Gamification Classification as a Framework for Analysing Gamification Elements in Digital Educational Tools

Ana Vrcelj Božić, Nataša Hoić-Božić, *Senior Member IEEE*, Martina Holenko Dlab, *Member IEEE*, Kristian Stančin, and Tomislav Jagušt, *Senior Member IEEE*

***Abstract*—Gamification is increasingly being adopted in education as a means to enhance student motivation. Compared to game-based learning (GBL), this approach is more suitable for use in the classroom as it does not require the development of specialised educational games. Instead, gamification can be achieved by incorporating game design elements that are available through widely accessible digital gamification tools. However, the selection of suitable tools and their gamification elements remains a challenge for teachers. This paper introduces a new classification for gamification and demonstrates its application in the evaluation of popular digital gamification tools. By examining the characteristics of these tools, the classification not only helps teachers to select suitable tools, but also enables them to evaluate other tools independently. This classification represents an initial step toward the development of a technological-pedagogical framework for designing and implementing gamified activities in schools. In addition, a survey was conducted among a group of computer science teachers to find out which gamification elements they, as experts, consider most important for the use of gamification in the classroom. The elements that are best suited for inclusion in gamification tools were filtered out and it is planned to implement them in the future proprietary gamification applications.**

***Index terms*—gamification in education, digital tools for gamification, MDA framework, gamification classification.**

I. Introduction

Gamification has the potential to enhance student motivation and engagement in a variety of educational activities [1, 2]. Both intrinsic and extrinsic motivation play a crucial role in shaping students' cognitive abilities, influencing learning outcomes, and boosting overall academic performance [3]. As a key driver of learning, motivation helps students pursue their goals by aligning with their individual interests. Given that students process information in diverse ways, gamified approaches allow them to select activities that align with their unique learning preferences, fostering a more personalized and effective educational experience [4, 5].

Although gamification has considerable potential to enhance student motivation and thereby improve learning outcomes, it remains underutilized by teachers in schools [6, 7]. Today, numerous tools are available for incorporating game design elements into the classroom; however, selecting the most suitable ones is not a straightforward task for educators [8]. Gamification classifications and frameworks can assist in this process [9]. These frameworks should integrate both technological and pedagogical aspects, which is also the aim of the research project 'Enhancing Motivation for Learning Through Gamification' [10]. The overarching goal of the project is to examine gamification elements to enhance student motivation, particularly in high school, and to develop a technological-pedagogical framework for designing and implementing gamified activities. A particular goal is to research technologies and digital tools for gamification together with pedagogical strategies, with the aim of creating a new tool for gamification. By combining the tools with suitable pedagogical methods, learning scenarios will be prepared that can be tested in real school environments.

The research is carried out using the methodology of design-based research (DBR), which consists of the following phases: Analysis of the practical problem, design of a solution to the analyzed problem, the experimental part of the research with a series of iterative DBR cycles, and reflection and analysis of the results [11]. Currently, the problem analysis phase is coming to an end, which is characterized by the fact that it takes place in collaboration between researchers and practitioners, in our case high school computer science teachers.

The technological aspect of the framework is being developed, which includes the creation of a classification of game design elements suitable for gamification in high schools. This classification will help teachers to select the appropriate digital tools for the implementation of gamification, because the research shows that teachers are interested in using gamification but do not have enough time to find and study digital tools and game design elements themselves. Therefore, they mainly use simple game design elements such as points and leaderboards [12]. The need for a

Manuscript received December 13, 2024; revised February 28, 2025. Date of publication March 6, 2025. Date of current version March 6, 2026. The associate editor prof. Ana Sović Kržić has been coordinating the review of this manuscript and approved it for publication.

A. Vrcelj, N. Hoić-Božić, M. Holenko Dlab and K. Stančin are with the University of Rijeka, Faculty of Informatics and Digital Technologies, Croatia (e-mails: ana.vrcelj@uniri.hr, natasah@inf.uniri.hr, mholenko@inf.uniri.hr, kristian.stancin@inf.uniri.hr). T. Jagušt is with the University of Zagreb, Faculty of Electrical Engineering and Computing, Croatia (e-mail: tomislav.jagust@fer.unizg.hr).

The paper was presented in part at the International Conference on Software, Telecommunications and Computer Networks (SoftCOM) 2024.

Digital Object Identifier (DOI): 10.24138/jcomss-2024-0111

separate classification has also become apparent because the existing taxonomies and gamification frameworks [9, 13] are often too extensive and too complicated for practical application in schools by secondary school teachers. They are mainly intended for gamification designers and not for teachers because they do not take sufficient account of pedagogical aspects.

This paper represents a significant advance in the field of gamification in education. Building on the research presented in [14], suitable gamification elements for use in high schools are explored in preparation for the next phase of DBR: design of new gamification applications. The most important contribution is our own classification of gamification elements, which has proven successful in evaluating popular digital gamification tools. This classification can be used by teachers to evaluate and select suitable tools. With the aim of developing our own tool, the developed classification was also used to determine which elements of game design are most commonly used in popular gamification tools.

