Enhancing student engagement with personalized gamification and adaptive learning strategies

Gordana Borotić
Department of Applied Computing
University of Zagreb, Faculty of Electrical Engineering and Computing
Zagreb, Croatia
gordana.borotic@fer.hr

Tomislav Jagušt
Department of Applied Computing
University of Zagreb, Faculty of Electrical Engineering and Computing
Zagreb, Croatia
tomislav.jagust@fer.hr

***Abstract*—This Research to Practice Work In Progress paper presents our experience and preliminary results of introducing adaptive and gamified digital learning lessons to lower primary school students. To improve motivation and engagement, besides the adaptivity of the learning content itself, the game elements like points, and rewards were added to the learning lessons. Additionally, the activities supported two different game modes, adventure and competitive. In adventure mode, students were solving the assigned tasks to discover interesting new facts about the world around them, and in the competitive mode, they were collecting points and trophies to beat their classmates.**

The preliminary study was conducted with two small groups of third-grade students (age 8-9, N=18) who used tablet computers to access and complete the prepared mathematics learning activities. A questionnaire was organized to collect additional information and student attitudes toward each of the approaches.

The preliminary results show that personalized gamification has the potential to improve student engagement, which could, eventually, lead to more successful learning.

Keywords—technology-enhanced learning, gamification, personalization, adaptive learning, engagement

I. Introduction

In recent years, gamification, described most often as the application of game elements to non-game environments [1], gained a lot of attention, from both educational researchers as well as teachers, and became a prominent tool for improvement of student engagement, motivation, and interest at all educational levels [2]. Gamification can be applied, and indeed is, to different contexts, from corporate intranets and CRM systems [3], user management systems [4], software development and localization [5] to the crowdsourcing and information collection systems like Foursquare Swarm or Google Maps, where users can earn points or collect badges by filling in missing details, adding their rating or uploading a photo related to some map location (e.g., a park, bar, or restaurant).

In a constantly active and dynamic field of technology-assisted learning, many different educational systems with gamification elements have been proposed and implemented, often as an add-on feature of the existing e-learning platforms, or as a digital enhancement for the classical educational courses [6]–[8]. In both cases, most of the scientific research was focused on the improvement in students' motivation and interest, increasing productivity, concentration, and students' willingness to perform an otherwise monotonous job, such as math exercises [9].

While the research results were mostly positive, a rather small number of papers reported mixed or negative results, mostly arguing that not all students are competitive [10][11], which leaves space for further exploration and improvements in the field. One possible improvement is the change of the gamification approach, instead of a one-size-fits-all gamified solution, one could offer a more diverse and personalized gamified system to the students. The system that better suits their character, personality, and interests. In this paper, we present the results of a small case study that plunges right into this topic. A mobile application for math exercises with a task difficulty adaptivity algorithm and two different game modes - competitive mode, in which students collect points, and adventure mode, where the prizes are virtual cards with interesting facts about the world around us, was given to a group of third-grade students. The usage results from application logs as well as answers to the short questionnaire were analyzed, to get a deeper understanding of students' interests, preferences, and their intrinsic motivation for learning.

II. Related Work

As stated in definition by Werbach and Hunter [1], gamification is "the use of game elements and game-design techniques in non-game contexts". Although the term itself was coined by Nick Pelling in 2003 [1], it was not until 2010 that it came into wider use [12]. From approximately the same period comes the second most common definition of gamification, which states that "gamification is using game-based mechanics, aesthetics, and game thinking to engage people, motivate action, promote learning, and solve problems" [13]. Game mechanics, or game elements, mentioned in both definitions are elements that are usually found in many computer games [14] - points, badges and leaderboards, which are the most common, but gamification can also use elements like levels, progress bars, virtual currency or avatars [15]. Although game elements are the most prominent part of the gamification, proper implementations include other game aspects like game design and game thinking [16].

Since it seems that gamification has a lot of potential to increase motivation and student engagement, a lot of research about application of gamification in education and training was conducted in recent years [17]. In the beginning, most of the gamification implementations adopted the "one-size-fits-all" model, but soon the shortcomings of the approach were

XXX-X-XXXX-XXXX-X/XX/$XX.00 ©20XX IEEE

noticed, so approaches to personalize or individualize the gamification experience were proposed [18]–[20]. Most of the approaches, adopted one of the existing player models from the computer games, like Bartle's Player type model [21] or Marczewski player and user type hexad [22]. More recently, papers that match some of the typical game elements to different player types emerged, offering other researchers in the field some guidelines and examples for implementing personalized gamification experiences [18], [23].

