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GAMIFICATION AND MATHEMATICS: PLAYING FOR BETTER LEARNING

S. El Bakkali [1] K. Raouf [2] M. Serghini [3] M. Barkatou [1] H. Nebdi [1]

1. Laboratory of Innovation in Science, Technology, and Modeling, Department of Physics, Faculty of Sciences, University of Chouaib Doukkali, El Jadida, Morocco, souniaelbakkali@gmail.com, barkatou.m@ucd.ac.ma, nebdi_hamid@yahoo.fr

2. Laboratory of Innovation in Science, Technology and Modeling, Department of Physics, Faculty of Science, University of Chouaib Doukkali, El Jadida, Morocco - Interdisciplinary Team, Science and Technology Teaching-Learning Systems, Casablanca-Settat Regional Center for Education and Training, El Jadida, Morocco raouf.crmef@gmail.com

3. LASTIE, Research Team GIDS&SE/ENS, Faculty of Science Ben M'Sik, Hassan II University, Casablanca, Morocco serghimido@gmail.com

Abstract- This study aims to experiment with a gamification device that utilizes the Kahoot tool and evaluate its impact on mathematics learning in the final year of secondary school. The selection of this level is justified by the fact that successful completion of this year results in a certificate that allows progression to high school. The objective is to make the mathematical concepts more accessible for the learners, to motivate them and help them overcome their difficulties, and to make them love mathematics through games. It is a device aiming at modeling and realizing a program of support and reinforcement of the learning program in the first semester to better prepare the learners for the regional standardized exam. To accomplish this, we utilized an experimental methodology involving a study population of 480 students who were segregated into two distinct groups: the control and the experimental group. The device's impact was assessed through a combination of methods, including pre-test and post-test evaluations for both groups, comparing the outcomes of the two groups, and analyzing the results of learners on the regional standardized exam. It appears that the device had a favorable impact on the students, as evidenced by increased motivation, comprehension, and engagement in the teaching and learning process.

Keywords: Mathematics, Gamification, Middle School, ICT.

1. INTRODUCTION

Mathematics, internationally, is considered by the majority of learners to be a difficult discipline [3, 5, 9], which discourages them from engaging in its learning process. In Morocco, despite the efforts made in terms of reforms for quality teaching- learning [13, 15], the results of the international studies TIMSS [16] and PISA [17], as well as the national study NAAP [11], show a weakness in mathematical achievements and skills among the majority of students. In fact, according to the TIMSS 2019 research [16], Moroccan students who were in their second year of middle school were positioned at the bottom of the mathematics rankings, albeit with a small improvement (+4 points) compared to the results of TIMSS 2019 [16]. The analysis of data from the PISA 2018 [17] survey, as presented in a report by the national agency responsible for evaluating the education, training, and scientific research system (2021), highlights a deficiency in the abilities of Moroccan students. A staggering 76% of these students were unable to achieve the minimum level of competency in mathematics, leaving them unable to perform fundamental tasks. Concerning the national NAAP 2019 program [11], which is a device aligned with international standards and which aims to assess the achievements and skills of students who are in their sixth year of primary school and third year of secondary school... the findings indicate that despite the efforts made, the challenges remain recurrent. Indeed, there is a general weakness in the achievements and skills of students in mathematics since 47% of students have assimilated less than 23% of the recommended mathematics program and only 12% have assimilated more than 85% of the program.

This same study revealed that the use of digital resources in school has allowed the improvement of scores from 4 to 11 points for primary school and from 6 to 9 points for middle school and has highlighted the contribution of the combination of digital development and learning on academic performance in mathematics. Moreover, as underlined in the analytical report NAAP 2019 [11], the transversality of digital requires the combination of learning reform and digital development to avoid the latter being subsidiary to classical teaching but rather a means integrated into teaching/learning [14].

Other elements that can improve academic performance include self-confidence and motivation, which Chatri et al. [2] consider be to the primary determinants. Hence the interest in proposing more attractive and motivating activities and approaches where the learner is an actor in the construction of his learning. Moreover, games provide this kind of opportunity, especially if they are played in a competitive context and an implicit manner. Based on these observations and our concern to improve learning in mathematics, we opted for the design and experimentation of a game-based mathematics teaching-learning device based on gamification as an active and motivating method.

