

PAPER

Artificial Intelligence Empowers Gamification: Optimizing Student Engagement and Learning Outcomes in E-learning and MOOCs

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ABSTRACT

In this era of Artificial Intelligence (AI) growth, characterized by advances in the Large Language Models (LLMs) used by ChatGPT and Bard, this study examines the effects of gamification and Automatic Question Generation (AQG) on student engagement and learning outcomes in the context of a Massive Open Online Course (MOOC). AQG, implemented via a Moodle plugin, transforms conventional assessments into an interactive, gamified experience, leveraging the “test effect” to improve learning outcomes. Research with 100 fifth-graders in a primary and secondary school shows that gamified assessments significantly boost student motivation and learning outcomes compared with traditional methods. The custom Moodle plugin facilitates the AQG process, generating contextually relevant and grammatically correct Multiple-Choice Questions (MCQs) from course content. The result is a dynamic, personalized assessment experience aimed at optimizing student retention. This paper concludes by discussing the implications of the study for educators and highlighting potential directions for future research.

KEYWORDS

automatic question generation, ChatGPT, e-learning, gamification, MOOC, natural language processing

1 INTRODUCTION

In the 21st century, the emergence of digital technologies has precipitated a profound transformation in the global educational landscape. The advent of Massive Open Online Courses (MOOCs) has expanded the reach and accessibility of education in unprecedented ways [1]. Despite their revolutionary impact on education delivery, these platforms present unique challenges, notably the effective assessment of student learning. Traditional assessment methods, while reliable, may not be congruent with the dynamism and scale of MOOCs. The swift expansion of Artificial Intelligence (AI), including its sub-domains such as Natural Language Processing (NLP) and machine

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learning, offers a promising avenue to address these challenges. By harnessing the potential of advanced AI technologies, including Large Language Models (LLMs) like OpenAI's GPT-3 and Google's LaMDA [2], we can evolve assessment methods to align with the preferences, needs, and learning contexts of digital learners.

Assessment in education is a critical component, serving not only to measure learners' comprehension and progress but also to provide essential feedback for educators to refine their pedagogical strategies. However, in the rapidly evolving digital education landscape, traditional assessment practices often fall short of meeting the diverse needs of learners, potentially impacting their engagement and academic performance. MOOCs, a significant facet of this digital transformation, necessitate innovative assessment mechanisms to sustain learner motivation and enhance learning outcomes.

This study addresses the emerging need for engaging and effective assessment strategies by integrating gamification and Automatic Question Generation (AQG) within a MOOC environment. This study aims to answer the central research question whether a gamified evaluation approach, implemented through a Moodle plugin that automatically generates multiple-choice questions, can enhance student engagement, motivation, and learning outcomes more significantly than conventional assessment methods. To provide a comprehensive answer, the study delineates specific objectives, including:

- Examining the effects of gamified assessments on student engagement in a MOOC environment.
- Investigating whether automatic question generation can enhance the quality and efficiency of assessments.
- Exploring how a gamified assessment experience impacts students' academic motivation.
- Measuring the effects of the gamified assessment approach on students' learning outcomes, with a particular focus on knowledge retention and recall.

Subsequent sections of this paper delve into these objectives in-depth. Section 2 presents an extensive literature review, highlighting previous research on MOOCs, gamification in education, and AI's role in educational assessments. Section 3 outlines the research methodology, detailing the development and application of the gamified AQG approach. Section 4 presents the empirical findings, followed by an in-depth discussion of these results and their implications in Section 5. The paper concludes in Section 6 with a summary of the study's contributions, acknowledging its limitations, and proposing directions for future research.

This study promises to provide valuable insights into how gamification and AI can transform educational assessments in a MOOC environment [3], thereby adding a new dimension to the ongoing discourse on innovative assessment practices in digital learning environments. Drawing on prior research, this study leverages the pedagogical potential of gamification and the technological advancements in AI to enrich educational assessments.

2 RELATED WORK

2.1 Gamification in education

Gamification engages and motivates users by using game design elements in non-game contexts. Gamification in education uses game design to motivate and engage students [4]. It has been frequently used in the field of science education, offering various

learning options [5]. Simulation and gamification improve social science education and are expected to continue [6]. Gamification is used in formal and informal e-learning [7]. E-learning platforms are used to deliver and learn in higher education [8]. Gamification can motivate and improve math learning [9]. In pharmacy education, gamification has been increasingly applied, applying game attributes to non-game contexts [10].

