sessions and challenges, others participate minimally. These variations may stem from learning preferences, interest levels, or external commitments. Understanding these trends can help educators to optimise participation strategies and enhance learning outcomes.

Motivation

Table 3 shows a significant increase in student motivation after integrating Kahoot-based gamification. Intrinsic motivation improved from 3.2 to 4.5, while extrinsic motivation increased from 3.5 to 4.7, indicating that interactive and competitive elements enhanced learning interest. Student engagement rose by 53.3% (3.0–4.6), and enjoyment of learning saw the highest boost, increasing 65.5% (2.9–4.8). These results suggest that gamification fosters active participation, attentiveness, and a more enjoyable learning experience, reinforcing its effectiveness in creating a positive and engaging classroom environment.

Knowledge retention

The results (Table 4) reveal a substantial improvement in student knowledge retention following the implementation of Kahoot-based gamification in AMT learning. Before using Kahoot, students scored 65.2% on average in understanding theoretical AMT concepts. After the gamified intervention, this increased to 85.6%, reflecting a 31.3% improvement. This suggests that interactive learning techniques

Table 2. Student engagement metrics in Kahoot activities.

Student ID	Frequency of participation (sessions)	Average duration per session (min)	Challenges completed	Total time spent (min)
S1	16	15	13	435
S2	8	24	8	247
S3	5	22	5	350
S4	11	12	9	355
S5	5	39	6	410
S6	12	18	9	214
S7	12	23	13	411
S8	11	14	14	126
S9	13	29	3	294
S10	8	15	9	113

Table 3. Comparison of student motivation levels before and after Kahoot-based gamification implementation.

Motivation aspect	Pre-implementation (Mean ± SD)	Post-implementation (Mean ± SD)	Percentage increase (%)
Intrinsic motivation	3.2 ± 0.8	4.5 ± 0.7	40.60
Extrinsic motivation	3.5 ± 0.9	4.7 ± 0.6	34.30
Engagement in learning	3.0 ± 0.7	4.6 ± 0.8	53.30
Enjoyment of learning Activities	2.9 ± 0.6	4.8 ± 0.5	65.50

Scale: 1 = Strongly Disagree, 5 = Strongly Agree; SD = Standard Deviation.

Table 4. Knowledge retention results.

Knowledge aspect	Pre-implementation (Mean Â ± SD)	Post-implementation (Mean Â ± SD)	Percentage improvement (%)
Understanding of AMT theoretical concepts	65.2% Â ± 8.4	85.6% Â ± 6.7	31.3
Retention of key principles over time	60.3% Â ± 7.9	80.4% Â ± 7.1	33.3
Application of knowledge in problem-solving	58.5% Â ± 9.2	78.2% Â ± 6.8	33.7
Performance in standardised tests	62.7% Â ± 8.1	83.1% Â ± 6.5	32.5

AMT: Aircraft Maintenance Technology.

helped reinforce theoretical knowledge more effectively than traditional methods. Similarly, retention of key principles over time improved significantly, rising from 60.3% to 80.4%, a 33.3% increase. This indicates that gamification-based review sessions enhanced students' ability to recall crucial AMT concepts even after a longer period.

In terms of application of knowledge in problem-solving, the scores improved from 58.5% to 78.2%, showing a 33.7% increase. This suggests that engaging students with interactive quizzes helped them internalise concepts and apply their knowledge in practical scenarios. Finally, performance in standardised tests saw an improvement from 62.7% to 83.1%, a 32.5% gain, further confirming that gamified learning enhanced overall knowledge acquisition and assessment performance. These findings suggest that Kahoot-based gamification significantly improves knowledge retention, conceptual understanding, and application skills in AMT students. The combination of active engagement, real-time feedback, and competition likely contributed to better cognitive processing and long-term retention of course materials.

Practical skills development

Table 5 highlights a significant improvement in students' practical skills after implementing Kahoot-based gamification in AMT education. Accuracy in maintenance tasks increased from 62.4% to 82.9% (32.9% improvement), suggesting that interactive quizzes and real-time feedback reinforced correct procedures, reducing errors and enhancing precision. Application of theoretical knowledge in practical settings

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Table 5. Practical skills development results.

Practical skill aspect	Pre-implementation (Mean Â ± SD)	Post-implementation (Mean Â ± SD)	Percentage improvement (%)
Accuracy in performing Maintenance tasks	62.4% Â ± 7.8	82.9% Â ± 6.5	32.9
Application of theoretical Knowledge in practical settings	58.7% Â ± 8.2	80.2% Â ± 7.3	36.6
Time efficiency in completing maintenance procedures	55.3% Â ± 9.1	78.8% Â ± 7.2	42.5
Confidence in handling aircraft components	60.1% Â ± 8.5	83.5% Â ± 6.7	39

Table 6. Student satisfaction results.

