

NEURAL NETWORKS IN IDENTIFYING TEACHERS' SELF-PERCEIVED COMPETENCIES IN DIGITAL GAMIFICATION

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ABSTRACT

In the last ten years, the integration of information and communication technology (ICT) into education has become more and more prevalent, as ICT has become an indispensable part of everyday educational life. With the development of ICT, the number of teaching strategies involving the use of ICT has also increased. One of the latest strategies for the use of ICT in education is digital gamification. ICT can serve as a technological basis for the creation and further development of gamification experiences. The development of new technologies and teaching strategies implies the development of teacher competencies for the application of teaching methods based on the use of ICT, including digital gamification. The application of gamification in education brings numerous benefits and is used for various purposes, from influencing student motivation and engagement, improving educational outcomes and creating interactive learning opportunities, to the application of gamification in student evaluation. With the aim of better understanding teachers' self-assessed competencies in the use of digital gamification, this paper focuses on the association between these assessments and their overall ICT use and gamification in student evaluation with other demographic variables. The aim was to develop a successful neural network model using these variables that is able to identify the teachers with a high level of competence. The best neural network model obtained had an overall classification accuracy of 75% and was able to identify all teachers with a high self-assessed level of competence in the use of digital gamification in the education of students.

Keywords: *digital gamification, information and communication technology, neural networks, self-assessments, teachers.*

Introduction

Accelerated development of information and communication technologies (ICT) is rapidly changing all spheres of life, including education, resulting in broader opportunities for the application of ICT in education. Numerous governments have made

significant investments in the process of providing educational institutions with ICT devices and resources which has led to a rapid development of ICT-related tools in educational practices (Fernández-Gutiérrez et al., 2020). Consequently, new educational practices were developed that included methods and strategies based on ICT tools. The global shift towards a digital economy and society necessitates modifications in the technology employed by educators in schools and educational institutions to train modern teachers (Desnenko et al., 2021). Ensuring equitable and high-quality learning requires teachers to possess the necessary competencies for effectively integrating ICT into their professional practice, enabling transformative pedagogy and empowering students to develop essential Knowledge Society skills such as critical thinking, innovation, problem-solving, collaboration, and socio-emotional abilities (UNESCO, 2018). Unlike traditional approaches, which put the teacher at the focus of the lesson, modern teaching strategies put the student at the centre. While the instructor serves as his guide and partner, the student actively participates in the learning process by gathering, considering, locating, and analysing information. Gamification, described as “the use of elements of play in a non-playing context” (Deterding et al., 2011, p. 10), emerges in the context of contemporary approaches to education. With more and more devices having digital technology installed, it is possible to implement the gamification method by using a variety of digital tools to improve student engagement and motivation. In addition to the fact that gamification in education increases student motivation and engagement (Rozhenko et al., 2021; Royas-López et al., 2019; Barna & Fodor, 2018), it can enhance interaction (Kepceoglu, 2019; Barna & Fodor, 2018) and achievement (Kepceoglu, 2019; Lopes et al., 2019) but also support student’s social, emotional or cognitive dimensions (Domínguez, et al., 2013). As reported by Mårell-Olsson (2022) it takes a variety of skills to prepare teachers to design gamification activities that effectively encourage and engage students while improving their learning. It requires specialized knowledge in creating engaging activities that incorporate learning material from a variety of areas and the flexibility to adjust to organizational changes. This preparedness entails modifications to educational practices that facilitate collaborative design processes in addition to the development of personal competency. Teachers need to have a supportive environment that encourages innovation in teaching methods in addition to their own areas of expertise in order to execute digitalized gamification activities using contemporary technologies (Mårell-Olsson, 2022). Gamification can be applicable in a variety of educational situations, from learning, through monitoring student progress to its application in student evaluation. According Menezes & Bortoll (2016) there are three forms of evaluation: formative, summative, and diagnostic, while Sudakova et al. (2022) specifies four types of assessments: formative, summative, diagnostic and evaluative. It’s important to recognize that formative and summative evaluations serve different assessment purposes, rather than simply being different evaluation types or formats, and in certain situations, the same type of data can be used both formatively and summatively (Dolin et al., 2018). It is widely accepted that feedback is a crucial component of a broader formative assessment framework (Wiliam, 2018, as cited in Morris, Perry, & Wardle, 2021). Both

feedback and formative assessment gathering and offering details regarding a student's present performance or understanding with the goal of improving their learning (Morris, Perry, & Wardle, 2021). The primary objective of summative assessment is often to provide a comprehensive evaluation of students' learning progress at a specific point in time, rather than to influence their continuing learning, as is the case with formative assessment (Dolin, et al., 2018). Given that the success of gamification may depend on context (Hamari, Koivisto, & Sarsa, 2014; Hamari, 2013; Thom, Millen, & DiMicco, 2012), the role of the teacher and his competences in the application of gamification is crucial.

