

BUILDING A CURRICULAR EDUCATIONAL PROGRAM FOCUSED ON GAMIFICATION, AI AND CHATGPT TO PROMOTE THE STUDY OF MATHEMATICS

PHD STUDENT DENISA GEORGIANA MAZURU¹, PROFESSOR
GEANINA HAVĂRNEANU²

¹ALEXANDRU IOAN CUZA" UNIVERSITY, PSYCHOLOGY AND EDUCATIONAL SCIENCES DEPARTMENT,
IASI, ROMANIA

²ALEXANDRU IOAN CUZA" UNIVERSITY, PSYCHOLOGY AND EDUCATIONAL SCIENCES DEPARTMENT,
IASI, ROMANIA

EMAIL: ¹denisa.mazurugeorgiana21@gmail.com, ²geanina.havarneanu@uaic.ro
ORCHID ID NUMBER: ¹0009-0008-0840-1315, ²0000-0003-2402-0789

ABSTRACT:

The present paper aims to analyse to what extent the construction of a curricular educational program focused on innovative didactic approaches through gamification and AI constitutes the answer to increasing school performance in learning mathematics and eliminating anxiety in mathematics lessons.

The theoretical sequence focuses on the methodology of structuring such a program, and it highlights AI and gamification as a complex educational strategy that involves not only the creation and use of games in the learning process but also captures the idea of building educational experiences that use gamification to promote specific values, attitudes, and behaviours. In the empirical sequence, we present the design focused on a construction composed of two groups, one control group, and one experimental group, subjected to a curricular educational program for one month. The program of the experimental group had in mind solving didactic tasks related to the curricular content using exclusively AI and gamification to solve problems by composing or using programs in Scratch. The results of the quasi-experiment are analysed, highlighting the specific advantages of using AI and gamification: increasing the ability to understand mathematical phenomena, increasing motivation for learning, shaping an efficient learning environment, and decreasing anxiety about learning mathematics.

KEYWORDS: AI, gamification, creative resolute demarch, curricular educational program, anxiety in mathematics lessons

1) INTRODUCTION:

Numerous studies state that mathematics is associated with effective modelling of reality [1]. In addition, mathematics offers the possibility of reconfiguring productive thinking on a different scale (fluidity, flexibility, originality, elaboration, sensitivity to problems) both in the context of "horizontal mathematization" (mathematical modelling of reality) and in that of "vertical mathematization" (the fundamental, complex restructuring of mathematics) [2].

Studies have shown that learning mathematics can be full of difficulties that lead to repeated experiences of low school performance, lack of motivation, and lack of involvement [3]. One of the solutions would be to teach mathematics attractively and actively, involving students in building mathematical operational background through problem-based activities and deep understanding [4]. Exposure to effective instructional strategies and practices results in improved student performance, providing them with a practical and operational background over time [5].

In this study, we began with an experimental design based on a curricular educational program to introduce students to a formal environment focused on gamification, AI, and ChatGPT to promote increased school performance in mathematics.

If well implemented, a correctly structured curriculum focused on elementary mathematics in early childhood education can significantly impact students' future academic performance [6]. Building a curricular educational program is increasingly used in modern educational experiences of structuring specific to mathematical subjects [7] since active learning is stimulated if teachers use innovative approaches in teaching mathematics [8]. One of these strategies is gamification [9], which helps students become more creative in solving problems [10]. It develops their critical thinking as a process of intentional evaluation of the data of the problem and as a process of logical inference [11].

In the introduction of gamification, it should be taken into account that the interest of the students in the proposed subject and the willingness to engage in a competitive environment are essential [12]. In addition, the achievement of the objectives proposed by the teacher is highly dependent on the cognitive involvement of the students in the

game, the context of the learning process, and the degree of success achieved by the students in the game, which can motivate or demotivate them [13].

Gamification can develop the metacognitive and self-regulatory processes, make correct decisions [14], and produce resolution strategies for a problem or a valid conclusion based on arguments [15]. Gamification as a mathematics teaching-learning-assessment strategy increases student academic performance by 25% [16], and it helps them understand the purposes of practical applications and the mathematical models involved in problem-solving design, thus making learning more meaningful [17].