Over the last decade, many studies explored the usage of gamification in education from different angles, but most of the papers highlighted its benefits in terms of learner performance and motivation while not differentiating between the impact of different game elements [19]. Jagušt et al. [24] showed that the gamified environment could have a positive effect on student motivation. In their study, students using the gamified application retained a focus on the given exercises longer, while students that used the non-gamified environment became bored more quickly and had less motivation to keep working, which eventually resulted in a lower number of solved mathematical tasks and more exercise interruptions. However, they also indicated that it is important to avoid possible demotivating effects of unadopted game elements. Researchers that investigate further in that direction found out that gamification does not have the same effect on all students, so they focused more on the context and personalized gamification considering students preferences and personality types [25], [26]. In the paper Adaptive Gamification for Learning Environments [27], authors propose a process for adaptation of the gaming features based on a different player type. The study showed that the most engaged learners, those with the adapted gaming features, spent significantly more time in the learning environment, while learners with features that are not adapted experience a higher level of demotivation.

Marczewski [22] identified four basic intrinsic types of players (persons participating in a gamified process): achiever - motivated by the desire to learn and improve their skills and abilities, socializer - motivated by a desire to interact and communicate with other players, philanthropist - motivated by a desire to help others, and free spirit player - motivated by a desire to explore and create. He also identified two extrinsic sub-types, players – hunting the rewards, and disruptors – wishing to change the system.

Denden et al. [28] focused on a way how different personality traits perceive different gamification elements and concluded that all traits, extroverts, introverts and ambiverts (balanced personality type) have high positive attitude for avatar game element, while they react differently to elements like leaderboard. Also, they showed that introverted types did not feel comfortable sharing their results with other learners, but still had positive attitude for game elements such as badges, levels, points, and feedback.

III. Methodology

A. Participans

The case study involved 18 third grade lower primary school students (age 8 to 9), from two separate classes. There were 9 girls and 9 boys. Students showed a lot of interest in tablet computers and a desire to participate in the study involving the usage of tablet computers in the classroom.

B. Research questions

The research questions that we pose here are:

RQ1: Do different students prefer different gamified activities?

RQ2: Could personalized gamification strategies improve student motivation and engagement?

C. Applications

Three different math learning mobile applications were prepared, one non-gamified and two gamified versions. While they differed in the gamification part, all three applications had the same user interface and almost identical graphic elements. Each application consisted of several pre-prepared collections of tasks; each collection corresponding to one teaching lesson from the third-grade mathematics curriculum. There were three types of tasks – multiple-choice including four possible answers, true-false questions, and tasks that required input of the numerical solution. Difficulty of all the tasks was pre-estimated on the scale from one to three – (1-easy, 2-medium and 3-hard). It is important to mention that all applications had a built-in adaptive algorithm which selected different subset of tasks for each user individually, based on student's previous results. After the user entered the answer to one task, solution was automatically checked, and a feedback message was displayed. Each user response was logged for later analysis. When student finished given set of tasks, each application version presented results in its specific way.

The first version of application did not contain any gamification elements. At the end of the lesson, students received feedback in a form of a simple 1-5 grade (calculated as a number of correct answers multiplied with the difficulty level of each task, then divided by a maximum possible score, and finally scaled to the 1-5 interval).

The second version of application included collectible knowledge cards (essentially a badge game element). This was the so-called adventure mode, where the main goal was to win and collect different knowledge cards. After successfully solving the set of tasks (achieving a "grade" 3 or more), user was awarded with a new card. Knowledge cards contained interesting information about various places in the world, e.g., the longest river in the world, the tallest building in the world, or a list of places where penguins live. Each rewarded card was placed in student's card collection - a dedicated application page that resembles a sticker card album (Fig. 1).