2.2 Theoretical foundations and gamification models

Gamification in education literature reviews various theoretical foundations and models. Kim & Lee [11] propose a dynamic model for gamifying learning that maximizes educational effectiveness by incorporating curiosity, challenge, fantasy, and control. Altukhova et al. [12] examines the “gamification of education” concept. The use of gamification in mathematics education is addressed in the study by [9]. Khalil et al. [13] emphasize that MOOC gamification research is still in its infancy. According to a systematic literature review [8], gamification in higher education reduces learner distraction and increases student engagement. Bigdeli (2023) reviews medical education gamification learning theories. Gamification and simulation are fun social science teaching methods [6]. Stoichkova [14] suggests using Kahoot to create customized educational materials and improve students' skills.

2.3 The role of artificial intelligence in education and assessment

Recently, AI in education and assessment has garnered attention. AI can improve education quality, practical learning and teaching methods, and assessment methods [15]. AI systems, including chatbots, are helping students with personalized feedback and support [16]. Online assessment AI models like ChatGPT generate human-like responses [17]. AI in education raises ethical issues, but it is seen as a development opportunity [18]. However, it is important to consider the challenges and problems that may arise with AI in education and find solutions. AI can personalize teaching, provide immediate feedback, and automate administrative tasks, transforming higher education [19]. In order to build a GLAR model that predicts student grades in hybrid online learning situations, Kanetaki et al. [20] identified and quantified the main factors affecting mechanical engineering student performance. An investigation was conducted into an automated answer scoring method that combines machine learning techniques with automatic natural language processing to produce a quick, scalable, and accurate result [21].

2.4 Integrating gamification and artificial intelligence in education

Gamification's engagement benefits and AI's personalized, adaptive learning potential are combined in education. AI in gamification can enhance and personalize learning, improving student engagement and outcomes [22]. Oliveira et al. [23] suggest using AI in gamified education to analyze student behavior and personalize learning. In gamified environments, AI can monitor and adapt to student responses to support adaptive learning. However, data privacy and infrastructure issues arise when integrating AI into gamified education systems [24]. Despite these challenges, AI and gamification can create engaging, personalized, and effective learning environments [25]. However, more research from Europe and Western countries is needed to better understand this field.

2.5 Automatic question generation for educational purposes

AQG generates questions from text using natural language processing and machine learning. AQG can create quizzes, tests, and study materials. AQG saves educators time and gives students immediate feedback [22]. AQG can generate low-quality questions and requires human oversight to ensure accuracy and relevance.

Educational question generation was automated to reduce costs [23].

Das et al. [24] create multiple-choice tests with distractors. The system selects informative sentences using topic-words or keywords. Answer key: best sentence keyword. The system removes the answer key (stem) to make this sentence a question. A template-based approach can generate high-quality and useful true/false questions from a passage for reading comprehension tests [25].

Automatic question generation is crucial in intelligent tutoring systems [26]. Automatic question generation helps teachers match question relevance and complexity to learning objectives. Alshboul & Baksa-Varga [27] reviewed theoretical AQG techniques for computer programming languages from 2017 to 2022.

3 METHODOLOGY

This paper investigates the potential for gamification to improve K-12 students' assessment engagement and learning outcomes. Specifically, we examine how gamification, through the use of automatically generated multiple-choice questions (MCQs) with a Moodle plugin [26] as shown in Figure 1, can make assessment more engaging and addictive for K12 students, while leveraging the testing effect to improve learning outcomes. Our research question is whether a gamified assessment approach is more effective than a traditional assessment approach at boosting student engagement and motivation while simultaneously improving learning outcomes.