Gamification must be based on respecting one's own pace of solving [18], an immediate feedback system, and a network of prior knowledge, which can be used in the puzzle-solving strategy involved in didactic gamification [19]. In mathematics, gamification means more than being involved in a competition [20]. The goal is to develop the relevant skills to move to the next level based on acquired competencies in mathematics. It has been found that students involved in such educational activities often create a sense of completeness and satisfaction once they have passed each level [21]. Gamification activities that allow students to evolve and interact are effectively educational, creating a collaborative and constructive learning experience [22].

Artificial intelligence can help in deep learning if it goes beyond algorithmic learning [23] and stimulates creativity, respectively, critical-heuristically thinking through dynamic learning environments that are interactive and student-centred [24]. The augmented reality components also make geometry problems more straightforward to understand by transforming real-time images into moving 3D images that are easier to comprehend [25]. Augmented reality is preferable to virtual reality because it is 75% reality, and 25% virtuality [26], representing a relatively faithful model of reality, immersing the student in an environment that simulates reality quite well, which the student must analyse [27].

Mathematics has an abstract and generalizing character, making it difficult for students to understand [28]. It represents a tool that uses symbolic language to illustrate abstract concepts that shape reality [29]. To help students go through the entire pyramid that summarizes the taxonomy of cognitive levels designed by Bloom [30] updating by Anderson and Krathwohl [31] and succeed in acquiring specific skills of knowing, understanding, applying, analysing, evaluating, and creating in the field of mathematics at the level of performance, success, and even school performance, the teacher needs to find the strategies that motivate the student to make an individual cognitive effort [32].

Strategies to ensure efficiency in learning mathematics must focus on student motivation, structuring an operational cognitive background, and accessibility of personalized support to students' individual needs [33]. The teachers must also consider parents' positive attitude regarding the essential influence of school on learning [34] and the teacher's affective support [35].

Although I do not believe that AI will ever replace the positive influence of a human teacher, the advancement of artificial intelligence has provided strategies to mediate the mentor's impact on the student in the teaching process [36]. The development of algorithms specific to complete deep learning applications capable of resolving problems, inferring, and making decisions [37] provides students with examples of good practices.

AI-controlled applications have even been created to help students cope with complex tasks [38], which focus on students' cognitive thinking [39]. AI aims to identify students exposed to school failure and create a customized educational program that students can complete on time, ensuring the knowledge necessary to move to a higher level of learning [40].

AI projects consider using a human-centric approach to augment human intelligence using digitization. In this sense, several trends have been structured. The first trend is Open Learner Modelling, a branch of intelligent tutoring systems research that provides relevant tools for managing the systems needed to model students' cognition and emotions to support human learning and teaching [41]. Another trend is the design of transferable intelligence that has proven more effective in machine learning by generating and adopting new deep learning algorithms and providing customized intelligent support such as Bidirectional Encoder Representations from Transformers (BERT) [42], or Generative Preforming (GPT) [43].

2) METHODS AND METHODOLOGY:

Based on recent research has proven that gamification meets the needs of visual, auditory, and kinesthetic learners [44], that math anxiety hinders learning and reduces school performance [45], and that the use of elements of gamification in mathematics education can help reduce stress among students [46]. In this sense, we built this research to study the influence of gamification, AI, and ChatGPT in the mathematical educational process on school performance according to the type of intelligence and their influence on reducing anxiety in mathematics study.

(a) Research question

Are complex educational strategies, such as artificial intelligence and gamification, involved in increasing school performance in learning mathematics and eliminating anxiety in mathematics lessons?