Moreover, gamification can be defined as the application of game features to non-game elements to promote motivation and engagement in learning. In this study, we targeted a sample of third-year college students. This choice is motivated by the importance of this cycle as a transition cycle between the primary and qualifying cycles and by the psychological and cognitive specificities of learners characterized by the period of adolescence. Conversely, the third year of the secondary school cycle is crucial in the learner's academic career because of its certifying nature. Assuming that gamification plays a crucial part in the teaching and learning of mathematics, and in enhancing the quality of education and student motivation, our research questions concern, on the one hand, the contribution of gamification to the teaching and learning of mathematics at the secondary school level and, on the other hand, the modalities of its exploitation to guarantee an efficient teaching-learning of mathematics at the college level.

2. THEORETICAL FRAMEWORK

According to Kapp [19], gamification is not solely restricted to video games. Rather, it is described as utilizing games to captivate people, encourage them to take action, facilitate learning, and solve problems. Primarily associated with technology, gamification enables individuals to develop various problem-solving, organizational, emotional regulation, leadership, and empathy-related skills, in addition to offering motivational benefits such as intrinsic motivation, commitment to goals, self-regulation, and the formation of a long-term outlook. This method promotes creativity, playfulness, commitment, and an overall positive atmosphere. In the field of education, a majority of research on gamification concentrates on its favorable impacts, especially on learners' involvement in the apprenticeship [4]. Provided that it is implemented prudently and conscientiously, gamification can be advantageous, and it has the potential to: Increase learner engagement through the use of challenging and fun game elements.

- Adapt the difficulty according to the levels of the learner by acquiring a mastery of skills at their own pace by dividing the learning into levels. on the other hand, the difficulty must be well adapted to the targeted learning, because some learners may be discouraged if it is poorly graded.

In addition, the use of individual elements or self-elements such as points, time, and badges … allows the evaluation of more difficult levels by making visible the progress in learning. However, the use of social elements like the scoreboard should be used with caution as they can generate an unhealthy social comparison however, they work very well if the learners have a competitive spirit.

- Encourage learners through trial-and-error learning, which is part of the behaviorist current, and done within or after each level thanks to immediate feedback mechanisms. In this context, learners are not afraid to test and make mistakes, because they can correct them and move forward while remaining engaged.
- Have positive effects in previous studies according to the literature review proposed by Hamari, Koivisto, and Sarsa [6]. Indeed, it would seem that the use of gamification processes improves motivation, pleasure, and user engagement [8, 18].

However, these positive effects depend on the context in which the gamification elements are implemented as well as the characteristics of users. In this sense, Kim and Lee [7] note the existence of internal factors that can influence the effectiveness of a gamified educational device such as the age, gender, and personality of the learners. Added to this is the type of player that the learners are. On the other hand, Montserrat, et al. [22] present a model allowing to adapt of the mechanics of gamification according to the player profile of the learners based on the Brainhex classification.

This typology of players includes seven different types of players based on data from neurological research. According to Marczewski [21], there are six profiles of players:

- Achievers: those who want to be the best at everything they do. They do it for themselves and are probably not embarrassed to show it to others. They struggle with others as a means to become better. They may also be motivated by mastery, which is a representation of their achievements. They are motivated by mastery. Indeed, they need a learning device that enriches them and leads them to mastery of a subject.
- Socializers: These are people who want to interact with others and enjoy being connected to others. They are interested in the parts of the device that allow them to do so. They are the ones who will evangelize the internal social networks of the system. They are motivated by the social relationship aspects of relatedness.
- Philanthropists: are those who want to feel part of something bigger. They want to give to others but expect nothing in return. They are the ones who answer all the questions on the forums, simply because they like to feel like they are helping. They want a device that allows them to enrich others and feel a sense of altruism, usefulness, and purpose.
- Free spirits: those who like to have power and freedom. They seek self-expression and autonomy.

They are characterized as:

➢ Explorers: they do not want to be limited in how they go about their journey to explore the system. They are also likely to find the most holes/errors in a system.

