Comparing Learning Outcomes in Traditional and Gamified Lecture Formats

Sylwia Babicz

Gdańsk University of Technology Faculty of Electronics, Poland

Abstract

This paper presents a comparative study of student learning outcomes achieved through two distinct approaches to lecture-based education in a technical university setting. The first group of students participated in traditional lectures and completed a final written test as their primary method of assessment. The second group experienced a gamified lecture format, which incorporated elements of educational gamification and required students to regularly complete homework assignments. These assignments were made available in limited time windows following each lecture topic, encouraging continuous engagement with the material and timely knowledge consolidation.

The study analyzes and contrasts the final performance of both student groups, focusing not only on their overall grades but also on the types and frequencies of errors committed. By identifying recurring mistakes and patterns in students' reasoning, the analysis provides deeper insight into the cognitive processes involved in both forms of learning. The evaluation includes qualitative and quantitative data derived from student submissions, enabling a nuanced comparison of how the two educational approaches affect knowledge retention, conceptual understanding, and problem-solving skills.

Preliminary results indicate that students engaged in the gamified format with regular homework opportunities demonstrated a higher consistency in mastering individual topics and made fewer conceptual errors on average. In contrast, students who followed the traditional model showed a tendency to forget or misunderstand foundational topics by the time of the final assessment. The error analysis suggests that continuous interaction with the course content, combined with a game-like structure that fosters motivation and accountability, significantly contributes to better learning outcomes.

The paper concludes with a discussion on the implications of these findings for the design of future university courses. It emphasizes the importance of timely feedback, student motivation, and ongoing assessment in enhancing the effectiveness of lecture-based teaching. The results support the growing body of evidence favoring active and engaging learning strategies over conventional lecture-and-exam formats.

Keywords: *academic teaching, gamification, lecture, metrology*

1. Introduction

In response to growing challenges related to student engagement and long-term knowledge retention, the lecture format of the Metrology course at Gdańsk University of Technology underwent a significant transformation. Traditionally, the course was assessed through a single, summative written online-test held at the end of the lecture series. However, this format posed logistical difficulties: each of the 26 student groups required a separate exam session scheduled in accordance with their individual timetables, which demanded extensive coordination. Additionally, academic staff had to supervise each group during the test, resulting in a significant time commitment [1].
Moreover, this approach often led to short-term memorization and superficial understanding, as students typically engaged with the material only shortly before the exam [2]. This proved insufficient, particularly considering the foundational knowledge required in laboratory classes conducted in the following semester.
To address these issues, a gamified structure [3] was introduced in the academic year 2024/2025. Students were offered an alternative path to course completion by participating in an educational game titled "The Metrological Adventures of Gabryś", named after a real campus cat known to the

university community. The game-based format is built around two main phases [4]: the Feeding Phase, which tests basic theoretical knowledge after each lecture, and the Care Phase, which challenges students with more advanced, application-oriented tasks.
The new format encourages systematic learning through the regular release of assignments and rewards students for both accuracy and consistency [5]. Tasks range from standard quizzes to exercises that involve reading and interpreting technical datasheets, device manuals, and industry literature [6]. Students earn points — referred to as "cans" and "veterinary vouchers" in the narrative — based on their performance, which not only contribute to their final grade but also simulate caring for the fictionalized version of Gabryś.
This paper compares the educational outcomes of two student cohorts: one that completed the course in the traditional format, and one that participated in the gamified version. The goal is to assess the impact of gamification on student performance, engagement, and the effectiveness of knowledge acquisition.

1.1 Structure and Mechanics of The Gamified Learning Format

After each lecture covering a specific topic, students have approximately two weeks to complete a corresponding assignment in the Moodle system. Each assignment consists of two parts: the Feeding Phase and the Care Phase [7]. In the Feeding Phase, students complete a quiz designed to test their understanding of fundamental, essential concepts. Successful completion of this phase is mandatory in order to unlock the Care Phase (Fig. 1).