The research presented in this paper extends our earlier work [14] by involving a group of computer science teachers in a quantitative survey to identify which gamification elements they, as experts, consider most important for the use of gamification in the classroom. To this end, a new research question was added, namely which gamification elements are most important for use in the classroom. The results provide new insights into the elements that should be prioritised for an effective application of gamification in the classroom. Based on these results, the elements most suitable for inclusion in gamification tools were filtered out and it is planned to implement them in the future proprietary gamification applications.

The main contributions of this paper are to: a) introduce a novel classification for integrating gamification in teaching, bridging both technological and pedagogical perspectives; b) provide new insights into the most impactful gamification elements for effective classroom implementation.

The remainder of this paper is organised as follows: Section II provides an overview of existing gamification frameworks. The research methodology described in Section III provides an overview of the research context, the research questions and the gamification classification that was used to evaluate the popular digital tools for gamification. Section IV of the paper presents and discusses the research results in relation to the research questions. The final section of the paper provides concluding remarks and outlines directions for future research.

II. Related Work

Various frameworks for both digital games and gamification have been developed for several years. Before frameworks for gamification were developed, there were already frameworks for digital games. One of the most recognized and widely used is the MDA framework [15]. MDA stands for *Mechanics*, *Dynamics* and *Aesthetics* and provides an approach for understanding, analysing and controlling the design of video games. '*Mechanics*' refers to the core rules, mechanisms and components of a game that support its dynamics and player interaction. '*Dynamics*' refers to how players interact with these mechanics, shaping the gameplay experience as the game progresses. '*Aesthetics*' captures the emotional responses and overall experience that the game evokes, focussing on how it affects the player. While designers tend to work from *Mechanics* to *Dynamics* to *Aesthetics,* players experience it in reverse order: *Aesthetics*, then the *Dynamics* and finally the *Mechanics*.

In recent years, a number of gamification frameworks have been created for different domains, and numerous authors have attempted to provide an overview of this area. In [13], a systematic literature review compared approximately twenty gamification frameworks, revealing that most were developed for the business context and only a few specifically for the education sector, particularly higher education. Additionally, this review emphasised the diversity of these frameworks and the lack of robust research evidence demonstrating their effectiveness in practical applications. Similarly, [16] examined gamification frameworks in different application domains, focusing on design models and stages of the gamification design lifecycle, making them more relevant for gamification developers.

The Gamification Octalysis Framework was created to deepen the understanding and application of gamification in various life and business contexts [17]. This framework focuses on eight core motivational factors that drive human behaviour.

The conceptual model eRIOOS presented in [18] aims to improve online education by integrating elements from computer games. Although it has been tested in several university courses, the model in its current form is not suitable for use in K-12 education.

Authors in [9] present a taxonomy or gamification framework for categorising and describing gamification elements, which is primarily aimed at gamification designers and developers. The elements are categorised into five dimensions, which the authors believe could also be adapted for gamification in education. They assume that future, more comprehensive studies will offer guidelines for the implementation of gamification in the classroom and make these guidelines accessible to educators.

These examples indicate a continuing gap in frameworks tailored to K-12 education, as most existing frameworks are intended for gamification designers rather than educators and do not integrate enough pedagogical aspects alongside the technological elements. To encourage the use of gamification in schools, a simplified framework with gamification elements is needed that teachers can easily apply in the classroom, as complex, detailed systems can be discouraging.

III. Methods and Tools

This paper continues the research conducted as part of the DBR analysis phase. A systematic literature review (SLR) was conducted with the aim of exploring the area of gamification in education, focussing on primary and secondary schools [7]. One of the main conclusions of the SLR is that almost all of the studies analysed found a positive impact of gamification,

particularly on student motivation and engagement, but often also on more successful achievement of learning outcomes.

The preliminary research on the application of gamification in high school teaching continued with a survey of teachers on the use of gamification and their attitudes towards gamification [12]. With the aim of forming a group of experts, the survey was also conducted with computer science teachers. The main finding was that computer science teachers use gamification to a greater extent compared to other teachers because they want to achieve a higher quality of teaching and believe that they know how to create gamified activities [19].

In order to develop a gamification classification, criteria for the selection of digital tools for gamification are developed [10]. Existing frameworks were examined, with the MDA framework serving as a starting point, as it is also suitable for analysing gamification models [20].

In the continuation of the research, we focused on further refining the classification based on the evaluation of selected gamification tools and providing answers to the following research questions [14]:

Q1: “How can the proposed gamification classification be used to analyse and evaluate gamification tools?”

Q2: “Which of the popular gamification tools contain the most gamification elements?”

Q3: “Which gamification elements are most frequently used in popular gamification tools?”

A group of computer science teachers who are experts in the use of gamification in the classroom were involved in the further investigation. The following research question was formulated to find out which gamification elements they consider to be the most important:

Q4: “Which gamification elements are most important for use in the classroom?”

The research methodology was based on a quantitative research method with an anonymous survey. 20 teachers were asked to complete a questionnaire to evaluate the gamification elements, of which 18 responded. For each of the gamification elements offered, they had to choose one of the answers offered on a Likert scale, where 1 stood for "Not at all important element" and 5 for "Extremely important element". A total of 18 gamification elements were assessed, i.e. the elements described in Table I were considered, with the exception of levels, progress bars, adaptation, live reactions and AI tools, which were found to be less commonly used for gamification in popular digital tools.