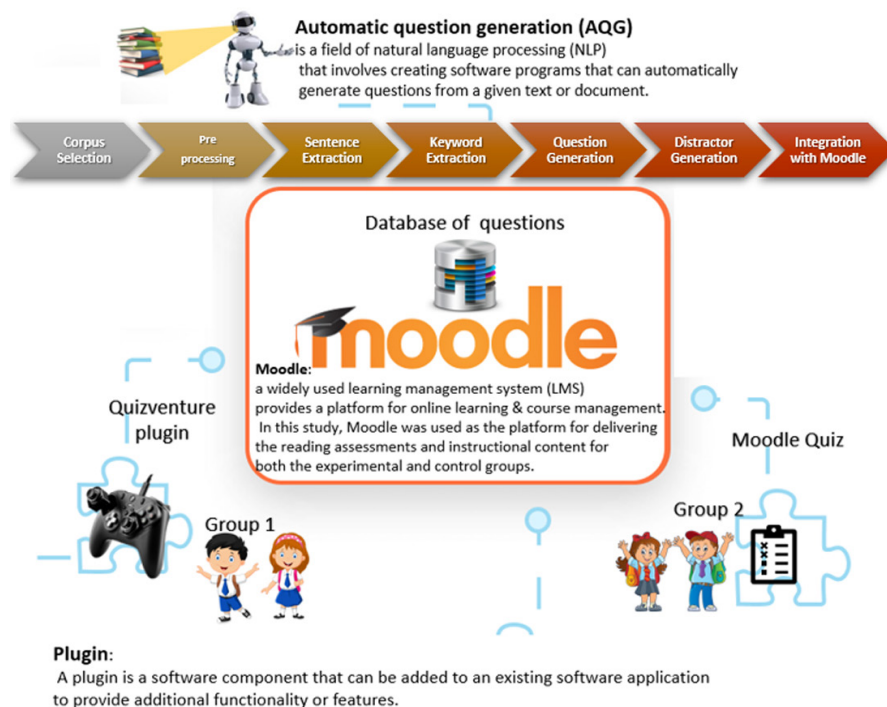


Fig. 1. Architecture of the system used

3.1 Automatic question generation method

The purpose of AQG is to generate relevant and meaningful questions automatically based on the content of a given text. The questions generated should be grammatically correct and capable of testing the reader's comprehension of the text [27].

Using a fine-tuned text-to-text model for automatic question generation in our study offers three key advantages over using APIs like OpenAI's or Google's. Firstly, it offers adaptability, enabling the model to generate questions that accurately reflect the unique content and context of a specific MOOC. Secondly, it provides more control over the question generation process, including the ability to influence question quality and difficulty. Lastly, it's cost-effective, as once the model is fine-tuned, it can be used indefinitely without incurring additional usage costs as opposed to APIs.

Selecting a corpus, preprocessing the corpus, extracting relevant sentences and keywords, applying machine learning models to generate questions and distractors, and integrating the generated questions with Moodle are all components of the methodology for generating questions for Moodle using automatic question generation. By leveraging NLP techniques and machine learning models, it is possible to generate high-quality questions that test the learner's comprehension of the text's key concepts and ideas; gamification integration in the system provides a more engaging and interactive learning experience.

Corpus selection. The first stage is to decide on a collection of texts that will serve as the basis for the questions that will be asked. A textbook, a series of articles, or a group of lectures all qualify as appropriate texts for classroom use.

Preprocessing. After a suitable corpus has been chosen, it must be preprocessed in order to draw out the necessary data. Tokenization, part-of-speech tagging, and dependency parsing are all part of this process, which aims to extract the most important ideas and connections from the text.

Sentence extraction. The next step is to extract sentences containing the most important ideas and connections from the preprocessed corpus. To do this, we must first determine which phrases provide the most useful information from which questions can be derived.

Keyword extraction. The next stage, following the selection of relevant sentences, is to extract keywords or phrases that capture the most vital information in the text. Various techniques, such as named entity recognition, keyword extraction, and topic modeling, can be utilized for this purpose. We used a classifier based on quadratic discriminant analysis to determine if the keyword is an answer [26].

Question generation. Following the selection of pertinent sentences and keywords, machine learning models, such as transformer-based models, are employed. The learner's comprehension is assessed by means of questions generated by these models, which take as input the selected phrases and keywords. To automate the process of question generation from a set of phrases and a desired response, an attention model was implemented using transformers as seen in Figure 2.