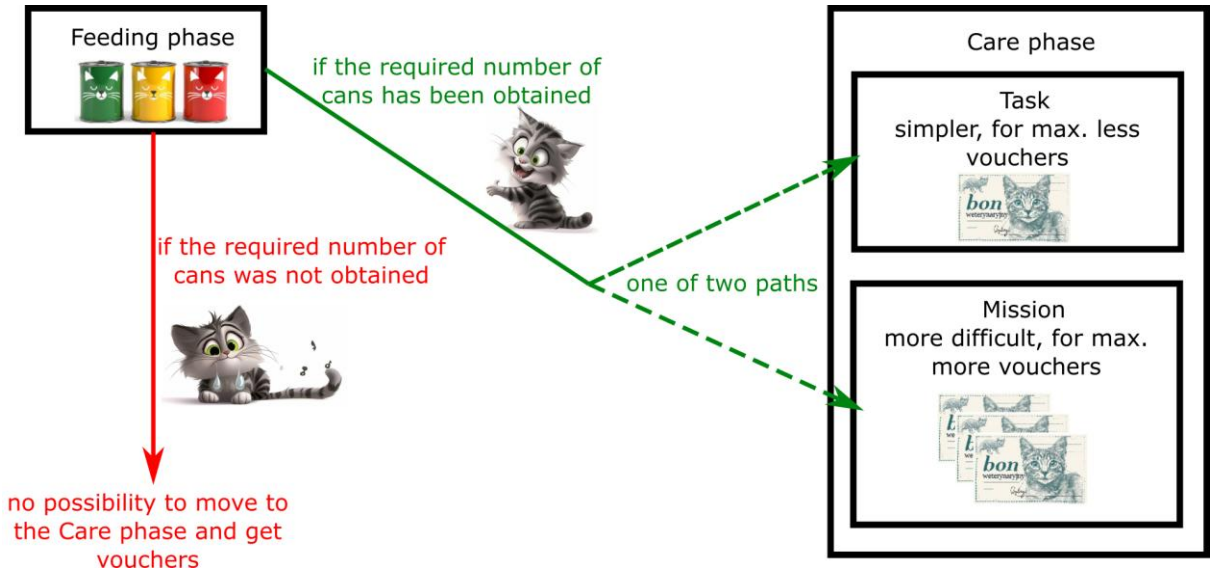

Fig. 1 The scheme of the game

The Care Phase presents more challenging tasks focused on the application and practical interpretation of the material discussed in class. In this phase, students are given the freedom to choose between two paths depending on their confidence, skills, and interests: a simpler test that awards fewer points, or a more difficult mission-like task that offers the potential — but not the guarantee — of earning more points [8]. The more advanced tasks often involve analysis of technical datasheets, real-world measurement scenarios or the interpretation of professional literature.
Student performance is assessed cumulatively. The final grade is determined based on the total number of points collected throughout the game, with each task contributing to the overall score. This structure not only promotes regular engagement with the course content but also gives students autonomy in managing their learning process. It accommodates different learning styles and levels of preparedness, while encouraging both mastery of basic knowledge and the development of problem-solving and analytical skills.

1.2 Traditional Assessment Format: Test

Before the implementation of the gamified approach, student learning outcomes in the Metrology course were assessed through a traditional test. This test consisted of twenty multiple-choice questions, each graded using an all-or-nothing principle. In order to receive a point for a given question, the student had to select the exact correct combination of answers. Partial correctness was not awarded: marking only some of the correct options, or including even a single incorrect choice, resulted in zero points for that question.
This strict scoring policy was intentionally designed to reduce the influence of guesswork and encourage precision in responses. It minimized the chance of gaining points through accidental selections and emphasized the importance of complete and accurate knowledge. While the format ensured objective grading and high standards, it also placed significant pressure on students and did not necessarily encourage regular study habits or deep understanding of the material. As such, it became one of the motivations for developing a more engaging and flexible system of evaluation through gamification.
Additionally, the questions included in the traditional test were purely theoretical and did not require any calculations. This limitation stemmed from the challenges associated with providing a controlled environment for performing computations. In order to maintain the integrity of the assessment and ensure that students completed the test independently, instructors opted to exclude tasks that would require the use of calculators or reference materials. The concern was that allowing such tools could increase the risk of violating academic honesty policies, especially given the scale of the course and the large number of students being examined simultaneously. While this approach simplified supervision and preserved fairness, it also restricted the scope of knowledge being assessed, as students were not given the opportunity to demonstrate practical skills or apply theoretical knowledge in problem-solving contexts.