A. Classification of the gamification criteria

In order to develop the technological part of the future gamification framework, a classification of gamification elements was developed.

The main objective was to create a classification based on the MDA framework, but also suitable for use in schools [15, 20]. The MDA categories were considered from a teacher’s perspective and the gamification elements were selected and described in such a way that they can be applied by teachers in schools.

The selection of elements was based on the results of a preliminary study conducted as a systematic literature review [7] to determine which elements of game design and which digital tools are used for gamification in schools.

It has been shown that the gamification of activities is most effective when at least two gamification elements are combined [21]. These can be various combinations of elements such as points, leaderboards, feedback, badges, rewards, stories, avatars, levels and challenges [9].

All selected elements are categorised into the 3 standard MDA categories of *Mechanics*, *Dynamics* and *Aesthetics*. In addition, a fourth category, *Other*, was added, which contains elements that are necessary for teachers to use gamification (Table I).

A.1 Mechanics

Mechanics refers to the specific game elements built into gamification tools to drive learner behaviour, including common game elements [20]. For our own classification, the *Mechanics* category includes the basic gamification elements: points, badges, leaderboards, levels and progress bars.

These elements have been identified as most suitable for use in schools based on a review of existing publications and surveys of secondary school teachers. The use of points and leaderboards is highlighted as the most common combination [7], supplemented by badges (acronym PBL [5]). Basic elements also include levels that allow students to progress through the gamification system which is tracked by students using a progress bar that also guides them through the gamified system.

A common feature of the selected elements in the *Mechanics* category is that teachers can easily verify that the selected gamification tool provides these elements. This is the first step in assessing the suitability of a particular digital tool, followed by checking the elements from the other categories.

A.2 Dynamics

Gamification *Dynamics* describes how the basic elements of *Mechanics* are applied and combined to influence learner behaviour, taking into account the types of interactions that are appropriate for learning [20]. It includes prizes/rewards, feedback, adaptation, puzzle, quiz system, synchronous use and asynchronous use.

This category represents a more abstract level where elements from the *Mechanics* category are applied and combined, focussing on the types of interactions that are appropriate for education. For example, collecting enough points or badges can lead to additional rewards for students. To increase students' motivation, it is important that they receive immediate feedback on their current activities, e.g. whether the answer to a question is correct or not. Some gamification tools or systems can be customised or adapted for individual students or include additional games and puzzles. Tools that include quizzes as an element of gamification are often used for gamification in schools (frequently this is the primary way the tool is used). For education, it is also

important whether the system can be used synchronously (in the classroom), asynchronously during independent learning by the student, or both.

A.3 Aesthetics

Aesthetics refers to the emotional and motivational aspects, i.e. the experiences that students gain from participating in the gamified system, such as satisfaction, sense of achievement, social interaction with other learners [20]. Gamification elements include: Avatar, live reactions, challenge, competition, cooperation, storyline/narrative and fantasy.

Students are motivated when they can choose their own avatars and react in real time during the game. Challenges encourage students to complete tasks, and important elements are competition and cooperation with other students.

The elements most strongly associated with games are story/narrative and fantasy, which also have a positive effect on students' motivation to use a gamified system.

TABLE I
CLASSIFICATION OF GAMIFICATION ELEMENTS

Mechanics	
Points	Students can collect numerical points that are automatically awarded for achievements, e.g., students can earn experience points (XP) for positive behavior such as collaboration, solving tasks, and participating in formative assessments in Classcraft.
Badges	Virtual medals awarded to students as a mark of success or for achieving goals, e.g. the teacher creates badges in Moodle and these are automatically assigned to students after they have successfully completed assignments.
Leaderboards	Ranking of students based on the results achieved, e.g. Kahoot! displays a podium at the end of the quiz showing the three students with the most points.
Levels	Completing a certain number of tasks, students are allowed to move up to the next level, e.g. in Breakout EDU there are five levels and students advance to a higher level when they have successfully completed the tasks.
Dynamics	
Progress bar	It displays the student's progress and guides them through the system, e.g. students in Classcraft are shown a dashboard with detailed information on their current level, rewards and points earned.
Prizes/ rewards	Additional virtual rewards or recognition can be awarded for students achievements e.g. in Quizzes students receive the 2X power-up, which gives them double points for a correct answer.
Feedback	Quick feedback on the student's current engagement, e.g. instant feedback on answers to questions in Socrative.
Adaptation	The system changes depending on the student's actions and data, e.g. creating personalised quizzes with questions tailored to individual students in Kahoot!.
Puzzle	Solving additional games and puzzles such as Hangman, Crossword, Millionaire and Sudoku in Moodle.
Quiz system	Solving quizzes with different types of questions, usually multiple choice e.g. in Quizizz.
Synchronous use	Gamification is using in the classroom, e.g. the quizzes are carried out by the teacher in the classroom in Kahoot!.
Asynchronous use	Gamification is used during students' independent learning, e.g. quizzes are used for independent learning in PeerWise.
Aesthetics	
Avatar	The student can choose his own character and/or nickname e.g. in ClasDojo students choose their avatars from a selection of "ClassDojo monsters".
Live reactions	The student can react with emoticons, pictures, or stickers, e.g. in Quizzes, students can react with stickers on the results screen after the quiz has finished.
Challenge	An element whose aim is to encourage the student to perform tasks, e.g. in Classcraft, the teacher can turn the entire lesson plan into quests or adventures.
Competition	Competition with other students using gamification elements, e.g. in PeerWise students compete against each other to achieve the highest reputation score and collect badges.
Cooperation	Cooperation with other students in teams, e.g. in Classcraft, students are divided into teams of 3-6 members and explore together while competing with other teams.
Storyline/ narrative	Creating a fictional narrative, e.g. in Genially is possible to choose templates that offer a storyline to students such as Escape Room.
Fantasy	Using sound, dynamic graphics, a 3D virtual world and/or AI to create a fantasy, e.g. in Breakout+ imaginative adventures (e.g. „Escape from the Haunted Pyramid“) utilise sound effects, dynamic graphics, and interactivity.
Other	
Reports	The teacher has access to student data on participation in gamified activities, e.g. in Breakout EDU on the completion and creation of games, organised by classes of students.
Lessons	Lessons can be created as presentations and training materials, e.g. in Genially teachers can create presentations and training materials that include games.
Classes	The teacher can create virtual classes and enrol their students, e.g. in PeerWise teachers create a course and enrol students in it.
AI tools	Availability of AI tools to create questions, check errors, etc., e.g. in Socrative, the AI makes it possible to add questions on a specific topic.