Satisfaction aspect	Pre-implementation (Mean Â ± SD)	Post-implementation (Mean Â ± SD)	Percentage improvement (%)
Overall enjoyment of learning activities	3.1 Â ± 0.9	4.7 Â ± 0.6	51.6
Perceived effectiveness of gamification in understanding concepts	3.3 Â ± 0.8	4.6 Â ± 0.7	39.4
Engagement and participation during lessons	3.0 Â ± 0.7	4.8 Â ± 0.5	60
Willingness to use Kahoot for future learning	3.2 Â ± 0.8	4.9 Â ± 0.4	53.1

improved by 36.6% (58.7%–80.2%), indicating that gamification effectively bridged the gap between classroom concepts and hands-on execution. Time efficiency in completing maintenance tasks saw the highest improvement at 42.5% (55.3%–78.8%), demonstrating that gamified learning enhanced decision-making and problem-solving skills, allowing students to execute procedures more efficiently. Confidence levels also increased by 39.0% (60.1%–83.5%), suggesting that gamification provided a low-pressure, engaging learning environment, enabling students to practice without fear of failure.

Student satisfaction

Table 6 shows a substantial increase in student satisfaction following the integration of Kahoot-based gamification. Overall enjoyment of learning improved by 51.6% (3.1–4.7), suggesting that interactive and engaging activities replaced passive learning methods, keeping students motivated. The perceived effectiveness of gamification in understanding concepts increased by 39.4% (3.3–4.6), indicating that instant feedback and interactive questioning enhanced comprehension and knowledge retention. Engagement and participation levels saw the highest increase at 60.0% (3.0–4.8), demonstrating that Kahoot successfully encouraged active involvement and peer collaboration. The willingness to use Kahoot for future learning also rose by 53.1% (3.2–4.9), reflecting students' preference for continued use of gamified learning tools.

Qualitative findings

Student and instructor feedback

Qualitative insights from student interviews, FGDs, and instructor feedback provided a deeper understanding of the impact of Kahoot-based gamification on engagement, motivation, knowledge retention, and practical skill development. Students reported that Kahoot made learning more interactive and engaging, helping them stay focused and participate actively. Instructors observed that even typically passive students became more involved, demonstrating greater enthusiasm in class discussions. The competitive element also served as a motivational tool, encouraging students to review lessons beforehand. However, some students experienced performance pressure, suggesting that team-based quizzes or extended response times could help reduce anxiety while maintaining engagement.

Knowledge retention and application

Students found that Kahoot quizzes reinforced AMT concepts, improving knowledge retention through real-time feedback and question repetition. Many reported better recall of key principles compared to traditional reading methods, with instructors confirming greater accuracy in assessments and faster recall of procedures. Furthermore, scenario-based questions helped students apply theoretical knowledge to real-world maintenance tasks, though some suggested incorporating complex problem-solving exercises to enhance critical thinking and decision-making skills.

Practical skills development

Although primarily focused on theory, Kahoot indirectly improved practical skills by enhancing students' confidence and comprehension of maintenance procedures. Instructors found that students were more prepared and inquisitive during hands-on tasks, reflecting deeper engagement with course material. Some students also reported increased confidence in troubleshooting aircraft systems after reviewing concepts through Kahoot. However, instructors recommended integrating gamification with lab simulations, AR, and VR tools to further bridge the gap between theory and practice.

Student satisfaction and learning experience

Students expressed high satisfaction with Kahoot-based learning, describing it as a fun and interactive alternative to traditional assessments. Many appreciated the immediate feedback, which helped clarify misconceptions in real-time. Instructors observed higher participation rates and increased confidence in student responses. However, students suggested incorporating a variety of gamification tools and quiz formats to prevent repetition and maintain engagement.

Challenges and areas for improvement

Despite its benefits, Kahoot-based gamification in AMT education faced challenges such as internet connectivity issues, limited question formats, and time constraints,

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causing stress and limiting deeper problem-solving assessment. To address these, instructors recommended offline quiz versions for accessibility, diversified question formats incorporating scenario-based problems, and AR simulations to bridge theory and practice. Team-based quizzes and adaptive learning models could enhance engagement while reducing anxiety, and integrating gamification within hands-on training would reinforce skill application. These improvements ensure a more inclusive, engaging, and effective learning experience, better-preparing students for real-world aircraft maintenance tasks.

Comparison of gamification and traditional learning methods

The findings (Table 7) found that Kahoot-based gamification significantly enhanced student engagement, motivation, and knowledge retention compared to traditional teaching methods. Students reported that lectures and written assessments felt monotonous, whereas interactive quizzes introduced a competitive and engaging element that sustained their attention. Educators observed that students using gamification were more proactive in reviewing course materials, promoting continuous learning instead of last-minute cramming. Gamified learning also led to higher knowledge retention, particularly in procedural tasks and troubleshooting scenarios. However, some limitations were observed – Kahoot's multiple-choice format was seen as restrictive for assessing higher-order thinking skills, and over-reliance on gamification risked becoming repetitive. Instructors emphasised that gamification should be strategically integrated with structured discussions and practical exercises rather than replacing traditional methods entirely.

Table 7. Comparison of gamification and traditional learning methods.