2. Analyzing Assessment Question Types

One of the essential roles of a university teacher — alongside inspiring students and delivering subject knowledge — is the verification of learning outcomes. Effective teaching does not end with the transmission of information; it also requires assessing whether students have understood, internalized, and are able to apply the acquired knowledge and skills. This evaluative function is crucial for maintaining academic standards, guiding student progress, and ensuring that the educational goals of the course and curriculum are being met. A well-designed assessment strategy allows instructors not only to measure student performance but also to identify areas where additional support or instruction may be needed. Thus, the role of the academic teacher extends beyond content delivery to include responsibility for designing meaningful, fair, and pedagogically sound methods of evaluation.
In the process of verifying learning outcomes, the form of assessment and the types of questions used play a crucial role. The way students are evaluated has a direct impact on their approach to learning, the depth of their engagement, and ultimately the knowledge and skills they retain. Assessment can take various forms, depending on the nature of the subject, the level of advancement, and the intended learning objectives. These forms include traditional end-of-course written tests, periodic quizzes, homework assignments, as well as more complex formats such as projects or case studies. Oral assessments, including structured responses and student presentations, are also commonly used, especially when evaluating communication skills and the ability to synthesize and explain concepts. Each of these methods supports different aspects of the learning process and offers unique insights into student achievement. Therefore, selecting the appropriate format and question type is essential to ensure that assessment is both fair and aligned with the educational goals of the course.
In addition to fulfilling intended educational goals, any method of verifying learning outcomes must also take into account the practical conditions under which the assessment is conducted. These conditions include the level of advancement of the students — whether they are in the early or more advanced stages of their studies — as well as the size of the group and the available logistical resources. While it is entirely feasible to assess a small group of students through oral examinations, in-depth questioning, case study discussions, or presentations, such methods become highly impractical when dealing with large groups, such as classes of 300 students.
In large-scale teaching scenarios, the time and staffing requirements for conducting individual assessments or open-ended evaluations grow significantly. Moreover, in an increasingly digital academic environment, reviewing handwritten work from hundreds of students — especially at a time when legible, structured handwriting is no longer a given — poses additional challenges for instructors. These constraints highlight the importance of selecting assessment formats that are not

only pedagogically effective but also administratively manageable, scalable, and adapted to the realities of contemporary higher education.

Due to the large number of students enrolled in the Metrology course at the Faculty of Electronics, Telecommunications and Informatics at Gdańsk University of Technology — approximately 700 each year — the instructors have never opted for open-ended assessments, whether oral or written. Managing such a volume of students using individualized, subjective evaluation methods would be logistically unfeasible and extremely time-consuming.

With the widespread adoption of the Moodle platform, the assessment process gradually transitioned from an analog (paper-based) format to a digital one. Instead of solving tests on paper, students began completing them online through dedicated e-learning modules. This shift brought several advantages: most notably, students now receive immediate feedback in the form of scores or grades as soon as they complete a test [9, 10]. This real-time response helps students better understand their performance and promotes transparency in the evaluation process.

On the logistical side, however, the change also introduced new constraints. Conducting three test sessions in a large lecture hall was already a challenge — but administering around 50 sessions in smaller computer labs (due to group size limitations and the need for adequate supervision) required substantial time and coordination. Despite these efforts, the shift to Moodle-based testing ultimately enabled more efficient exam administration, while maintaining the consistency and integrity of the assessment process across a very large student population.