A.4 Other

The classification category *Other* contains elements that are not directly related to gamification, but which teachers must take into account when selecting gamification tools, as they make it easier for them to prepare and monitor gamified activities. The selected elements in this category are: Reports, lessons, classes, AI tools.

Reports are needed because it is important for teachers to have all the data about students' participation and results in the system during gamification. Teachers often want to create their own teaching materials (lessons) for the students and use them during gamification. The ability to create classes and have students participate in certain classes is also important. Recently, there have been more and more tools with AI support. This also applies to gamification tools that make it easier for teachers to create questions for quizzes, for example.

B. Digital tools for gamification

In order to verify the proposed classification of gamification elements in practise, 9 publicly available digital tools and platforms for gamification were selected for analysis. Their common feature is that they can be used in different domains and areas of learning and that they offer teachers different ways to use gamification in the classroom [14].

The following digital tools for gamification were considered:

- Kahoot! - It enables teachers to create, share and conduct quizzes, tests, surveys and discussions with students in real time. It is used for gamified assessment of student knowledge, formative assessment or as a break from traditional classroom activities.
- Moodle (Loomen) - A learning management system with additional plugins for gamification, such as the Quizventure game in the Loomen, version used in Croatian schools.
- PeerWise - It enables students to create their own questions, share them with other students, and comment it.
- ClassDojo - An online classroom management platform where teachers can record and track student behaviour, and promote classroom activities in gamified way.
- Socrative - A tool where the teacher asks questions and students can compete against each other in teams while answering the questions.
- Quizizz - It enables teachers to create and run interactive quizzes where students can learn through a fun competition.
- Breakout EDU - A tool to create an online version of the "escape rooms'," where students solve puzzles and challenges to decipher codes to unlock a virtual room.
- Classcraft - An online platform that allows teachers to create lessons like role-playing game in which students choose roles, compete, collaborate and move through a virtual world while solving tasks and challenges.
- Genially - A digital tool, with special category of Gamification templates, for creating multimedia teaching content that can take the form of presentations, interactive images, infographics, posters, video presentations and various games.

The tools were selected primarily on the basis of preliminary research [7] that showed that both customised gamification applications and publicly available tools are used in schools. The tools used to create gamified educational content in different subjects include Kahoot!, Moodle, Edmodo, PeerWise, Los Cokitos and ClassDojo. As the tools available in English were selected, Los Cokitos was excluded from the analysis as it is only available in Spanish. The gamified Edmodo platform was no longer used after 2022 and was also excluded from the analysis.

The other tools analysed were selected based on their popularity among teachers [12] (Genially) and by consulting the large language model ChatGPT 3.5 (Quizizz, Breakout EDU, Socrative, Classcraft) as described in [14]. In the preliminary phase of the study [10], an analysis of Kahoot! tool was conducted according to the proposed categorisation because the studies [7, 22] found out that Kahoot! is the most popular tool successfully used for gamification in education. Kahoot! fully contains 2 elements in Mechanics, 6 in Dynamics, 7 in Aesthetics, and 4 in Other (Table II).

IV. Results and Discussion

A. Evaluating Gamification Tools with the Proposed Classification

To address research question Q1, "How can the proposed gamification classification be used to analyse and evaluate gamification tools?", the nine selected tools were evaluated using elements from the four established categories. Each element for a given tool was rated by 3 researchers as fully supported (2 points), partially supported (1 point), or not supported (0 points) as described in [14].

These results indicate that the proposed gamification classification was effectively used to evaluate the selected tools and has potential for application to additional tools.