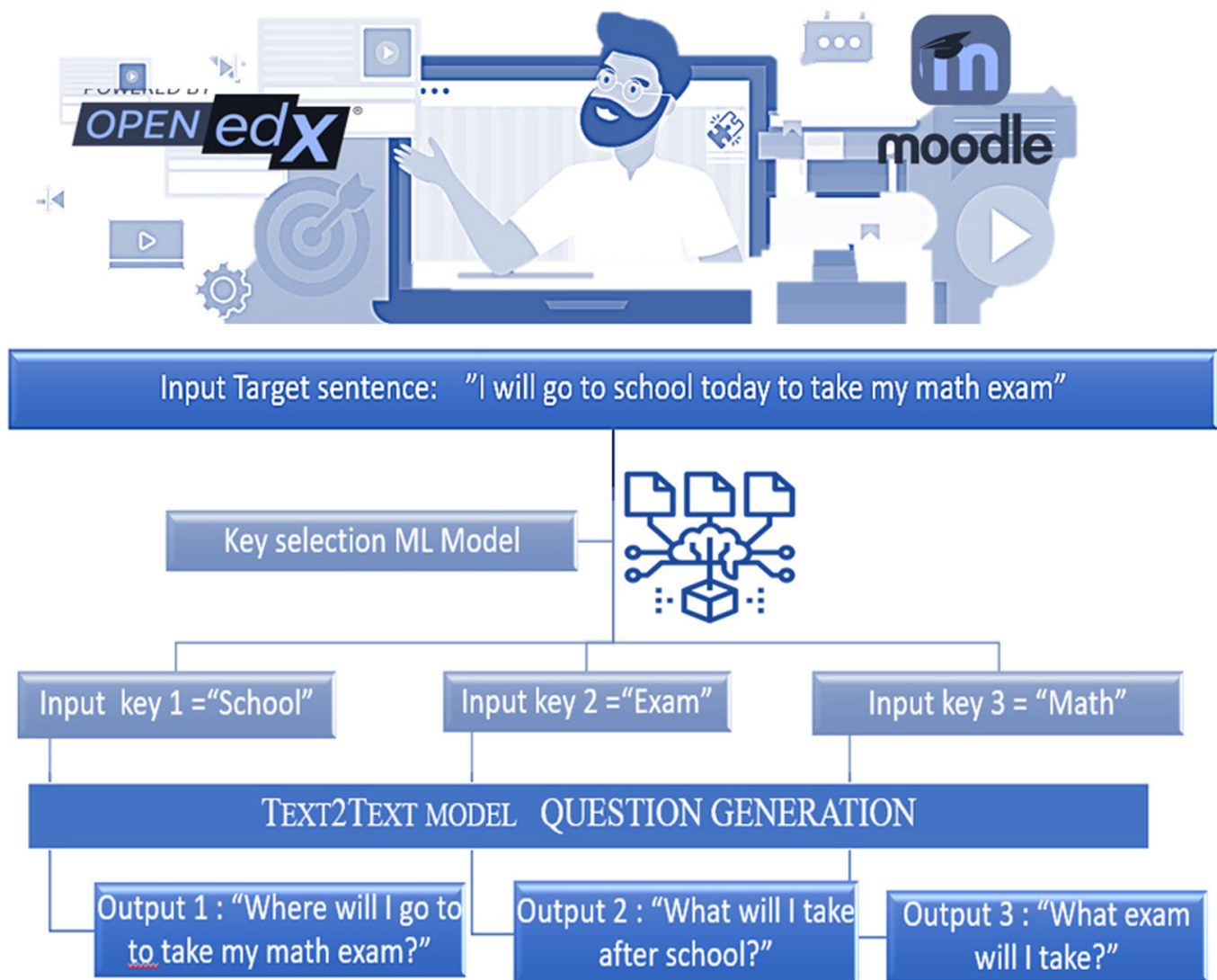


Fig. 2. Example of questions generated by the text2text model

Distractor generation. In addition to generating questions, it is necessary to generate distractors to make the queries more difficult. Distractors are typically generated using techniques such as generation based on similarity or generation based on rules. This involves identifying plausible erroneous answer choices that resemble the correct answer but are incorrect.

Integration with Moodle. As shown in Figure 3, we designed a Moodle plugin block capable of creating questions from any given text. This plugin harnesses the power of Moodle’s question bank, facilitating the storage and organization of the generated questions within the Moodle educational management system.

The procedure starts when a text is fed into the plugin block. The plugin then examines the text and formulates multiple-choice questions based on the content. These questions are automatically deposited in the Moodle question bank, making them immediately accessible for use in quizzes and evaluations.

To enrich the learning experience and incorporate gamification aspects, we integrated QuizVentor with the Moodle plugin. QuizVentor is a tool that introduces gamification to Moodle quizzes, empowering teachers to weave game-like elements into their assessments.