Literature preview

According to the available literature, a smaller number of studies focused on the research of teacher competences for the application of gamification.

Nousiainen, et al. (2018) conducted an analysis on the specific competences required by teachers while employing game-based pedagogy, which encompasses the utilization of educational games or entertainment games, learning through game creation, and the implementation of gamification in the learning process. The results revealed four primary competence areas: pedagogical, technological, collaborative, and creative (Nousiainen et al., 2018).

Hanifah et al. (2021) investigated the application of the gamification strategy in the context of teacher education and training sessions. The study primarily centered on three key variables: gamification knowledge, gamification skills, and the utilization of gamification among Geography trainee teachers. Based on the findings, it can be concluded that the degree of knowledge regarding the gamification approach is rather high. Additionally, the skill level and the level of use are also quite high. In conclusion, the findings indicate that trainee teachers frequently employ the gamification technique when imparting knowledge and facilitating learning.

The scientific community in the last few years is far more interested in studying the use of gamification in student assessments. The performed studies focused on traditional assessment model vs. game-based mode comparison (Areed et al., 2021; Sanchezm et al., 2020; Zainuddin et al., 2020; Sánchez-Rivas et al., 2019), how students with reading difficulties viewed and used a gamified assessment (Reed et al., 2019), importance of online gamification flip learning using gamified formative assessment (Zainuddin et al., 2021), using assessment tools such as Quizizz (Ccoa et al., 2023; Handoko et al., 2021; Prestiadi et al., 2021; Orhan Göksün & Gürsoy, 2019), Kahoot! (Jones et al., 2019; Orhan Göksün & Gürsoy, 2019) or others game-based assessment tools (Jo et al., 2021). Some authors focused on analysing negative impact of gamified assessment activities (Kwon & Özpolat, 2021).

Several studies have indicated that the implementation of gamification for assessment purposes has led to enhanced academic performance (Jones et al., 2019; Orhan Göksün & Gürsoy, 2019), increased student engagement (Orhan Göksün & Gürsoy, 2019), enhanced learning motivation (Ccoa et al., 2023; Zainuddin et al., 2020; Jo et al., 2021),

reduced levels of stress (Ccoa et al., 2023), alleviated the learning load (Jo et al., 2021). Also, gamification might yield positive outcomes in the short term, and demonstrated that interpersonal differences may have an impact on those benefits (Sanchez et al., 2020). The results demonstrated that taking the gamified online quiz was more successful than taking traditional paper quizzes (Areed et al., 2021; Sánchez-Rivas et al., 2019). They are more effective in formative assessment when it comes to evaluating the students' learning outcomes (Areed et al., 2021). Also, most students exhibit a preference for Quizizz as an assessment tool when compared to paper and Google Forms (Handoko et al., 2021). Learner engagement has been positively impacted by formative assessments that use online flipped learning strategies and gamified learning (Zainuddin et al., 2021). The findings of the study on the utilization of Quizizz gamification as an online assessment tool indicate that it can serve as an effective means of evaluating students (Prestiadi et al., 2021). Additionally, it offers a more enjoyable and visually appealing assessment experience (Prestiadi et al., 2021). Students preferred Kahoot and Quizizz apps in the classroom for their need for motivation and rapid feedback on test performance (Orhan Göksün & Gürsoy, 2019). Compared to Kahoot, Quizizz proved to be less successful for educational activities (Orhan Göksün & Gürsoy, 2019). Students with reading difficulties was fully engaged in the gamified reading assessment and were motivated by activities that provide a suitable level of challenge without being excessively frustrating (Reed et al., 2019). In contrast, Kwon and Özpolat (2021) discovered that the implementation of gamification in assessment activities led to a notable decline in content knowledge, contentment, and overall course experience.

Despite the contradictory results, most studies show that gamified quizzes can be successfully applied in student assessment and can serve as an alternative way of evaluating students. According to the available literature, there is no research that examines the association between teacher competencies and the application of gamification in student evaluation, this paper focuses on research into this topic. With the aim of better understanding teachers' self-assessed competencies in the use of digital gamification, this paper focuses on the association between these assessments and their overall ICT use and gamification in student evaluation with other demographic variables. The aim was to develop a successful neural network model using these variables that is able to identify the teachers with a high level of competence.