B. Analyzing Gamification Tools by Element Inclusion

Upon completing the evaluation for each tool, the points from the scoring table were used to calculate the total score for each tool and each category, addressing research question Q2: “Which of the popular gamification tools contain the most gamification elements?' and allowing the tools to be ranked by the number of gamification elements they encompass. The results (Figure 1) show that Kahoot!, Quizizz and Classcraft are the tools with the highest scores (38 or 39 out of 46) or total number of elements in all categories. On the other hand, Socrative contains the fewest elements and the lowest score (20).

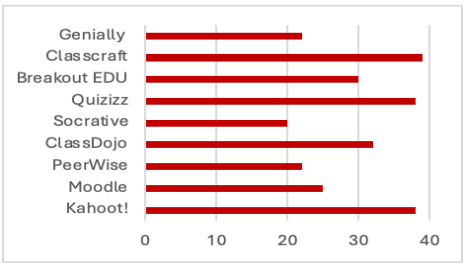

Fig. 1. The points for gamification elements included in tools

In short, in the *Mechanics* category, PeerWise and Quizizz stand out as they both include PBL, the commonly referenced combination of three core elements. Other tools do not have an outstanding combination of elements, and some only partially implement individual elements. In the *Dynamics* category, Classcraft fully integrates all elements, closely followed by Kahoot! with one less. Quizzes are a key feature in many tools, and even the main feature in some. With the exception of Socrative, all tools support asynchronous use, and most also support synchronous modes. In the *Aesthetics* category,

Kahoot! includes all elements completely, closely followed by ClassDojo and Classcraft. In the *Other* category, Kahoot! and Quizizz include all elements, especially features that allow teachers to incorporate AI tools.

TABLE II
GAMIFICATION ELEMENTS IMPLEMENTED IN THE KAHOOT! TOOL

Mechanics	
Points	Students earn numerical points for answering questions, which are awarded based on accuracy, but also on the speed of the answer.
Leaderboards	The top 5 students are ranked and displayed after each question. At the end of the quiz, a podium is displayed with 3 students.
Dynamics	
Feedback	Students receive immediate feedback after answering a question.
Adaptation	Personalized *Kahoots* can be created that have questions tailored to individual students (e.g. adapted to the student's knowledge level).
Puzzle	Additional games are offered e.g. *Duck-Duck Fractions game* for teaching Math.
Quiz system	Quizzes (called "Kahoots") with various types of questions (e.g. multiple-choice, type answer, slider,...) are the basic way of using.
Synchronous use	Synchronous use is the basic type of use, as the quiz questions are solved in class under the guidance of the teacher.
Asynchronous use	The system also allows student-paced *Kahoots* that students solve independently on their own devices.
Aesthetics	
Avatar	The student can choose their own nickname and one of the offered characters (themed character) and accessories for the character.
Live reactions	Students can react using emoticons (*emojis*) during presentations or quizzes.
Challenge	In addition to the basic challenge (answer correctly as quickly as possible), there is also an additional challenge.
Competition	When solving the quiz questions, students can compete independently against other students, and teams can compete against other teams.
Cooperation	Students can be divided into teams and solve the quizzes together.
Storyline /narrative	The classroom is temporarily transformed into a game show where the teacher is the quizmaster, and the students are the participants. Additionally, imaginative stories have been created e.g. *Treasure Trove.*
Fantasy	Different themes, music and sound effects can be used for slide layouts and questions. More advanced ways of running *Kahoots* have their own imaginative story and multimedia.
Other	
Reports	The teacher has access to student results and other data in the form of various reports (tables, leaderboards and graphical displays).
Lessons	In addition to quizzes (*Kahoots*), slides can be created that include questions, explanations of correct answers and other content.
Classes	The teacher can create courses that organize collections of *Kahoots* on the same topic and join students to them.
AI tools	AI enables question generation, there is also a PDF-to-kahoot generator.

A detailed overview of the representation of gamification elements in nine selected tools by category can be found in [14] and the Fig. 2 shows a detailed view of all elements for the Kahoot! tool as an example. Elements from different categories are displayed in different colours. Since all elements are fully (and not partially) supported in the Kahoot example, they have the value 2 points.

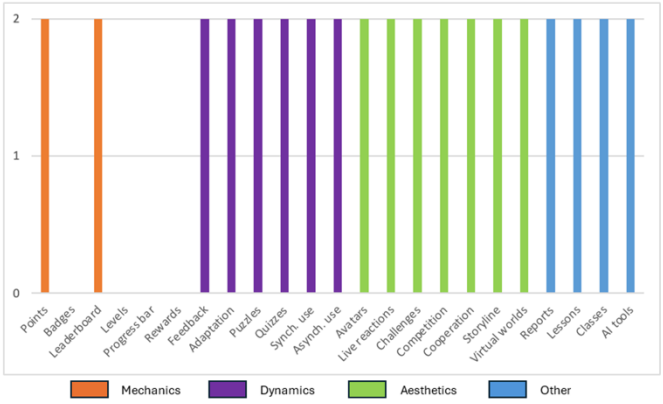

Fig. 2. Representation of elements in the Kahoot! tool

C. Identifying the Most Frequently Used Gamification Elements

To address research question Q3, "Which gamification elements are most frequently used in popular gamification tools?", the points awarded for each element were aggregated, providing valuable insight into the prevalence of specific game design elements and identifying those that are supported by the majority of tools (Fig. 3). In the *Mechanics* category, points were the most commonly used element. In the *Dynamics* category, feedback and asynchronous use were the most commonly supported features. In the *Aesthetics* category, competition and cooperation are particularly well represented. In the *Other* category, which is essential for educational applications, all of the selected tools include options for reporting and class management, which are crucial for teachers when organising gamified lessons.