➢ Creators: they want to build new things, choose the fanciest avatars, and create the most personal content.
❖ Players: they are important to recognize because most people who enter a gamified device are probably there initially because of the possible rewards (points, badges, etc.). The trick is to try to get them to evolve into an intrinsically motivated type of profile (sociable, free spirit, achiever, philanthropist). They like to be rewarded for their efforts (reward). They are characterized as:
❖ Self-Seeker: they act in the same way as philanthropists. They answer questions from others, share their knowledge, and make themselves useful - but only if there is a reward. If there is no reward, they will not get involved.
❖ Consumers: Individuals with this profile will go to any extent to acquire rewards. If this entails acquiring new skills or tackling challenges (similar to achievers), they are willing to do so. They are comparable to individuals who engage in competitions solely to win prizes.
❖ Networker: where socializers look for kinship, networkers look for contacts that can be useful to them. These individuals track influencers on social media with the expectation that doing so will result in gaining recognition, enhancing their influence, and eventually, receiving a reward.
❖ Exploiters: Like "free spirits," exploiters seek to discover the boundaries of a system, what they can achieve within those boundaries, and how they can accomplish it. Their objective is to identify novel ways of gaining rewards. They are the ones most likely to take advantage of a system and engage in dishonest practices.
❖ Disruptors: disrupt a device in some way. They may act on other users or on the device itself. Like the player type, the disruptor type has several subtypes. They are motivated by change (change) and are characterized by what they are:
❖ Griefers: they are killers, and they want to negatively affect other users, just because they can. It's probably because they don't like the device, or just for fun. They don't belong in most gamification devices, so it's important to find ways to change their minds or get rid of them:
➢ Destroyers: this type wants to "break" the device, by hacking it or finding loopholes in the rules that allow them to ruin the experience for others.
➢ Influencers: they try to change the way a device works by influencing other users. If they feel that the device needs to be changed and they have the opportunity to make their voice heard, they may become strong advocates for the device and recommend it to others.

To apply gamification techniques to an educational context, five steps are identified by Huang and Soman [20], in their practical guide to gamifying education:

1. Identifying the target audience and the context: define all the characteristics such as age, learners' learning abilities, skills, attention span, and also their motivation, context, the learning environment, timing, and mode of work.
2. Note that it is also necessary to take into account other factors such as the physical state (fatigue hunger), or the emotional state which are context-dependent and which can also influence the learning capacities of individuals.
3. Defining learning objectives: Huang and Soman identify three different types of objectives:
• General instructional goals: this means the general objectives of the application.
• Specific learning goals are the more specific objectives (performing a particular task or understanding a particular concept).
• Behavioral goals are behavioral goals (focusing on a task, for example).
4. Structuring the experience: defining the different stages of the desired learning through which learners will be able to access the different objectives defined beforehand.
5. Identifying resources: identify the gamification techniques that can be used in the steps defined upstream. At this stage, it is useful to be able to refer to the different classifications of gamification techniques.
6. Applying gamification elements: select and apply the most relevant and applicable game mechanics in the current context.

To achieve the defined learning objectives, it is necessary to identify applicable gamification techniques (resources) and structure. We can identify two categories of game elements that can be integrated into a device that is supposed to increase the motivation of learners in the accomplishment of predefined tasks.
▪ Self-elements: such as badges, points, or levels;
▪ Social elements, such as scoreboards promote learning through player competitiveness and social interaction.

You can also find badges, points, feedback mechanisms, exchanges between players, personalization of the service, scoreboards, levels, bets, risk, narration, and rewards. It should be noted that gamification also has disadvantages. Moreover, one of the major risks of using gamification is that the learner may perceive the learning as being controlled by all the mechanics used. If the level is not well adapted it can cause a wrong scaling of difficulty, as well as rewards and badges, which can be harmful if the learner is already motivated. On the other hand, scoreboards only work in the presence of a competitive spirit and sometimes they can lead to unhealthy comparisons if they are misused [1].

3. METHODOLOGY OF THE RESEARCH

The aim of this study is to examine how gamification can be used as a means of assessing and remedying learning for college students in their third year. The study's sample consists of 480 students, segregated into two groups: a control group and an experimental group. The formation of these groups, which are relatively similar in nature, was determined using the results of a pre-test created for this purpose. The first stage of this research was devoted to the design of a device based on gamification by exploiting the Kahoot tool and aiming at the evaluation of the learning program during the first semester (Table 1). The second stage was dedicated to the experimentation of the device with a sample of students of the targeted level and the third stage was to the evaluation of its effect on learning, motivation, and self-confidence.