Methodology

The study was conducted online during the academic year 2022/2023. The social network Facebook was used as a research tool to collect data from teachers from different parts of Croatia. An online questionnaire was created, which consisted of three blocks of questions to collect general demographic data (4 variables), data on formative and summative assessment of students (48 variables), data on the frequency of use of ICT in teaching, its usefulness and self-assessed competences (12 variables). The first block of questions was used to collect data on gender, age, the county in which the participants

work at the school and the area (rural or urban) in which the school is located. The second block was designed to find out whether the participants use digital tools for formative or summative assessment of students and which digital tools they have used for these purposes so far. For these purposes, participants could indicate which of the 22 tools offered they use, indicate that they have not used any of the tools offered, or give the name of another tool they have used. The last block of questions dealt with the frequency with which the participants use information and communication technology in teaching, its use in the assessment of students (8 Likert scale were used for this), whether the participants consider it useful in the teaching process and how they themselves assess their competencies in the use of information and communication technology and digital gamification in teaching.

A total of 159 participants took part in this study. The majority of them were female (88.54%) with the mean age of 40.5 years (SD = 9.54). The participants came from all 21 Croatian counties (see Figure 1), with most of them coming from Vukovar – Srijem County (19.10%) and almost equal numbers of respondents came from rural (49.68%) and urban (50.32%) areas.

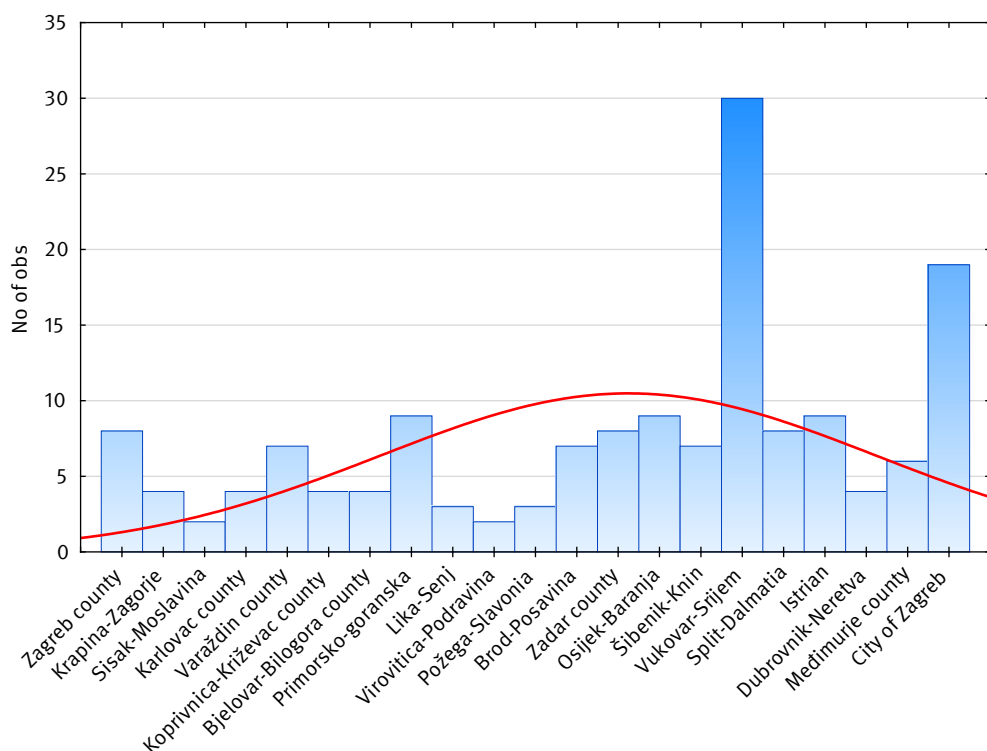


Figure 1 Number of participants according to the county in which the school in which the participants are employed is located

Results

The majority of participants indicated that they use digital tools for formative assessment of students (85.35%) and 64.97% of them indicated that they also use digital tools for summative assessment. When asked which digital tool participants use for formative assessment of students, most indicated they use Wordwall (75.80%), 71.97% indicated Kahoot, and more than two-thirds of participants (69.43%) indicated they use Microsoft Office tools for formative assessment. Although these tools were also most commonly used by participants for summative assessments, a lower percentage of them indicated that they used these tools for this purpose. Thus, 52.87% of participants stated that they use Microsoft Office tools for this type of assessment, 33.76% Wordwall and 31.85% Kahoot.

Most of the participants (42.67%) stated that they use ICT in class every day and only 2.55% stated that they do not use ICT in class at all. Furthermore, the majority of participants (91.08%) consider ICT in the classroom to be useful, most of them (48.41%) self-assessed their level of competence in using ICT in the classroom as advanced but most of the participants (43.31%) self-assessed their level of competence in using digital gamification in the classroom as basic.