Furthermore, this analysis has shown that the elements levels, progress bars, adaptation, live reactions and AI tools are very rarely used, i.e. they are only available in a few gamification tools.

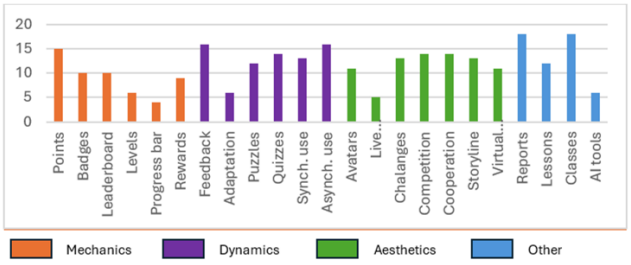

Fig. 3. Representation of gamification elements in tools

D. Key Gamification Elements for Effective Use in the Classroom

The results obtained in the previous step of the study were used to answer further research question Q4: "Which gamification elements are most important for use in the classroom?" A group of computer science teachers who are

experts in the use of gamification in the classroom were included in this research [19].

The Table III shows the results of the questionnaire, with the gamification elements ordered from those that teachers found most useful to those that they found least useful. Teachers rated all elements from the *Other* category (classes, reports, lessons) as well as feedback and collaboration as important with an average rating of 4.5 and above.

They also consider quiz system, points, competition, challenges, leaderboards, puzzle and asynchronous usage elements to be useful. On the other hand, they least emphasise badges, avatars and fantasy as important elements for the use of gamification. To summarise, it can be said that points and leaderboards are important for teachers from the *Mechanics* category. From the *Dynamics* category, feedback, puzzles, quiz system and asynchronous use are important to them and from the *Aesthetics* category, challenge, competition and collaboration.

As previously mentioned, existing classifications are primarily technical, designed for gamification designers rather than educators, and often fail to adequately integrate pedagogical elements alongside technological ones. For comparison, the taxonomy proposed by [23] for the gamification of information systems was selected. This taxonomy focuses on game mechanics from a technical perspective but lacks consideration of pedagogical aspects. It was chosen for comparison because it, like the proposed classification in this paper, is based on the MDA framework.

While there are overlaps between the two approaches, such as the inclusion of Points, Leaderboards, Feedback, Avatars, and Challenges, the proposed classification in this paper extends further by emphasizing elements crucial for classroom use, such as Adaptation, Classes, Reports, Cooperation, and Lessons. These additions are vital in educational settings as they enable activities to be tailored to individual students, improve the organization of activities by subject area, and provide better access to student performance data, which can inform the design of future activities.

The importance of these additional elements is supported by teacher feedback gathered through the beforementioned questionnaire, where they were consistently ranked among the top five most useful gamification elements for classroom implementation.

E. Limitations

Although this study provides valuable insights from the perspective of computer science teachers, the small sample of only 18 participants may limit the generalisability of the results. However, this number was intentional as participants were selected based on their expertise to ensure the quality of the feedback. The study also examined a small number of gamification tools (nine), which may not represent the full range of gamification tools available. Future studies examining a wider range of gamification tools could contribute to extending our findings. For the purposes of our research, however, the current results are sufficient to draw meaningful conclusions and inform the development of a framework to effectively integrate gamification in schools.

TABLE III
RESULTS OF THE GAMIFICATION ELEMENTS EVALUATION

	AVG	SD	MIN	MAX
Feedback	4,722	0,436	2	5
Classes	4,611	0,660	1	5
Reports	4,556	0,484	2	5
Cooperation	4,500	0,669	1	5
Lessons	4,500	0,487	4	5
Quiz system	4,333	0,562	3	5
Points	4,278	0,782	3	5
Competition	4,278	0,543	2	5
Challenges	4,222	0,612	2	5
Leaderboards	4,167	0,811	2	5
Puzzle	4,056	0,759	3	5
Asynchronous use	4,000	0,795	3	5
Storyline/narrative	3,944	0,759	3	5
Synchronous use	3,778	0,831	3	5
Rewards	3,722	1,016	2	5
Fantasy	3,611	0,867	4	5
Avatars	3,444	0,809	4	5
Badges	3,333	1,026	3	5

V. CONCLUSION AND FUTURE PLANS

This paper presents a research work in the field of gamification in education that focuses on the technological aspect of gamification and proposes our own classification of gamification elements based on the revised and adapted MDA framework so that it is suitable for the application of gamification in schools. The proposed classification consists of 23 elements divided into four categories: *Mechanics*, *Dynamics*, *Aesthetics* and *Other*.