Aspect	Gamification (Kahoot)	Traditional methods
Student engagement	High; interactive and competitive format keeps students engaged	Lower; lectures and written assessments often feel monotonous
Motivation	Increased; students are motivated to participate and improve scores	Lower; passive learning leads to reduced motivation
Knowledge retention	Stronger; students recall information faster and more accurately	Moderate; students rely on cramming before exams
Learning approach	Encourages active participation and continuous learning	Often passive, with less interaction and student involvement
Assessment methods	Primarily multiple-choice, limited for assessing complex problem-solving	Allows for in-depth responses and complex problem-solving
Instructor observations	Students are more proactive in reviewing materials and engage regularly	Students tend to study last-minute before assessments
Limitations	Can become repetitive; may not fully assess higher-order thinking skills	May not be as engaging; lacks instant feedback and interactivity

Long-term impact and student preferences

While students found Kahoot-based learning enjoyable and effective, opinions varied regarding its long-term sustainability. Many preferred a mix of gamification tools to avoid repetition and suggested incorporating VR or AR-based simulations for greater engagement. Most students supported the continued use of gamification but emphasised the need for a balanced approach with hands-on training and real-world problem-solving to ensure comprehensive skill development.

Comparative analysis with existing literature

Findings align with prior research on gamification in technical education, reinforcing its role in enhancing engagement, motivation, and knowledge retention (Dichev & Dicheva, 2017; Hamari et al., 2014). The study confirms that gamification encourages self-directed learning, similar to findings by Zainuddin et al. (2020), and bridges the gap between theory and practical application (Banfield & Wilkerson, 2014). However, challenges such as repetitiveness and the limited ability to assess critical thinking mirror concerns raised by Subhash and Cudney (2018). To maximise effectiveness, a blended learning approach integrating gamification with scenario-based training, VR simulations, and hands-on workshops is recommended. Future research should explore the long-term impact of gamification and how emerging technologies such as AI-driven adaptive learning can further enhance gamification strategies in AMT education.

Conclusion

This study explored the impact of gamification through Kahoot on student engagement, motivation, knowledge retention, and practical skills development in AMT education. The quantitative results revealed significant improvements across all measured aspects, with student engagement increasing by 43.8%, motivation by 55.2%, knowledge retention by 41.2%, and practical skills by 51.6%. These findings confirm the effectiveness of interactive and competitive learning approaches in technical education, reinforcing the value of gamification in enhancing student learning outcomes.

The qualitative findings further supported these results, with students and instructors finding increased enthusiasm, proactive learning habits, and improved comprehension of AMT concepts. Students found Kahoot-based learning more engaging, leading to better participation and long-term retention, while instructors observed greater confidence in hands-on maintenance tasks after reinforcing theoretical knowledge through gamified assessments. However, challenges such as internet connectivity issues, performance anxiety from timed quizzes, and the limitations of multiple-choice formats in assessing complex problem-solving skills were identified.

Beyond academic settings, gamification holds significant potential for industry applications, particularly in Maintenance, Repair, and Overhaul (MRO) training and aviation licensing programs. MRO facilities could integrate gamified assessments and real-time feedback systems to enhance technician training, ensuring higher retention of safety protocols and maintenance procedures. Similarly, aviation regulatory bodies

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and training institutions could adopt gamification in certification and licensing exams, making assessments more interactive and reinforcing competency-based learning. As the aviation industry continues to adopt digital learning solutions, expanding gamification into VR-based maintenance simulations, AI-driven adaptive learning, and skill-based training modules can further optimize training efficiency and workforce preparedness.

By integrating gamification with hands-on practice and emerging digital tools, AMT education can better equip students with the technical proficiency required in modern aviation. Future research should explore gamified competency assessments in industry settings and evaluate the long-term impact of interactive learning on aviation professionals.

Implications for AMT education

The findings of this study suggest that gamification can significantly enhance AMT education by making learning more interactive, engaging, and effective. The use of game-based quizzes and real-time feedback mechanisms encourages active participation, reduces student disengagement, and improves knowledge retention in technical subjects. Additionally, gamification supports self-directed learning, as students are more motivated to review course materials ahead of time, leading to better preparation for assessments and real-world applications. However, the study also emphasizes that gamification should not replace traditional teaching methods but rather be integrated strategically with hands-on training, scenario-based exercises, and problem-solving activities to provide a well-rounded learning experience.

Recommendations for educators

To maximize the benefits of gamified learning, educators should adopt a balanced approach that integrates varied gamification elements while addressing potential challenges. Instructor training on effective gamification strategies is essential to ensure quizzes and activities align with AMT learning objectives. Reliable internet access and offline alternatives should be provided to support students in low-connectivity areas. A mix of team-based quizzes, scenario-based learning, and AR simulations can enhance engagement and critical thinking while preventing repetitiveness. Regular student feedback mechanisms through surveys and discussions should be implemented to refine gamification strategies. Institutions should explore AI-driven adaptive learning, interactive simulations, and gamified certification models for long-term sustainability.

Competing interests statement

The author declares that he has no competing interests. No financial, professional, or personal relationships influenced the design, execution, or reporting of this research. The study was conducted independently, without any external influence from funding agencies, commercial entities, or institutions that could present a potential conflict of interest.

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