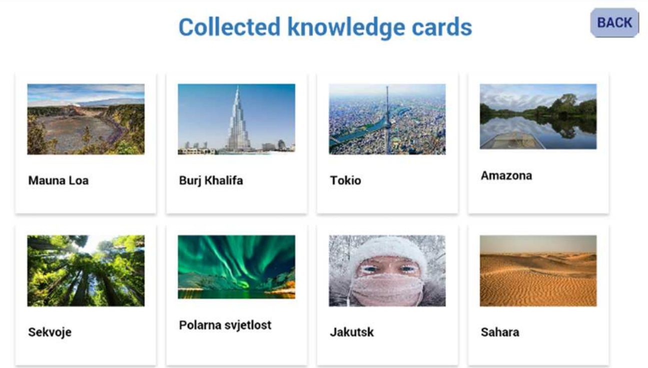

Fig. 1 Example card collection

The third, competitive version of application included points and a leaderboard game element. Each correctly solved task was awarded by one to three coins (1 coin for correct answer to an easy task, 2 for medium and 3 for hard tasks). Besides coins, the trophies (gold, silver, and bronze) were also available (Fig. 2). Each player had just a partial insight into the leaderboard, being able to see only two players ranked above, and two players beneath his or her own score.

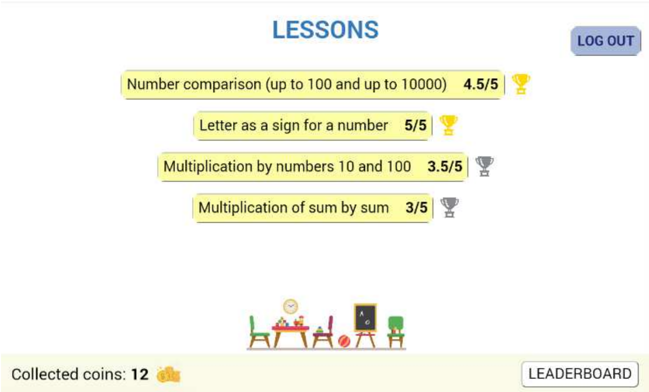

Fig. 2 Competitive mode, with points and trophies

D. Adaptive algorithm

In order to make it easier for students to learn, master and permanently adopt the learning material, at the same time minimizing the possibility of repetitive task solving becoming boring for students, all three applications included a custom adaptivity algorithm [29]. Each math task was given an estimated difficulty level and was put into a specific task subgroup within the group of similar tasks in the lesson.

Based on the data log information, algorithm tried to assess the estimated knowledge level of each student and select a set of 15 most appropriate tasks from a given lesson (Fig. 3).

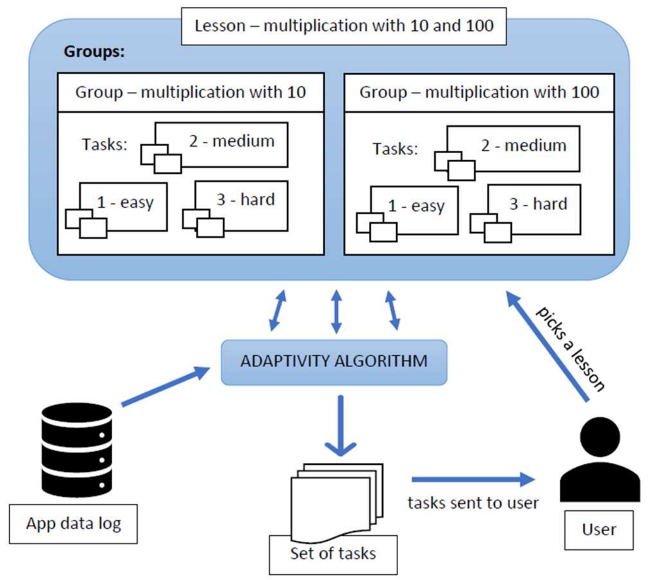

Fig. 3 Selection of a set of tasks aligned with student's current knowledge level

In the selection process, priority was given to the tasks that student had not yet solved correctly and tasks from the same group of tasks, as long as they were of the right difficulty level for that student. If students answered correctly to the given tasks, the adaptivity algorithm increased their estimated knowledge level, which means that in the future it will select more difficult tasks for the given student. That way, gradually, students will receive more and more complicated tasks, slowly improving their knowledge.

E. Experiment design

After the short introduction to the experiment, students were given the tablet computers with the three test applications. They run each of the applications for 15 minutes. First, the non-gamified application was introduced. After 15 minutes, students were asked to switch to the gamified version with knowledge cards. Finally, students tested the competitive gamified version with the points and leaderboard (Fig. 4). After the experiment, students were allowed to continue using any application they preferred. The extra time was not included into the results and data analysis but was considered in the discussion part of this paper.