(b) Research variables

Dependent variables: curricular educational program through gamification and AI. Independent variables: school_efficiency, school_efficiency_level, intelligence type, anxiety

(c) Operationalization of variables; used tools

We constructed a quantitative variable called *school_efficiency*, which represents the difference between the result obtained in the final docimological test, the posttest, and the result obtained in the pretest, which preceded the educational interventions based on gamification and AI. We considered a positive difference to be an increased yield, highlighting an improvement in student performance due to participation in the educational intervention program that provides for administering an educational treatment based on gamification, using programming languages such as Scratch or Blockly, respectively, using AI. A difference very close to 0 suggests stagnation, reflecting the absence of significant changes in school performance, and a negative difference suggests low school performance. Based on this variable, we built a new ordinal variable *school_efficiency_level* with five categories: with categories like Likert scale: "low" (label for values in the range $[-3,2,-1,64]$), "below basic" (label for values in the range $[-1.64,-0.08]$), "basic", (label for values in the range $[-0.08,1.48]$), "proficient" (label for values in the range $[1.48,3.04]$) and "advanced" (label for values in the range $[3.04,4.6]$).

The level of each type of intelligence was identified using the Walter McKenzie [47] Multiple Intelligences (M.I.) Inventory, 1999, nonhierarchical intelligences, operationalised by naturalistic_intelligence, musical_intelligence, logical-mathematical_intelligence, existential_intelligence, interpersonal_intelligence, kinesthetic_intelligence, linguistic_intelligence, intrapersonal_intelligence, and visual-spatial_intelligence.

The instrument used to determine the level of anxiety related to the study of mathematics is the School Anxiety Scale (SAS), developed by psychotherapist Beeman N. Phillips (1978) [48], operationalised by *school_anxiety*, *experiencing_social_stress*, *frustration_of_the_need_to_achieve_success*, *fear_of_self-expression*, *fear_of_a_knowledge_test_situation*, *fear_of_not_meeting_the_expectations_of_others*, *low_physiological_resistance_to_stress*, *problems_and_fears_in_relationships_with_teachers*.

(d) Research hypotheses

H_0 : No correlation exists between school performance obtained within a gamification and AI-based curriculum educational program and mathematics anxiety, filtered by the types of intelligence.

H_1 : A statistically significant correlation exists between school performance obtained within a gamification and AI-based curricular educational program and mathematics anxiety, filtered by the types of intelligence.

(e) Study participants

The study participants are two groups of non-voluntary 10–11-year-old students. The first group, called gamification and AI group, followed a curricular educational program for a month to teach students about problems and projects that can be solved exclusively through gamification or AI. To this end, students were introduced to the basic concepts of the programming languages Scratch and Blockly and ways to use AI chatbots responsibly and ethically.

The control group only participated in the tests, and the contents studied were according to the curriculum.

(f) The experimental design

The groups participating in the study benefited from a pretest, and depending on its results, we determined the experimental group. To ensure that hidden variables would not distort the experiment's results, we determined that the group that obtained the lowest mean on the pretest must be the experimental group, and the group with the highest mean must be the control group.

For one month, the experimental group was subjected to a curricular educational program (following the same contents as the control group) designed to propose and solve projects and problems through creative solutions that exclusively used gamification and AI.

3) RESULTS:

We used the Spearman correlation to determine if there are correlations between the numerical variable *school_efficiency* (*school_efficiency*) that does not follow a normal distribution and the ordinal variables that denote all types of anxiety. Following the use of the Spearman correlation, the following results were recorded between the variable *school_efficiency* and:

- *School_anxiety*: G1: $\rho(11) = 0.027$, $p = 0.93$; G2: $\rho(15) = 0.125$, $p = 0.63$;
- *Experiencing_social_stress*: G1: $\rho(11) = -0.186$, $p = 0.543$; G2: $\rho(15) = -0.369$, $p = 0.144$;
- *Frustration_of_the_need_to_achieve_success*: G1: $\rho(11) = 0.355$, $p = 0.234$; G2: $\rho(15) = -0.014$, $p = 0.956$;
- *Fear_of_self-expression*: G1: $\rho(11) = -0.276$, $p = 0.362$; G2: $\rho(15) = 0.415$, $p = 0.097$;
- *Fear_of_a_knowledge_test_situation*: G1: $\rho(11) = -0.102$, $p = 0.74$; G2: $\rho(15) = 0.364$, $p = 0.151$;
- *Fear_of_not_meeting_the_expectations_of_others*: G1: $\rho(11) = -0.038$, $p = 0.902$; G2: $\rho(15) = 0.125$, $p = 0.632$;
- *Low_physiological_resistance_to_stress*: G1: $\rho(11) = 0.054$, $p = 0.86$; G2: $\rho(15) = 0.078$, $p = 0.767$;
- *Problems_and_fears_in_relationships_with_teachers*: G1: $\rho(11) = -0.092$, $p = 0.76$; G2: $\rho(15) = 0.326$, $p = 0.202$.