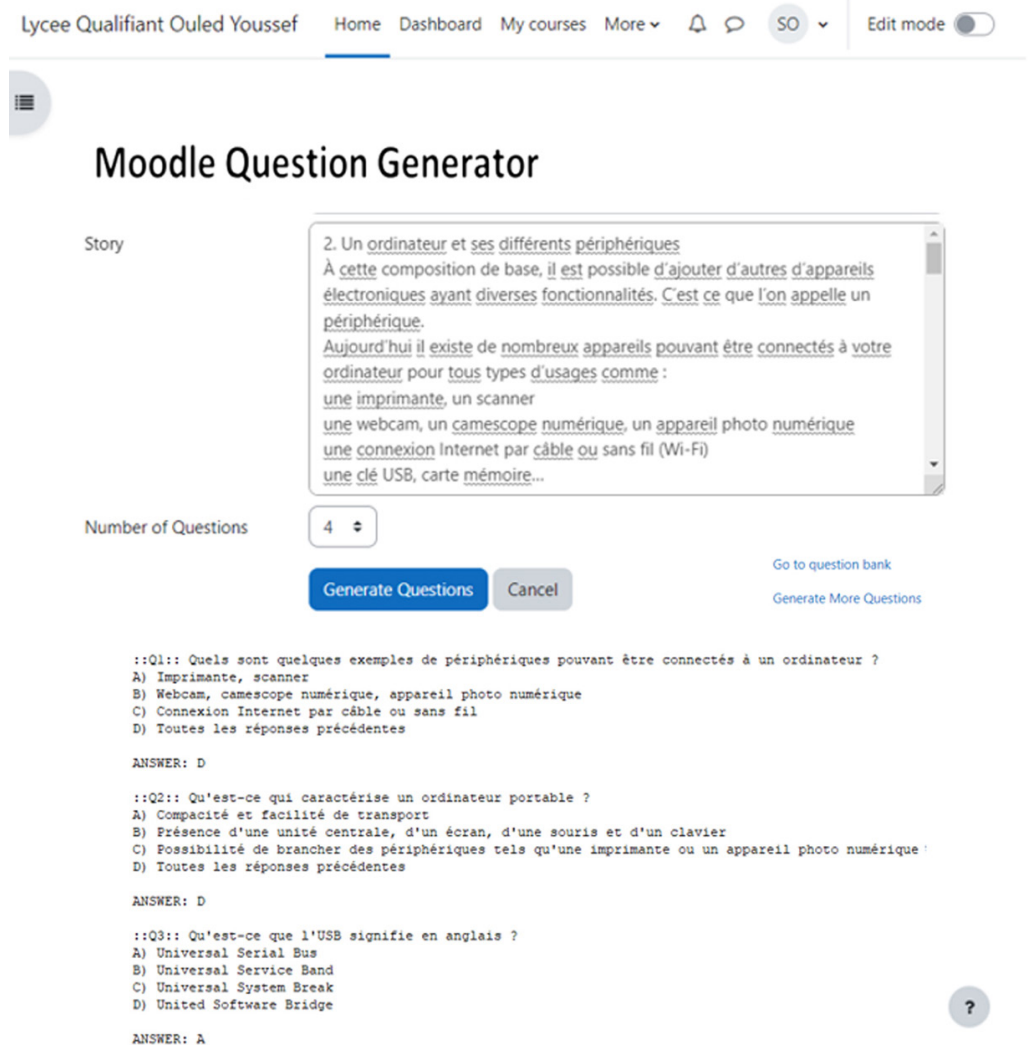


Fig. 3. Moodle question generator

By fusing the question generation feature of our Moodle plugin with the gamification attributes offered by QuizVenton, we aspire to craft an engaging and interactive learning atmosphere for students. This integration empowers instructors to exploit the advantages of automatic question generation while amplifying student motivation and engagement through gamified quizzes.

3.2 Gamification in moodle

Gaming features and mechanisms are used to engage students in learning. Moodle quizzes, activities, and materials can be gamified.

Gamified Moodle courses award points, badges, and awards for tasks and evaluations. Users can level up or earn rewards. These features can make students feel competitive, hard-working, and successful, encouraging them to study.

Simulations and interactive media can make learning more immersive with gamification. In a history class, a simulation can replicate an event so students can try different outcomes and learn by trial and error.

Gamification in Moodle can improve students' learning experience by appealing to their desire for accomplishment, feedback, and social interaction [29].

Quizventure, a Moodle plugin, lets students create game-based quizzes and learning activities [30]. Quizventure turns Moodle quizzes into interactive games that make learning fun.

Quizventure has multiple-choice, matching, and image-based game templates. Change the game's time limit, lives, and scoring system.

The plugin offers levels, achievements, and badges for game-based learning. Quizzes and badges help students progress through levels.

Quizventure's reporting dashboard tracks student progress and performance. Individual student reports and class-wide quiz completion and success rates are available. Quizventure is an excellent tool for gamifying your Moodle quizzes and making your students' learning more engaging and interactive.

3.3 Setting up experiments

We conducted a qualitative survey-based investigation to determine the efficiency of gamification in improving assessment engagement and learning outcomes among K-12 students. A single K-12 school with 100 fifth graders participated in the study.

There were two groups in the study: a gamified assessment group and a traditional assessment group. The gamified assessment group consisted of 50 students who completed a gamified assessment using automatically generated MCQs with a Moodle plugin [15], while the traditional assessment group consisted of 50 students who completed a traditional assessment without gamification as shown in Figure 4.