3.1. Device Design Phase

The game developed was structured progressively according to the following logic:

- Items related to knowledge
- Items related to the application of knowledge
- Items related to the mobilization of resources in different situations.

These items are related to the concepts covered during the first semester, namely:

Table 1. Mathematics program for the first semester of the 3rd college year [10]

Concept	Expected capacities
Square roots	• Know that if a is a positive real number $\sqrt{a}$ then is a positive real number having the square a • Use the calculator to determine the approximate values of a square root • Utilize $\left(\sqrt{a}\right)^2$ and $\sqrt{a^2}$ such that a is positive • Search using examples on the number x such that $x^2 = a$ • Use the properties $\sqrt{ab} = \sqrt{a}\sqrt{b}$, $\sqrt{\frac{a}{b}} = \frac{\sqrt{a}}{\sqrt{b}}$ and $\frac{1}{\sqrt{a}} = \frac{\sqrt{a}}{a}$ in numerical examples to simplify some expressions • Put the denominator of a fraction in the form of a rational number in simple cases
Notable identities	• Use the following remarkable identities: $(a+b)^2 = a^2 + 2ab + b^2$ $(a-b)^2 = a^2 - 2ab + b^2$ $(a+b)(a-b) = a^2 - b^2$
Powers	• Know the properties of powers and use them • Use the power of base 10 in particular during the study of order, the approximate value, or scientific writing
Order and operations	• Master the order properties, and operations and use them in problem-solving • Master the different techniques for comparing two numbers and use what is appropriate according to the situation studied
Thale's theorem	• Know and use the following two theorems in different situations: ❖ Let (D_1) and (D_2) be two lines that intersect at point A Let B and M be two points in (D_1) and different at A. Let C and N be two points in (D_2) and different at A If the two lines (BC) and (MN) are parallel, then: $\frac{AB}{AM} = \frac{AC}{AN} = \frac{BC}{MN}$ ❖ Let (D_1) and (D_2) be two lines that intersect at point A. Let B and M be two points of (D_1) and different from A. Let C and N be two points of (D_2) and different from A If $\frac{AB}{AM} = \frac{AC}{AN}$ and the points A, B, and M and the points A, C, and N have the same order, then the two straight lines (BC) and (MN) are parallel
Right triangle and trigonometry	• Know and use the relations between sine, cosine, tangent, and the length of the two sides in a right triangle • Using the calculator to determine the rounded values of the trigonometric ratios of acute angles and vice versa • The use of the Pythagorean theorem and its converse in plane geometry and certain regular polygons • Comparison of an inscribed angle and a central angle intercept the same arc
Isometric and similar triangles	• Know two congruent triangles • Use of likeness cases

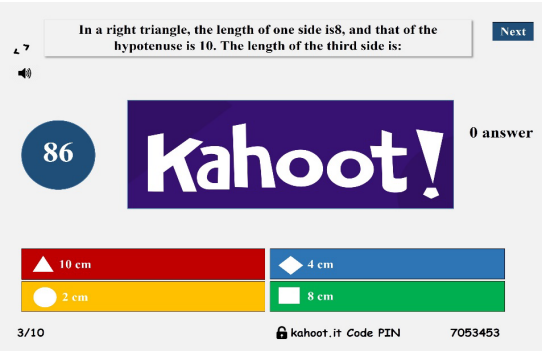

Figure 1. Example question in the activity

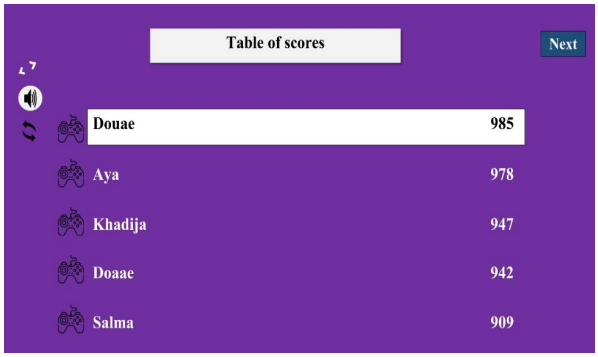

Figure 2. Learners/Players Scoreboard

The Kahoot platform that has been implemented is a type of learning platform that incorporates game-based learning. It enables students to rapidly create, share, and participate in learning games or quizzes, which are referred to as "Kahoots" [12]. This platform can be utilized for various purposes such as reinforcing students' knowledge, conducting formative assessments, or deviating from conventional classroom activities.