Thanks to the capabilities of the Moodle platform and the shift toward gamification — implemented primarily through structured homework assignments — course instructors gained the opportunity to move beyond the constraints of traditional multiple-choice testing and explore a wider range of question types. This transition allowed them to shift the focus from mere fact recall to the development and assessment of more complex cognitive skills.

In the gamified format, instructors could design questions and tasks that not only tested factual knowledge but also required students to perform calculations, interpret technical content, and extract information from various sources, such as measurement equipment manuals, scientific articles, or electronic component datasheets. These types of tasks engaged students in deeper learning processes and mirrored real-world engineering scenarios more closely than standard theoretical tests.

By diversifying assessment formats, the instructors were able to emphasize skills such as critical thinking, practical application of theoretical knowledge, problem-solving, and the interpretation of technical data — all of which are essential for engineering practice. The flexibility of the Moodle environment supported the creation of interactive tasks, including numerical input, drag-and-drop, short answer, and matching formats, which allowed students to actively engage with the material. This multidimensional approach not only enriched the learning experience but also created opportunities for students to practice competencies that are highly valued in both academic and professional settings.

3. Learning Outcomes Before and After Gamification

To explore the impact of gamification on student achievement, we conducted a comparative analysis of learning outcomes from two consecutive academic years. The first cohort (2023/2024) completed the Metrology course using the traditional model, where assessment was based solely on a single multiple-choice end-of-course test. The second cohort (2024/2025) participated in the newly implemented gamified system, in which students completed topic-based assignments over several weeks, earning points through regular engagement.

The gamified version was piloted in the winter semester with a group of 60 part-time Computer Science students. Out of this group, 58 students (96.7%) passed the course through gamified assignments, while only 2 students (3.3%) chose exam in the traditional format.

In order to ensure a fair comparison, only the theoretical questions from the gamified format were included in the analysis. This decision was made because the traditional exam consisted exclusively of theoretical, fact-based questions that did not require calculations or application-oriented reasoning. In both assessment formats, the question type was designed to minimize the possibility of guessing correct answers: students were required to select the exact set of correct responses, and any omission or inclusion of incorrect options resulted in no points being awarded.

This methodological consistency allowed for a meaningful comparison of students' theoretical knowledge retention and understanding across both formats. By isolating the theoretical component in the gamified group, we aimed to assess not the overall success of the game as a whole, but specifically whether the shift in structure and engagement affected students' mastery of core

theoretical concepts. The analysis provided insights into how the new format may have influenced learning outcomes in terms of accuracy, retention, and pass rates for foundational material.
Table 1 presents a comparison of the percentage of incorrect answers given by students from two academic years: 2023/2024 (traditional end-of-course test) and 2024/2025 (gamified assessment format). To ensure comparability, the analysis focused solely on theoretical questions, as these were the only type used in the traditional format. Although students in the gamified cohort had access to supporting materials — including lecture content, online resources, and industry publications — this was not considered a limitation. On the contrary, this open-resource approach reflected a deliberate pedagogical shift toward developing students' ability to locate, interpret, and apply information within a specialized context.

Topic	**2023/2024**	**2024/2025**
Error theory	28	25
Multimeters	42	26
Oscilloscopes	23	20
Time, frequency and phase measurements	25	21
Direct/alternating voltages	33	28
Converters	35	30
RLC and non-electrical measurements	26	24

Table 1. Comparison of Error Rates (%) on theoretical questions between academic years 2023/2024 and 2024/2025

The results reveal a consistent decrease in error rates across all topics for the gamified group. For instance, in the topic of *Multimeters*, the error rate dropped from 42% to 26%. Similarly, in *Error theory*, it declined from 28% to 25%, and in *RLC and non-electrical measurements*, from 26% to 24%. While the differences may seem modest — typically ranging from 2 to 16 percentage points — they suggest an overall improvement in content comprehension and exam readiness.
These findings are particularly meaningful given the time-constrained nature of the quizzes in the gamified format. Students had only 10 to 20 minutes to complete each test, which meant that relying solely on external materials without prior understanding of their structure and content would not have been effective. The observed performance therefore indicates not just better access to information, but also stronger familiarity with the course material and improved information retrieval strategies — skills that align well with modern engineering competencies.