The research has shown that the proposed classification is suitable for the analysis and evaluation of gamification tools by successfully analysing nine popular gamification tools. The classification represents a valuable contribution as it enables teachers to independently select and analyse other gamification tools with the aim of using them in the classroom.

In addition, the classification and the results obtained are valuable for further research. With the aim of developing our own tool, the classification developed was also used to determine which gamification elements are used most frequently. In this way, the elements most suitable for inclusion in our own future gamification applications were filtered out. In addition, these elements were evaluated by a group of computer science teachers who are experts in the use of gamification in teaching and with whom we will continue to collaborate in the experimental part of the research through a

series of iterative DBR cycles. The effectiveness of different combinations of gamification elements will be analyzed in order to find out which elements would motivate students to learn the most.

In the further course of the research within the project, besides developing our own gamification tool, it is planned to explore the pedagogical aspect of gamification in order to propose a suitable framework that supports the effective application of gamification in schools and creates a motivating learning environment for students.

ACKNOWLEDGMENT

The research has been co-funded by the University of Rijeka (Croatia) under the project “Enhancing Motivation for Learning Through Gamification” (uniri-iskusni-drustv-23-21).

REFERENCES

[1] E. Abdykerimova and G.A. Kaliyeva, “Analysis of the possibilities of using gamification tools in the education system,” *Yessenov Science Journal*, vol. 48, no. 3, pp. 39-52, 2024. doi: 10.56525/nyvl8470

[2] I. Bouchrika, N. Harrati, V. Wanick and G. Wills, “Exploring the impact of gamification on student engagement and involvement with e-learning systems”, *Interactive Learning Environments*, vol. 29, no. 8, pp. 1244-1257, 2021. doi: 10.1080/10494820.2019.1623267

[3] M.A. Adeoye, “Gamification Intervention on Student Academic Performance in Private Secondary School,” *Journal of education technology*, vol. 8, no. 2, pp. 326-332, 2024. doi: 10.23887/jet.v8i2.79540

[4] M. Dindar, L. Ren and H. Järvenoja, “An experimental study on the effects of gamified cooperation and competition on English vocabulary learning”, *British Journal of Educational Technology*, vol. 52, no. 1, pp. 142-159, 2021. doi: 10.1111/bjet.12977

[5] M.A. Hassan, U. Habiba, F. Majeed and M. Shoaib, “Adaptive gamification in e-learning based on students’ learning styles”, Interactive Learning Environments, vol. 29, no. 4, pp. 545-565, 2021. doi: 10.1080/10494820.2019.1588745

[6] C. Dichev and D. Dicheva, "Gamifying education: what is known, what is believed and what remains uncertain: a critical review," *International Journal of Educational Technology in Higher Education*, vol. 14, 2017. doi: 10.1186/s41239-017-0042-5

[7] A. Vrcelj, N. Hoić-Božić and M. Holenko Dlab, "Use of Gamification in Primary and Secondary Education: A Systematic Literature Review," *International journal of educational methodology*, vol. 9, no. 1, pp. 13-27, 2023. doi: 10.12973/ijem.9.1.13

[8] A. Vrcelj, N. Hoić-Božić and M. Holenko Dlab, "Using Digital Tools for Gamification in Schools," *44th International Convention Proceedings / Skala, Karolj (ur.). Rijeka: Croatian Society for Information, Communication and Electronic Technology- MIPRO, 906-910*, 2021.

[9] A. M. Toda, A. C. T. Klock, W. Oliveira, P. T. Palomino, L. Rodrigues and L. Shi, "Analysing gamification elements in educational environments using an existing gamification taxonomy," *Smart Learn. Environ.*, vol. 6, no. 16, 2019. doi: 10.1186/s40561-019-0106-1

[10] A. Vrcelj Božić, N. Hoić-Božić and K. Strančin, "Technological Aspects of Gamification: Criteria for the Selection of Digital Tools and Platforms," in *Proceedings of the 23rd European Conference on e-Learning - ECEL 2024*, Porto, 2024. doi: 10.34190/ecel.23.1.2568

[11] F. Wang and M. J. Hannafin, "Design-based research and technology-enhanced learning environments," *Educational Technology Research and Development*, vol. 53, no. 4, pp. 5-23, 2005.

[12] A. Vrcelj, N. Hoić-Božić and M. Holenko Dlab, "Attitudes of Secondary School Teachers towards Gamification," in *CRESS 2023 - International Conference on Research in Education and Social Sciences Proceedings Book*, Istanbul, 2023. doi:10.12973/ijem.9.1.13

[13] A. Mora, D. Riera, C. González and J. Arnedo-Moreno, "Gamification: a systematic review of design frameworks," *Journal of Computing in Higher Education*, vol. 29, no. 3, pp. 516-548, 2017. doi: 10.1007/s12528-017-9150-4

[14] A. Vrcelj Božić, N. Hoić-Božić, M. Holenko Dlab, K. Stančin and T. Jagušt, "Analysis of the Gamification Aspects of Digital Educational Tools Using Gamification Classification," in *Proceedings of the 32nd International Conference on Software, Telecommunications and Computer Networks (SoftCOM) 2024*, Split, 2024. doi:10.23919/softcom62040.2024.10721650

[15] R. Hunicke, M. LeBlanc and R. Zubek, "MDA: A Formal Approach to Game Design and Game Research," in *Proceedings of the challenges in Game AI Workshop, nineteenth*, Menlo Park, CA, 2004.