The game is based on a simple principle. The students access the game by logging in with a game code that is generated and shown on a shared screen. They then use their own device to answer questions that have been created by the teacher. These questions can be customized to award points, which are displayed on a leaderboard after each question. Kahoot can be played either as an individual (Player vs. Player) or as a team game. It also offers four

different usage types, which are Free, Pro, Premium, and Premium. Figures 1 and 2 illustrate respectively an example of programmed questions and the score table of the learning players.

3.2. Experimentation Phase of the Device

The second stage of this research was dedicated to the experimentation of the said device with 240 learners. The constitution of control groups (240 learners) and experimental groups (240 learners) of relatively homogeneous composition was carried out thanks to a pre-test designed for this purpose. This test is composed of 7 items. Each of these items consists of 2 to 3 questions in the form of multiple-choice questions (MCQs) or true/false questions.

The mean and standard deviation of the scores for both the control and experimental groups of learners were calculated. This comparison is made using a non-parametric statistical test. The choice of the test is justified by the normality result of the samples. First, the learners of the experimental group are divided into small groups of 6 in an atmosphere of competition between the groups and then between the members of the group with the best score. This competition is crowned by prizes for the first three winners and the learners' classification indicators cover the time constraint and the correct answer.

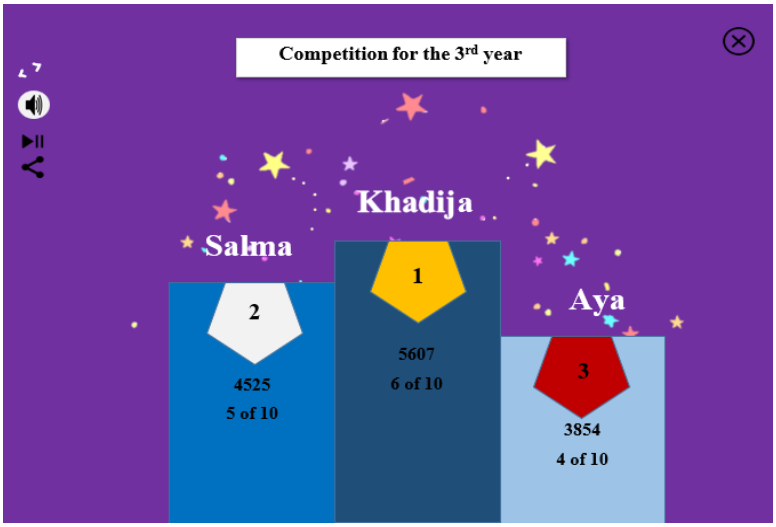

Figure 3. In-game winner's podium

The teacher intervenes in two stages:

- During the competition between the groups reinforce the learners' knowledge as they go along.
- At the end of the individual competition adopting the pedagogy of error.

The teacher uses a test administered to the control groups in a classical way and to the experimental groups via gamification devices. This test is developed according to same structure and logic as the pre-test. The objective is to evaluate the learners' knowledge, develop remediation strategies, and train learners in time management.

In the second step, the teacher gives access to the learners, in remote mode, to be able to redo the test individually while respecting the rhythm of each one. The goal is to reinforce the knowledge acquired at the individual's own pace. The effectiveness of the gamification device in enhancing the teaching-learning process was assessed by analyzing the results of both the learners and the post-test using statistical software. This evaluation involved comparing the post-test results of the two groups and also comparing standardized exam results.

3.3. Evaluation Phase of the Gamification Effect

A post-test was conducted after the experiment on both the control and experimental groups to evaluate the impact of the device. Additionally, the standardized test results were taken into account.

XLSTAT 2023 was utilized to analyze and interpret the outcomes of both the pre-test and post-test, which is specifically designed for statistical data analysis, visualization, and modelling, was utilized. Which is specifically designed for statistical data analysis, visualization, and modelling, was utilized.

The following assumptions are made:

- H_0: there is no significant difference between teaching mathematics by the classical method and teaching based on gamification.
- H_1: There is a significant difference between traditional and gamification-based mathematics education.

In order to evaluate the device's efficacy, a posttest was developed and conducted on both the control and experimental groups after the experiment.