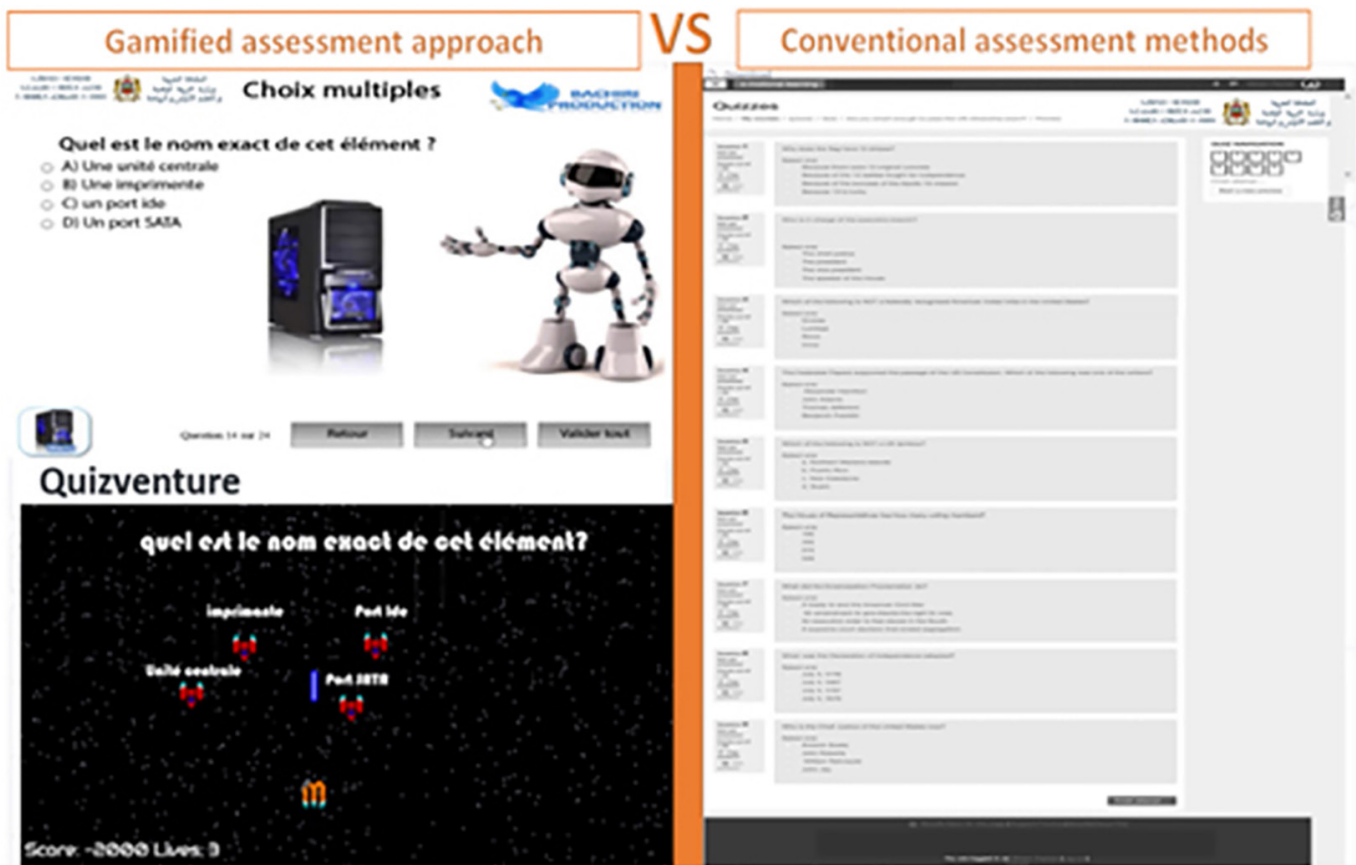


Fig. 4. Gamified assessment versus traditional assessment

3.4 Procedure

The study was carried out over a period of three weeks. In the first week, both groups were given pre-tests. Over the next two weeks, the two groups were taught the same content but were assessed using different methods. The gamified group underwent assessments using the AQG method integrated with the gamified Moodle platform, while the traditional group underwent traditional assessments. At the end of the third week, post-tests were conducted. Then, we administered a questionnaire to both groups to collect their feedback on the assessment experience. In addition to their perceptions of their own learning outcomes, the survey inquired about their engagement, motivation, and satisfaction with the assessment.

3.5 Data analysis

Data were analyzed using descriptive and inferential statistics. Descriptive statistics, including mean, standard deviation, and frequencies, were calculated for demographic data, test scores, and survey responses. Independent samples t-tests were conducted to compare the pre-test and post-test scores between the gamified and traditional assessment groups. The effect size was calculated using Cohen's *d*.

Statistical analysis was carried out using the Statistical Package for the Social Sciences (SPSS) version 26. The level of statistical significance was set at $p < 0.05$. All data were checked for assumptions of normality and homogeneity of variance before conducting the t-tests.

4 FINDINGS AND DISCUSSION

This study explored the potential for gamification to improve K-12 students' assessment engagement and learning outcomes. The results of our randomized controlled trial demonstrated that the gamified assessment strategy significantly increased student engagement and motivation, as well as learning outcomes, as measured by test scores and retention. The responses to the survey also indicate that the gamified assessment approach resulted in greater levels of engagement, motivation, and perceived learning outcomes than the traditional assessment approach.

4.1 Demographics

The demographic characteristics of the participants in the gamified assessment and traditional assessment groups are shown in Table 1. Each group had 50 students, as shown in the table. The gender distribution in both groups was similar, with slightly more males in the gamified assessment group (26) than in the traditional assessment group (28). The mean age was similar in both groups, with the gamified assessment group having a slightly higher mean age (10.6 years) than the traditional assessment group (10.5 years).