We wanted to check whether school performance decreases with increasing general anxiety about the school environment, and we applied the Spearman correlation. The results of the Spearman test, $p(47) = -0.176$, $p > 0.05$, show no association between the two variables. Then we applied the Gamma association test for ordinal variables; we analysed the relationship between students' anxiety towards the school environment and their

school_efficiency_level. The results show a significant negative association ($p = 0.043 < 0.05$), but relatively weak, between these two variables because the correlation coefficient Gamma is -0.223 . The obtained data suggest that the decrease in school performance is associated to a certain extent with the increase in the anxiety level of students.

4) DISCUSSIONS

These results suggest that the null hypothesis is excluded, and hypothesis H_1 is validated. There is, however, a statistically significant correlation between the efficiency_school_level and students' anxiety in test situations, as the significance threshold is $p = 0.05$. However, according to Cohen's criteria, the Spearman correlation coefficient value, $\rho(47) = -0.281 < 0.3$, suggests a weak and inversely proportional correlation between school performance and test anxiety, which means that there is a slight tendency that students with higher academic performance to have lower levels of anxiety towards assessment situations, but the effect is relatively small.

We notice that among the students who did not show any anxiety towards the school environment, 33.3% obtained a "below basic" level performance, and the other 66.7% fell into the "advanced level". Also, of the students with a low level of anxiety, 16.7% achieved the performance "proficient", and the other 83.3% achieved scores that placed them in the "advanced" category. In the case of students with a moderate level of anxiety towards the school environment and all that it entails, 6.2% obtained a low performance, 12.5% fell into the "below basic" category, 12.5% were classified at the "basic" level, 12.5% were in the "proficient" category, and the majority, 56.3%, obtained scores that placed them in the "advanced" category. Among students with a high level of school anxiety, 17.6% achieved low performance, 29.4% achieved the "below basic" performance level, 5.9% achieved a score in the "basic" category, 5.9% fell into the "proficient" category, and 41.2% were considered advanced. Finally, among students with very high school anxiety, 14.2% achieved low performance, 14.2% achieved below basic level, 28.7% achieved "proficient" performance and 42.9% were classified as "advanced".

5) CONCLUSION

It can be stated that the students who interacted with the Scratch application and solved problems using technology achieved significantly better school performance than those who participated in unmodified activities, their mean being 8.69, much higher than the control group's mean of 6.61. The following results were obtained after analysing the fulfilment of the objectives of the curricular educational program. In the post-test, the experimental group achieved a success rate on the program objectives of 88.55%, a percentage value that reveals the total success of the curricular educational program. Therefore, the intervention program successfully improved the students' mathematics results by exposing this experimental group to gamification, AI, and digital applications. The results of the students in the control group showed a partial degree of success on program objectives, as the percentage rate was 67.94% [49].

After implementing the gamification, AI, and digital applications-based intervention program, the student's test scores increased significantly in the post-test compared to the pre-test.

In addition, the negative scores for Experiencing social stress (-0.186), Fear of self-expression (-0.276), Fear of a knowledge test situation (-0.102), Fear of not meeting the expectations of others (-0.038) Problems and fears in relationships with teachers (-0.092), as well as deficient scores on the other anxieties, prove that the virtual environment is considered safe by the students and helps them to be more involved in the task, more motivated to solve the task successfully, and more excited about the activity carried out.

In conclusion, the results of the quasi-experiment highlight the specific advantages of using artificial intelligence and gamification: increasing the ability to understand mathematical phenomena, increasing motivation for learning, modelling an effective learning environment, and decreasing anxiety about learning mathematics.

6) Data Availability:

The data that support the findings of this study are available from https://www.researchgate.net/publication/383693465_Articol_Gamificare-Anxietate?channel=doi&linkId=66d728922390e50b2c2c25fb&showFulltext=true

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