4. ANALYSIS AND DISCUSSION OF RESULTS

4.1. Pre-Test Results

The table below displays the pre-test outcomes for both the control and experimental groups, categorized by score ranges.

➢ Control group:

Table 2. Pre-test scores of the control group

[0-5]	[5-10]	[10-15]	[15-20]
48	100	60	32

➢ Group receiving the intervention/treatment:

Table 3. Pre-test scores of the experimental group

[0-5]	[5-10]	[10-15]	[15-20]
51	99	59	31

4.1.1. Study of the Normality of the Data

To determine the appropriate statistical test for testing our hypotheses, we must first study the normality of the data obtained. In our case, the Shapiro-Wilk, Lilliefors, Anderson-Darling, and Jarque-Bera tests agree on the same result. We present below the result of the Anderson-Darling test based on the following assumptions:

• Null Hypothesis (H_0): The sample was drawn from a variable that conforms to a normal distribution.

• Alternative Hypothesis (H_a): The sample was taken from a variable that does not exhibit a normal distribution.

Table 4. Anderson-Darling test for the control group in the pre_test

A^2	2.215
P-value for a two-tailed test	< 0.0001
Significance level (alpha)	0.05

Table 5. Anderson-Darling test for the experimental group in the pre-test

A^2	3.236
P-value for a two-tailed test	< 0.0001
Level of significance (alpha)	0.05

Test's interpretation: Since the calculated p-value is below the pre-set significance level of 0.05, the null hypothesis (H_0) is rejected in favor of the alternative hypothesis (H_a). Therefore, it can be concluded that the scores of the two groups are not normally distributed.

4.1.2. Study of the Homogeneity of the Groups: Mann-Whitney Test

Since the data did not exhibit a normal distribution, the Mann-Whitney test was employed and its findings are presented below. The following hypotheses were established:

• Null Hypothesis (H_0): The difference in sample location has a value of 0.

• Alternative Hypothesis (H_a): The difference in sample location has a value other than 0.

Table 6. Mann-Whitney test results for the pre-test

U	29501
U (normalized)	0.623
Mean	28560.500
Variance of *U*	2278300.569
P-value for a two-tailed test	0.533
Level of significance (alpha)	0.05

Test's interpretation: Since the calculated p-value is greater than the pre-set significance level of 0.05, there is insufficient evidence to reject the null hypothesis (H_0). The data presented in the tables below suggest that the control and experimental groups are quite comparable.

4.2. Outcomes of Posttest and the Standardized Test

The Following the experiment, an assessment was carried out on the experimental group to gauge the impact of gamification on their learning. The recorded outcomes are presented in Table 7.

Table 7. Learners' scores after the post-test

[0-5]	[5-10]	[10-15]	[15-20]
20	68	93	59

4.2.1. Study of Data Normality

We present below the result of the Anderson-Darling test based on the following assumptions:

• Null Hypothesis (H_0): The sample was drawn from a variable that conforms to a normal distribution.

• Alternative Hypothesis (H_a): The sample was taken from a variable that does not exhibit a normal distribution.

Table 8. Anderson-Darling test for the control group in the post-test

A^2	1.354
P-value for a two-tailed test	0.002
Significance level (alpha)	0.05

Table 9. Anderson-Darling test for experimental group in the post-test

A^2	1.808
P-value for a two-tailed test	0.000
Level of significance (alpha)	0.05

Test's interpretation: Since the calculated p-value is below the pre-set significance level of 0.05, we can reject the null hypothesis (H_0) and accept the alternative hypothesis (H_a).

4.3. Verification of the Research Hypotheses: Mann-Whitney Test

Since the data were non-normally distributed, we employed the Mann-Whitney test, and the ensuing results are presented below. The following hypotheses were posited:

• Null Hypothesis (H_0): The difference in sample location has a value of 0.

• Alternative Hypothesis (H_a): The difference in sample location has a value other than 0.

Table 10. Results of the Mann-Whitney test for the post-test

U	18186.500
U (normalized)	-6.873
Mean	28560.500
Variance of *U*	2278040.400
P-value for a two-tailed test	< 0.0001
Level of significance (alpha)	0.05

Test's interpretation: As the computed p-value is lower than the significance level of *alpha*=0.05, we reject the null hypothesis H_0 and accept the alternative hypothesis, H_a. Therefore, incorporating the suggested gamification approach has a favorable impact on enhancing mathematics learning in the secondary school phase. To measure this improvement, we have presented the difference between the pre-and post-test scores of the experimental group in Table 11.