Table 1. Demographic characteristics of participants in game-based and traditional evaluation groups

Characteristics	Gamified Assessment Group (n = 50)	Traditional Assessment Group (n = 50)
Gender (male/female)	26/24	28/22
Age (years)	Mean (SD) 10.6 (0.3)	Mean (SD) 10.5 (0.4)
Grade level	5th grade (100%)	5th grade (100%)

Furthermore, both groups were made up entirely of fifth-grade students, ensuring that any differences in performance between groups can be attributed to the type of assessment used rather than grade level or age. This information is critical to include in the paper in order to demonstrate that the study groups were well-matched and that any observed differences in outcomes between groups can be attributed to the intervention rather than demographic factors.

4.2 Engagement and motivation

Responses to the student engagement and motivation survey (see Table 2) were overwhelmingly in favor of the gamified assessment approach. A significant majority (92%) reported finding the gamified assessments engaging and fun compared to less than half (48%) for traditional assessments. Similar trends were seen in terms of motivation, where 89% of students in the gamified group felt motivated to do their best compared to 54% in the traditional group. These findings clearly indicate the potential of gamification to boost student engagement and motivation, a critical aspect of successful learning and retention.

Table 2. Student responses to survey on commitment and motivation

Survey Questions	Gamified Assessment Approach	Traditional Assessment Approach
I found the assessments engaging and fun.	92%	48%
I felt motivated to do my best on the tests.	89%	54%
I would like to take more assessments like this.	94%	38%
I enjoyed the rewards and feedback in the gamified assessment.	87%	N/A
I felt challenged by the gamified assessment.	81%	N/A
I found the traditional assessment boring.	N/A	63%

4.3 Perceived learning outcomes

Perceived learning outcomes, as depicted in Figure 5, were also significantly more positive in the gamified group. The gamified approach was associated with increased learning (84% versus 48%), improved memory retention (78% versus 42%), and a significant boost in confidence (81% versus 49%). This suggests that gamification not only improves the learning process but also enhances students' confidence and perceived mastery of the material, an essential aspect of student-centered learning.

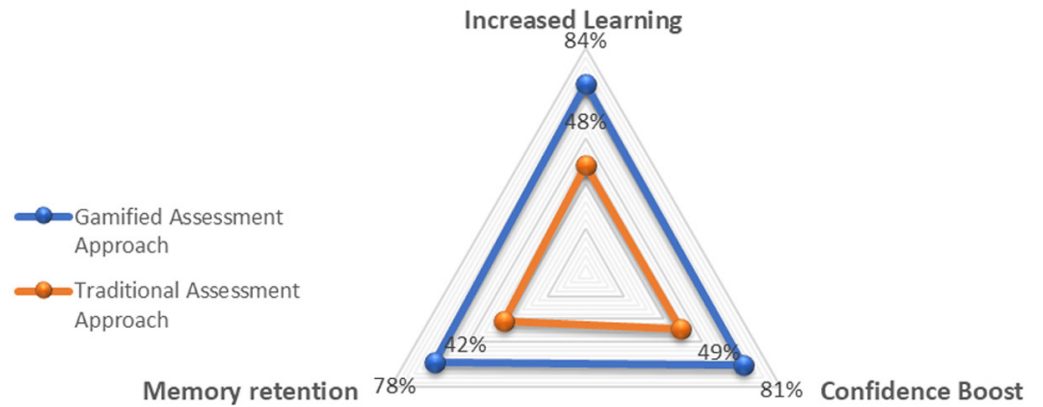


Fig. 5. Survey results on perceived learning outcomes

4.4 Comparison of test scores

A comparison of pre-test and post-test scores (see Table 3) provided objective evidence supporting the perceived learning outcomes. The gamified assessment group exhibited a larger average improvement (21.1%) than the traditional assessment group (8.8%). This demonstrates that the fun and engaging nature of gamified assessments does not compromise, but rather enhances, academic performance.

Table 3. Comparison of test scores between gamified and traditional assessment groups

Test Type	Gamified Assessment Group (Mean ± SD)	Traditional Assessment Group (Mean ± SD)
Pre-Test Scores	70.5 ± 7.8	70.1 ± 8.2
Post-Test Scores	85.4 ± 5.6	76.3 ± 7.9
Score Improvement	21.1%	8.8%

4.5 Discussion

In our research, we decided to use a fine-tuned text2text model [15] over the APIs provided by OpenAI or Google due to its greater customization potential and cost-efficiency [28]. The fine-tuned text2text model allowed us to train the model on our specific dataset, enhancing its performance and relevance to our research context. This not only improved the quality of the automatically generated questions but also increased the overall effectiveness of the gamified assessments. Additionally, utilizing our own model helped us avoid the recurring costs associated with API-based services, making it a more economical choice for long-term research.