4. From Memorization to Information Literacy

It is important to note that students completing theoretical questions in the gamified format were allowed to use all available resources during their assignments. This included not only lecture materials and instructor-provided resources, but also internet-based content and external publications. The course instructors were fully aware of this practice and, in fact, welcomed it as an intentional component of the reformed teaching strategy. In today's educational landscape — and particularly in engineering disciplines — the ability to locate, verify, and apply reliable information is more valuable than rote memorization. By allowing access to resources, the course aimed to support the development of information literacy and critical evaluation skills that are essential in modern, information-rich workplaces.
It is also worth noting that every field, including metrology, contains nuanced terminology and exceptions to general rules. Students were informed that terms commonly used in everyday scientific contexts might carry distinct meanings within metrology. As such, success in answering the questions required consulting materials that were embedded specifically in the context of this scientific discipline. Relying on generic internet sources without a solid understanding of domain-specific language could lead to mistakes — therefore, students had to be selective and precise in their use of references.
To preserve the value of the test as an assessment tool and to encourage familiarity with the material beforehand, time limits were imposed on each quiz. Depending on the topic, students had between 10 and 20 minutes to complete the test once they started. This time frame was adequate for answering questions correctly — even with access to resources — but only if students were already acquainted with the materials and knew where to locate specific information quickly. This design supported the course's underlying philosophy: that students should not be expected to memorize every detail, but

they must understand how and where to access the correct information within a specialized knowledge domain.

4. Future Work

While this paper focused on theoretical knowledge, further analysis should explore how students perform on more application-oriented tasks, such as those presented in the Care Phase of the gamified format. These tasks require the consolidation of facts and practical interpretation of information. Although a direct comparison with previous cohorts is not possible due to the absence of such tasks in the traditional model, this area represents a valuable direction for future research.
It is also important to note that the present comparison was based on only one program — part-time Computer Science students — with approximately 60 students in each cohort. However, this represents a non-negligible group of nearly 120 participants. The results should be interpreted as preliminary findings from the first implementation of the gamified model. Currently, the new format is being tested by over 700 students from other programs, which is expected to provide a rich dataset for broader analysis in the future.

5. Conclusion

This study compared the learning outcomes of two student cohorts enrolled in the Metrology course at Gdańsk University of Technology — one assessed through a traditional end-of-course test and the other through a gamified, assignment-based format. The findings indicate a consistent reduction in the percentage of incorrect answers on theoretical questions across all major topics for the gamified group. This improvement is likely the result of more frequent interaction with the material, increased student autonomy, and the development of information-seeking and critical thinking skills — key competencies for modern engineers.
The course redesign emphasizes not only memorization but also the ability to search for, interpret, and apply information under time pressure and within the context of a specific discipline. Rather than expecting students to recall every detail, the new format encourages them to know how and where to find the necessary knowledge — reflecting the demands of real-world problem solving in technical fields.
While this paper focused on theoretical knowledge, further analysis should explore how students perform on more application-oriented tasks, such as those presented in the Care Phase of the gamified format. These tasks require the consolidation of facts and practical interpretation of information. Although a direct comparison with previous cohorts is not possible due to the absence of such tasks in the traditional model, this area represents a valuable direction for future research.
The article concludes with a discussion on the implications of these findings for the design of future university courses. It highlights the importance of timely feedback, student motivation [11], and continuous assessment in enhancing the effectiveness of lecture-based teaching. The results contribute to a growing body of evidence in favor of active and engaging learning strategies over conventional lecture and exam formats. Gamification, when thoughtfully implemented, offers a promising path toward improving learning outcomes and aligning academic instruction with the evolving needs of students and the labor market.

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