Table 11. The subsequent analysis compares the pre-test and post-test outcomes of the experimental group

Type of test	Mean	Deviation	C.V
Pre-test	8.951	4.905	54.80%
Post-test	12.090	2.417	19.99%
Gain	3.13912134	2.48783651	

The outcomes reveal a substantial disparity in the average score of the experimental group as compared to the control group, indicating an increase of three points. Thus, the standard deviation decreased (difference of 2.48) which shows that the group is less dispersed and more homogeneous. It should be noted that there are other factors (institutional, didactic, repetition of the experience) that can influence this difference, which can be more significant with the assurance of these factors and the improvement of the pedagogical and technical circumstances and with the repetition of the method.

Therefore, the method argues the pre-excellence of learners after the adoption of gamification in mathematics education. Meanwhile, the standardized exam results of both the control and experimental groups are documented in Table 12.

Table 12. Comparison of normalized scores of controls and experimental groups

	Success percentage (Have a score greater than or equal to 10)	Overall average	Highest rate	First grade in math
G. experimental	92.72%	11.69	18.40	20
G. witness	61%	9.89	14	16.5

According to the results of this study, the gamification device allowed the learners, subjects of the experimentation compared to the control group, to acquire four fundamental knowledge

- Knowledge: because playing is always an opportunity to learn new knowledge, especially in the presence of an adult, in this case, the teacher.
- Know-how: through practice, implementation, and the gestures that games imply.
- Knowing how to be: through the reinforcement or learning of new behaviors allowing the child to integrate into a group or society.
- The will to do: without desire, there is no learning or evolution. Hence the interest in gamification as a means of motivation to want to do.

Gamification can help learners to explore and broaden their perspectives about the world and other people. They can also learn how to respond to situations, manage social tensions, and be more creative in transforming their environment. In short, the more varied the games, the more beneficial they are to the learner: exercise games, symbolic games, construction/creation games, and then rule-based games and cooperative games, which allow for the development of sensory, psychomotor, cognitive, social, and emotional abilities.

The findings of this investigation corroborate the utilization of gamification in middle school mathematics education as a pedagogical tool given its positive effect on the development of learners' fundamental knowledge. Indeed, the experimentation of the gamification device was an opportunity for learning, fun, exchange, challenge, and positive energy thanks to the benefits of the educational game as well as the exploitation of ICT that allows the use of sound effects and many other advantages.

The results of this study about the increase in self-confidence and motivation among students corroborate those of Chatri, et al. [2] who experimented with a sample of second-year college learners. The authors point out that student motivation and self-confidence can be fostered by a variety of conditions related to teaching practices or various factors in the student's environment.

5. CONCLUSION AND PROSPECTS

This study allowed us to answer an important question centered on games, gamification, and ICT and their effect on learning because even if the primary function of games is fun, playing is also an essential element for the proper development of our learners. Indeed, the questions related to the problem were: What role does gamification play in the teaching-learning process? And how can it help to overcome mathematics learning difficulties in middle school students?

To answer these questions, we first formed two relatively homogeneous groups (control and experimental) based on the results of a pre-test. The experimentation of the gamification device using the "Kahoot" tool was carried out with 240 learners while the control group (240 learners) benefited from the same learning process but via the classical method. We assessed the impact of the device on the learners' learning by juxtaposing the pre and post-test results of the experimental group, as well as contrasting the pre-test outcomes between the experimental and control groups. Furthermore, we took into account the standardized test results of both cohorts. Results of this research seem to support the integration of gamification in middle school mathematics education, and learners found during the classroom game, a space for growth, joy, competition, involvement, and relaxation as well as flexible learning and acquisition of mathematics while giving oral interactions great importance. Teaching is always an art and the teacher must have a creative spirit to be able to transmit knowledge, and gamification is considered a kind of pedagogical innovation. To support this kind of initiative and practice, it is necessary to integrate gamification in the specific pedagogical orientations of mathematics teaching as well as in the initial and continuous training of teachers.