The findings of this study suggest that gamification has the potential to significantly improve K-12 students’ engagement, motivation, and learning outcomes. Our randomized controlled trial showed that students who used the gamified assessment approach reported higher levels of engagement, motivation, and perceived learning outcomes than those who used the traditional assessment approach. This has also been confirmed in previous studies [29–31].

As reported in [26], both evaluations showed that this system’s machine-generated questions evaluated skills and similarity as well as human-created questions.

The results also show that the new technology improves e-assessment for up to 82% of the questions.

Specifically, the survey results indicated that the gamified assessment approach was more engaging and fun for students, with 92% of students reporting that they found the assessments engaging and fun compared to only 48% in the traditional assessment group. The inclusion of game elements in the gamified assessment approach also appeared to challenge and motivate students, with 81% reporting feeling challenged compared to the traditional assessment approach.

Moreover, the gamified assessment approach was found to be effective in promoting students' perceived learning outcomes, with 84% reporting that they learned more from the assessments compared to only 48% in the traditional assessment group. Additionally, 78% of students in the gamified assessment group remembered more from the assessments compared to 42% in the traditional assessment group.

The demographic characteristics of the participants in both groups were well-matched, which suggests that any observed differences in outcomes can be attributed to the intervention rather than demographic factors. Moreover, the fact that both groups consisted of fifth-grade students ensures that any observed differences in outcomes can be attributed to the assessment approach rather than grade level or age.

The findings of this study have significant implications for K-12 educators who want to improve assessment effectiveness and student learning outcomes. By incorporating game elements into assessments, educators may be able to increase student engagement, motivation, and learning outcomes [32,33]. Additionally, alternative assessment approaches, such as gamification, should be considered to improve learning outcomes, especially for students who struggle with traditional assessment methods.

However, there are some limitations to this study that should be acknowledged. First, the study only included fifth-grade students, which limits the generalizability of the findings to other grade levels. Second, the study was conducted in one school, which may limit the generalizability of the findings to other schools. Third, the study only examined short-term outcomes, and it is unclear if the effects of the gamified assessment approach are sustainable over time.

In conclusion, this study suggests that gamification has the potential to improve K-12 students' engagement, motivation, and learning outcomes. The findings of this study have important implications for K-12 educators who are seeking to improve assessment effectiveness and student learning outcomes. Future research is needed to examine the long-term effects of gamification on student learning outcomes and to explore the effects of gamification across different grade levels and educational contexts.

4.6 Challenges, limitations and future work

During the study, we encountered a few challenges. The main challenge was ensuring that the gamified elements did not distract from the learning process. To overcome this, we carefully designed the gamified elements to be engaging but not overly distracting. We also provided clear instructions to the students on how to use the gamified elements to enhance their learning.

Additionally, while our current system focuses on automatically generating questions and gamifying assessments, there is potential to extend it further using AI for automated analysis of pain and feelings during assessments. As discussed in [34–36], techniques like facial expression recognition could allow for real-time adaptation

of the assessment based on students' affective states. Integrating such capabilities poses technological and ethical challenges, but represents a promising direction for creating intelligent, emotionally aware assessment systems.

The study has some limitations worth noting. First, it was conducted in a single grade level, limiting generalizability. Second, it relied on self-reported engagement measures which can involve bias. Third, long-term impacts were not analyzed. Further research should address these limitations by including multi-grade samples, objective metrics, and longitudinal data.

5 CONCLUSIONS

This study investigated whether a gamified assessment approach, utilizing automatic question generation, could enhance student engagement and learning outcomes compared to traditional assessments. The results clearly demonstrate the effectiveness of gamification in transforming the assessment experience.

Specifically, the randomized controlled trial revealed that the gamified assessment group reported higher engagement, motivation, perceived learning gains, and memory retention of the material. Additionally, this group showed a significantly larger improvement in academic scores from pre to post-test compared to the traditional assessment group.

These findings provide compelling evidence that incorporating game elements and automatically generated questions can make assessments more enjoyable and impactful for learning. By leveraging engagement and the psychological “testing effect”, gamification improves not just the assessment process, but also students' mastery and retention of knowledge.

However, some limitations exist in the study's scope and methodology. As discussed earlier, the convenience sampling and single grade level affect generalizability. Nevertheless, within its defined context, the study offers valuable insights and recommendations for adopting alternative assessment strategies.

In conclusion, this research makes key contributions in underpinning the potential of gamification and AQG to redefine assessment experiences, promoting engagement, motivation and learning gains. The results have profound implications for the integration of these technologies into future assessment design. Further research can build on these results by extending the study to other educational contexts.

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