[16] O. Azouz and Y. Lefdaoui, "Gamification design frameworks: a systematic mapping study," in *Internatonal Conference on Mulimedia Compuing and Systems Proceedings*, 2018. doi: 10.1109/ICMCS.2018.8525900

[17] S. Mohanty and P. Christopher B, "A bibliometric analysis of the use of the Gamification Octalysis Framework in training: evidence from Web of Science," *Humanities and Social Sciences Communications* , vol. 10, p. 836, 2003. doi: 10.1057/s41599-023-02243-3

[18] A. Bernik, "Gamification Framework for E-Learning Systems in Higher Education,," *Tehnički glasnik, Vol. 15, No. 2,* 2021.

[19] A. Vrcelj Božić, N. Hoić-Božić and M. Holenko Dlab, "Exploring the Attitudes of Computer Science High School Teachers Towards Gamification: A Work in Progress," in *2024 IEEE Frontiers in Education Conference (FIE) Proceedings*, Washington D.C., 2024. doi: 10.1109/fie61694.2024.10893489

[20] G. P. Kusuma, E. K. Wigati, Y. Utomo and L. K. P. Suryapranata, "Analysis of Gamification Models in Education Using MDA Framework," *Procedia Computer Science*, vol. 135, p. 385-392, 2018. doi: 10.1016/j.procs.2018.08.187

[21] D. Gibson, N. Ostashewski, K. Flintoff, S. Grant and E. Knight, "Digital badges in education," *Education and Information Technologies*, vol. 20, no. 2, pp. 403-410, 2013.

[22] A. I. Wang and R. Tahir, "The effect of using Kahoot! for learning – A literature review," *Computers & Education*, vol. 149, p. 103818, 2020. doi:10.1016/j.compedu.2020.103818

[23] S. Schöbel and A. Janson, " Is it all about having Fun? – Developing a Taxonomy to gamify Information Systems," *26th European Conference on Information Systems (ECIS2018)*, 60, 2018.

Ana Vrcelj Božić is a PhD student at the doctoral study of Informatics at the Faculty of Informatics and Digital Technologies, University of Rijeka (Croatia). She received M.S. degree in Mathematics and Informatics at the University of Rijeka, Faculty of Mathematics. She works as a computer science teacher at a vocational high school “Civil Engineering Technical School” in Rijeka. Her research interests include game-based learning, gamification and the use of digital tools for teaching and learning. The subject of her doctoral thesis is the use of gamification in secondary education, and she has published several articles on this topic.

Nataša Hoić Božić is a full professor at the Faculty of Informatics and Digital Technologies, University of Rijeka and head of the Laboratory for the Application of Information Technologies in Education. She holds a PhD in Computer Science from the Faculty of Electrical Engineering and Computing University of Zagreb. She teaches courses on multimedia and web design, e-learning and computer science teaching methods in undergraduate, graduate and postgraduate study of Informatics. She has participated in scientific and professional projects and is the author of numerous articles in journals and conference proceedings. Her main research areas are: technology-enhanced learning (e-learning), including gamification, recommender systems, blended learning approaches and ICT tools for teaching and learning.

Martina Holenko Dlab is an associate professor at the Faculty of Informatics and Digital Technologies, University of Rijeka and head of the Chair of Multimedia Systems and e-learning. She holds a PhD in Computer Science from the Faculty of Electrical Engineering and Computing, University of Zagreb. She is the author of numerous articles published in scientific journals and conference proceedings and has actively participated in scientific and professional projects. She teaches undergraduate, graduate and postgraduate courses in Informatics, covering computer graphics, teaching methods in computer science, computer-supported learning systems and operations research. Her research interests include technology-enhanced learning (e-learning), blended learning approaches, digital tools for teaching and learning, recommender systems, game-based learning and gamification.

Kristian Stančin is a postdoctoral researcher at the Faculty of Informatics and Digital Technologies, University of Rijeka, Croatia. He completed his PhD at the same faculty where he currently works. He is actively involved in teaching various courses on databases, information systems, and business informatics. His research focuses on technology-enhanced learning (e-learning), with a particular emphasis on innovative methods and tools for improving teaching and learning experiences. This includes exploring game-based learning and gamification strategies to boost engagement and motivation among students. He is especially interested in how these approaches can be adapted to meet the needs of students with disabilities, leveraging inclusive design principles and accessible ICT tools. He is actively engaged in various projects in the field of e-learning.

Tomislav Jagušt is Vice Dean for Students at the Faculty of Electrical Engineering and Computing University of Zagreb (Croatia). He graduated and received his PhD in Computer Science at the Faculty of Electrical Engineering and Computing in Zagreb, where he is currently an assistant professor in the Department of Applied Computing. He teaches a number of courses in programming and software engineering and is scientifically involved in computer-assisted education, the use of mobile technologies in education and gamification. He has worked on a number of projects and published scientific papers in the field of computer-based education and the popularisation of STEM subjects.