Fig. 4 Student testing one of the applications

F. Questionnarie

After the experiment, a short questionnaire with five groups of questions (25 questions in total) was given to the students. First group included statistical and general questions about mathematics, next three groups were related to the three tested application versions; with 5-Point Likert Scale (1-strongly disagree, 5-strongly agree). Last group of questions was open ended, offering students opportunity to describe which application they liked and disliked the most and why.

IV. Results

To explore students' interest and preferences for different types of gamifications, information on the applications usage was collected in the centralized server database log and analyzed. The analysis also included information from questionnaires, completed right after the intervention.

In total, students solved 496 tasks in the non-gamified application, 651 in adventure application and 850 in competitive application. The total number of solved tasks for each individual student is presented in Fig. 5. Generally, all students showed more interest and solved more tasks in gamified than in the non-gamified applications. Some students were extremely interested in the competitive application (students no. 3, 4, 6, 10, 17), the number of tasks they solved in competitive mode by far exceeds the number of tasks in the other two applications. Other students (e.g., students no. 5, 8, 12 and 15) were more interested (though not so drastically) into the adventure mode, or showed similar level of interest for both gamified applications.

The accuracy of solving the tasks was 77% for the non-gamified version, while in the gamified applications the accuracy was 83% for adventure, and 89% for competitive application.

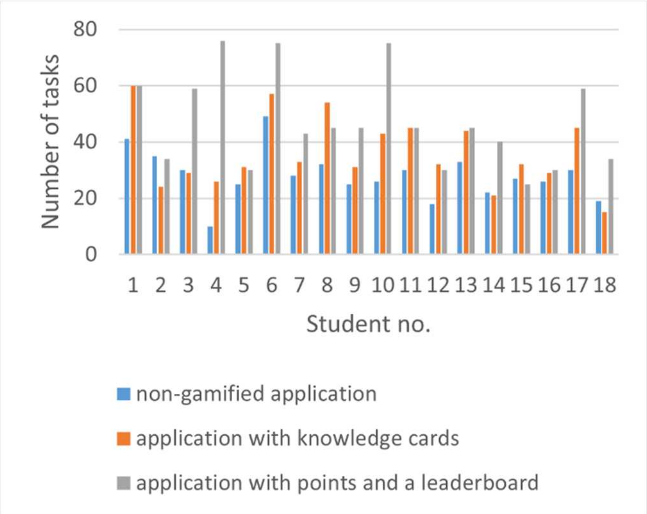

Fig. 5 Number of solved tasks per student

Besides logged data, 18 responses to the questionnaire were collected and analyzed. When asked "Which application did you like the most, and why?", only one student chose a non-gamified application, while 7 students chose adventure gamified application, and 10 opted for the competitive gamified application. The most common argument for choosing the competitive gamified application was "Because I can earn coins and compete with other students" or "Because it has a ranking list / leaderboard". On the other hand, students who chose the adventure application with knowledge cards gave the following explanation: "Because we can learn a lot" or "I like to explore other countries". When asked "Which application you liked the least, and why?" 13 students chose the non-gamified app, 2 students chose the adventure application, while 3 students chose the competitive one. Most students didn't like the non-gamified application because it was "boring" and "they didn't win anything while playing the game", while some didn't like the competitive application with points and leaderboard because they don't like competitions.

From the results it can be inferred that there are different types of students, some prefer adventure mode, while other go for competitive mode (RQ1), which is in line with the theory that the learner's personality can affect the attitude of preferring to use a particular game element [28].

The recorded log data showed that the accuracy of solving the tasks is much higher in gamified applications, and even higher in competitive mode than in the adventure mode. In gamified applications students must work hard to win cards or overtake their classmates by earning coins. It could be possible that the gamified environment has a stronger motivational effect to the students - when they see their peers progressing on the leaderboard, they try to make fewer mistakes because they want to catch up with them, and the results are visible to others (RQ2).

After the experiment, some students chose to continue playing the competitive application, to further improve their score within the class. However, Denden [28] showed that only extroverts and balanced personality learners have high positive attitudes towards using the leaderboard game element. This could explain the fact that despite the high acceptance of the competitive application, three students in the case study marked competitive application as the one they liked the least.

V. Conclusion, Limitations and Future Work

In this paper, the case study which introduced adaptive and gamified digital learning lessons to lower primary school students was presented. The research consisted of different math learning mobile applications, one gamified and two non-gamified. Considering different personalities and presumption that not everyone prefers the same game elements, one gamified application was in the so-called adventure mode, while the other one was competitive. An adaptive algorithm was built into each of the applications to make it easier for students to learn, master and permanently adopt the learning material.