In addition, most participants often use digital tools for formative assessment of students (45.86%) as well as summative assessment (33.76%), sometimes use elements of digital gamification for formative assessment (31.85%) and never use elements of digital gamification for summative assessment (25.48%). They often use feedback obtained through the use of ICT in assessment (33.76%), feedback obtained through the use of gamification in assessment (26.11%) and feedback obtained with ICT and gamification to analyze the achievement of educational outcomes (36.31%) and to adapt and plan lessons (34.40%).

The χ^2 -association test showed that there was a statistically significant association at the 0.05 level of significance between the self-reported level of competence in the use of digital gamification in teaching and: the use of digital tools for formative assessment ($\chi(3) = 21.78, p = .000$), summative assessment ($\chi(3) = 8.52, p = .036$), some tools previously used for formative assessment (MS Office tools ($\chi(3) = 23.35, p = .000$), BookWidgets ($\chi(3) = 17.80, p = .000$), Edmodo ($\chi(3) = 9.66, p = .022$), GoogleClassroom ($\chi(3) = 11.19, p = .011$), Google Forms ($\chi(3) = 35.25, p = .000$), Kahoot ($\chi(3) = 27.87, p = .000$), LearningApps ($\chi(3) = 12.25, p = .007$)), some tools previously used for summative assessment (MS Office tools ($\chi(3) = 14.30, p = .003$), Edmodo ($\chi(3) = 10.12, p = .02$), Google Forms ($\chi(3) = 20.18, p = .000$), Kahoot ($\chi(3) = 11.57, p = .009$), Quizlet ($\chi(3) = 10.95, p = .012$)), no use of summative assessment tools ($\chi(3) = 8.11, p = .044$), self-assessment of how often they use ICT tools in the classroom ($\chi(12) = 24.41, p = .018$), self-assessed level of competence in using ICT in teaching ($\chi(9) = 103.59, p = .000$) and all 8 variables used to assess the frequency of use of information and communication technology and gamification in student assessment (use of digital tools for formative assessment of students ($\chi(12) = 68.15, p = .000$), use of digital tools for summative assessment ($\chi(12) = 46.89,$

$p = .000$), use of elements of digital gamification for formative assessment ($\chi(12) = 77.24$, $p = .000$), use of elements of digital gamification for summative assessment ($\chi(12) = 48.65$, $p = .000$), use of feedback obtained through the use of ICT in assessment ($\chi(12) = 32.16$, $p = .000$), use of feedback obtained through the use of gamification in assessment ($\chi(12) = 51.27$, $p = .000$), use of feedback obtained with ICT and gamification to analyze the achievement of educational outcomes ($\chi(12) = 39.59$, $p = .000$) and to adapt and plan lessons ($\chi(12) = 43.27$, $p = .000$).

Statistica 13 software was used to model the neural networks and the random sampling method was applied. In addition, the sample was split up into three subsamples: a test (20%), a validation (10%), and a training (70%). Binary variable was the output variable in which the teachers with high self-competence in the use of digital gamification were assigned to category 1 and the other participants to category 0. All variables that showed a statistically significant association with the selected output variable of the NN model were removed from the modelling and a total of 38 variables were used for this purpose.

The type of NN chosen was a multilayer perceptron, the minimum number of hidden units was set to 8 and the maximum to 25, the error functions used were the sum of squares and the cross entropy, the activation functions used were the logistic, the hyperbolic tangent, the exponential and the sine function. In addition, 200 neural networks were modelled. The best NN model was obtained with the exponential activation function. This model had an overall accuracy of 75% and was able to recognize 60% of teachers who did not have high competence in the use of digital gamification and all of those who did.

Conclusion

This paper examines the association between teachers' self-assessed digital gamification competencies and their overall use of ICT in student evaluation with other demographic variables to better understand them. Results showed statistically significant association between several variables, and we successfully developed a neural network model. Detecting teachers with a high or low level of self-assessment of competence in digital gamification is important for several reasons. Identifying teachers with a high degree of self-assessment enables the identification of best practices in the use of digital gamification in teaching. This may result in the development of a model for training other teachers to improve their skills in this area. Teachers with low self-esteem may need additional support and resources to improve their skills in using digital gamification. Using digital gamification can have a positive impact on student engagement and motivation, as well as on their learning outcomes. Identifying teachers with high levels of self-esteem allows the promotion of these practices that can improve learning outcomes.

Like most research, ours also has several limitations which are primarily related to the size of the sample, but also the greater representation of female respondents. Therefore, future research should include a larger number of respondents, but also a more

balanced gender ratio. Furthermore, it would be good to expand the research to more countries in the surrounding area.

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