Information on the applications usage shows that the gamified environment has a positive effect on the number of solved tasks and the accuracy of solving, which indicates students' focus on tasks. After conducting the experiment, in an interview with the teachers, the researchers found out that the students were much more motivated and solved more tasks than they would have solved at the same time in normal, offline class. Information collected from the questionnaires indicate students' willingness to learn and use digital educational applications, both, in school and in their free time.

There are some limitations to this study, primarily the short timeframe and rather small sample size. Since this study is the first phase (or a pilot) of a bigger project on different personalized gamification strategies, the future research will include more experiments and with a larger group of participants, which should provide more reliable and statistically more relevant data. Also, the questionnaire was not validated, which will be done in the future research as well.

Future research will include additional personalized gamification paths for students to choose, building on the findings and experience from this case study, especially the fine-grained difference between various gamification modes and its' implementations.

REFERENCES

[1] K. Werbach and D. Hunter, "For the Win: How Game Thinking Can Revolutionize Your Business," p. 149, 2012, doi: 10.1017/CBO9781107415324.004.

[2] J. Majuri, J. Koivisto, and J. Hamari, "Gamification of education and learning: A review of empirical literature," *CEUR Workshop Proc.*, vol. 2186, no. May, pp. 11–19, 2018.

[3] D. Basten, "Gamification," *Ieee Softw.*, vol. 34, no. 05, pp. 76–81, 2017.

[4] A. Darejeh and S. S. Salim, "Gamification Solutions to Enhance Software User Engagement—A Systematic Review," *Int. J. Hum. Comput. Interact.*, vol. 32, no. 8, pp. 613–642, 2016, doi: 10.1080/10447318.2016.1183330.

[5] R. Smith, D. Bean, and R. Moeur, "On the Integration of Human Computation into Traditional Business Processes Productivity Games in Microsoft Windows Development," *Assoc. Comput. Mach.*, 2015, [Online]. Available: http://www.42projects.org/docs/LQG.pdf.

[6] J. Garcia, J. R. Copiaco, J. P. Nufable, F. Amoranto, and J. Azcarraga, "Code it! A gamified learning environment for iterative programming," *Dr. Student Consort. - Proc. 23rd Int. Conf. Comput. Educ. ICCE 2015*, pp. 373–378, 2015, [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84979707911&partnerID=40&md5=79de8b8f745d9cbbd94ef16538938795.

[7] L. de-Marcos, E. Garcia-Lopez, and A. Garcia-Cabot, "On the effectiveness of game-like and social approaches in learning: Comparing educational gaming, gamification & social networking," *Comput. Educ.*, vol. 95, pp. 99–113, 2016, doi: 10.1016/j.compedu.2015.12.008.

[8] I. Yildirim, "The effects of gamification-based teaching practices on student achievement and students' attitudes toward lessons," *Internet High. Educ.*, vol. 33, no. 2016, pp. 86–92, 2017, doi: 10.1016/j.iheduc.2017.02.002.

[9] T. Jagušt, I. Botički, and H.-J. So, "Examining competitive, collaborative and adaptive gamification in young learners' math learning," *Comput. Educ.*, vol. 125, no. June, pp. 444–457, Oct. 2018, doi: 10.1016/j.compedu.2018.06.022.

[10] R. D. Frost, V. Matta, and E. MacIvor, "Assessing the Efficacy of Incorporating Game Dynamics in a Learning Management System," *J. Inf. Syst. Educ.*, vol. 26, no. 1, pp. 59–70, 2015

[11] M. D. Hanus and J. Fox, "Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance," *Comput. Educ.*, vol. 80, pp. 152–161, 2015, doi: 10.1016/j.compedu.2014.08.019.

[12] S. Deterding, R. Khaled, L. Nacke, and D. Dixon, "Gamification: toward a definition," *Chi 2011*, pp. 12–15, 2011, doi: 978-1-4503-0268-5/11/0.

[13] K. M. Kapp, *The Gamification of Learning and Instruction: Game-Based Methods and Strategies for Training and Education*, vol. 2012. San Francisco: John Wiley & Sons., 2012.

[14] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, "From game design elements to gamefulness: Defining 'gamification,'" *Proc. 15th Int. Acad. MindTrek Conf. Envisioning Futur. Media Environ. MindTrek 2011*, no. March 2014, pp. 9–15, 2011, doi: 10.1145/2181037.2181040.

[15] D. Dicheva, C. Dichev, G. Agre, and G. Angelova, "Gamification in Education : A Systematic Mapping Study Gamification in Education : A Systematic Mapping Study," *Educ. Technol. Soc.*, vol. 18, no. June, pp. 75–88, 2015.

[16] C. Cheong, J. Filippou, and F. Cheong, "Towards the gamification of learning: Investigating student perceptions of game elements," *J. Inf. Syst. Educ.*, vol. 25, no. 3, pp. 233–244, 2014.

[17] I. Caponetto, J. Earp, and M. Ott, "Gamification and education: A literature review," *Proc. Eur. Conf. Games-based Learn.*, vol. 1, no. 2009, pp. 50–57, 2014.

[18] I. Rodríguez, A. Puig, and À. Rodríguez, "Towards Adaptive Gamification: A Method Using Dynamic Player Profile and a Case Study," *Appl. Sci.*, vol. 12, no. 1, 2022, doi: 10.3390/app12010486.

[19] E. Lavoué, "LudiMoodle: Adaptive Gamification to Improve Learner Motivation," *Spec. theme Educ. Technol.*, pp. 19–20, 2020, [Online]. Available: https://hal.archives-ouvertes.fr/hal-03218980.

[20] D. Codish and G. Ravid, "Personality based gamification: How different personalities percive gamification," *ECIS 2014 Proc. - 22nd Eur. Conf. Inf. Syst.*, no. January 2014, 2014.

[21] R. Bartle, "Hearts, Clubs, Diamonds, Spades: Players Who Suit Muds," *J. MUD Res.*, vol. 1, no. 1, p. 19, 1996, [Online]. Available: https://www.hayseed.net/MOO/JOVE/bartle.html%0Ahttps://www.researchgate.net/profile/Richard_Bartle/publication/247190693_Hearts_clubs_diamonds_spades_Players_who_suit_MUDs/links/540058700cf2194bc29ac4f2.pdf.

[22] A. Marczewski, *User Types. In Even Ninja Monkeys Like to Play: Gamification, Game Thinking and Motivational Design*. CreateSpace Independent Publishing Platform., 2015.

[23] S. A. Kocadere and S. Çağlar, "Gamification from player type perspective: A case study," *Educ. Technol. Soc.*, vol. 21, no. 3, pp. 12–22, 2018.

[24] T. Jagust, I. Boticki, V. Mornar, and H. J. So, "Gamified Digital Math Lessons for Lower Primary School Students," *Proc. - 2017 6th IIAI Int. Congr. Adv. Appl. Informatics, IIAI-AAI 2017*, pp. 691–694, 2017, doi: 10.1109/IIAI-AAI.2017.17.

[25] A. Mora, G. F. Tondello, L. E. Nacke, and J. Arnedo-Moreno, "Effect of personalized gameful design on student engagement," *IEEE Glob. Eng. Educ. Conf. EDUCON*, vol. 2018-April, pp. 1925–1933, 2018, doi: 10.1109/EDUCON.2018.8363471.

[26] S. Hallifax, A. Serna, J. C. Marty, G. Lavoué, and E. Lavoué, "Factors to consider for tailored gamification," *CHI Play 2019 - Proc. Annu. Symp. Comput. Interact. Play*, pp. 559–572, 2019, doi: 10.1145/3311350.3347167.

[27] É. Lavoué, B. Monterrat, M. Desmarais, and S. George, "Adaptive Gamification for Learning Environments," *IEEE Trans. Learn. Technol.*, vol. 12, no. 1, pp. 16–28, 2019, doi: 10.1109/TLT.2018.2823710.

[28] M. Denden, A. Tlili, F. Essalmi, and M. Jemni, "Educational gamification based on personality," *Proc. IEEE/ACS Int. Conf. Comput. Syst. Appl. AICCSA*, vol. 2017-Octob, pp. 1399–1405, 2018, doi: 10.1109/AICCSA.2017.87.

[29] G. Borotić, G. Gledec, and T. Jagušt, "Exploring the Usage of an Adaptive Learning System for Elementary School Math Classes," Submitted to *Central European Conference on Information and Intelligent Systems*, 2022.