6. LIMITATIONS AND PERSPECTIVES OF THE RESEARCH

This research is limited to the design and experimentation of the gamification device in the secondary college cycle. During the study, difficulties were encountered especially in the choice of games determined by the age range of the learners, the nature of the lessons, and the objectives. To overcome these difficulties and to support and encourage colleagues to use games in certain middle school mathematics lessons, an e-

book (digital support) is being developed. Several resources will be integrated into the form of puzzle lessons, exercises, and educational videos as well as links to educational game sites.

NOMENCLATURES

Acronyms

ICT	Information and Communications Technology
PISA	Program for International Student Assessment
NAAP	National Achievement Assessment Program
TIMSS	Trends in Mathematics and Science Study

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BIOGRAPHIES

Name: **Sounia**
Surname: **El Bakkali**
Birthday: 17.07.1992
Birthplace: Kenitra, Morocco
Bachelor: Mathematical and Computer Sciences, Ibn Tofail University, Kenitra, Morocco, 2014
Master: Mathematics Teaching and Training, Ibn Tofail University, Kenitra, Morocco, 2017
Doctorate: Student, ICST, Department of Mathematics, Faculty of Sciences, Chouaib Doukkali University, El Jadida, Morocco, Since 2019
Last Scientific Position: Teacher of Mathematics, Middle School, Lalla Meryem Middle School, Kenitra, Morocco, Since 2016

Research Interests: Didactic of Mathematics, Analysis of, Teaching Practices, Information and Communication Technologies, Education, Cognitive Psychology
Scientific Publications: 1 Paper, 5 National and International Communications
Scientific Memberships: ISTM Laboratory

Name: **Khadija**
Surname: **Raouf**
Birthday: 09.10.1966
Birthplace: Kenitra, Morocco
Bachelor: Physical Chemistry, Faculty of Sciences, Ibn Tofail University, Kenitra, Morocco, 1991
Master: Physical Chemistry, University of Franche Comte, Besancon, France, 1993
Doctorate: Physical Chemistry of Toulouse III, Paul Sabatier University, Toulouse, France, 1997
The Last Scientific Position: Prof., Department of Physics and Chemistry, El Jadida Regional Centre for Education and Training Professions, Morocco, Since 2011
Research Interests: Didactics Sciences, Analysis of Teaching Practices, Inclusive Education, Interdisciplinary, Learning Disabilities of Physical Sciences, ICT
Scientific Publications: 21 Papers, Co-Supervisor of 7 Theses
Scientific Memberships: ISTM Laboratory, LMSEIF Laboratory, SEAST

First Name: **Mohamed**
Surname: **Serghini**
Birthday: 20.03.1991
Birth Place: Kenitra, Morocco
Bachelor: Physics, Faculty of Sciences, Ibn Tofail University, Kenitra, Morocco, 2012
Master: Teaching and Training Professions in Physics and Chemistry Sciences, Faculty of Sciences, Ibn Tofail University, Kenitra, Morocco, 2015
Doctorate: Student, Didactics, Faculty of Science Ben M'Sik, Hassan II University, Casablanca, Morocco, Since 2019
The Last Scientific Position: Teacher of Physics Chemistry, Idriss I High School, Kenitra, Morocco, Since 2014
Research Interests: Didactics Sciences, Analysis of Teaching Practices
Scientific Publications: 3 Papers
Scientific Memberships: LASTIE, GIDS, SE/ENS

Name: **Mohammed**
Surname: **Barkatou**
Birthday: 10.04.1965
Birthplace: Casablanca, Morocco
Bachelor: Applied Mathematics, Faculty of Mirande, University of Bourgogne, Dijon, France, 1991
Master: Mathematics and Applications, Department of Mathematics, Faculty of Sciences, University of Franche Comte, Besancon, France, 1993
Doctorate: Mathematics and Applications, Department of Mathematics, Faculty of Sciences, University of Franche Comte, Besancon, France, 1997
The Last Scientific Position: Prof., Department of Mathematics, Faculty of Sciences, Chouaib Doukkali University, El Jadida, Morocco, Since 2003
Research Interests: Didactic of Mathematics, Shape Optimization Free Boundaries, Elliptic PDE, Combinatorial Optimization
Scientific Publications: 26 Papers, 7 Theses
Scientific Memberships: ISTM Laboratory

Name: **Hamid**
Surname: **Nebdi**
Birthday: 01.10.1968
Birthplace: El Jadida, Morocco
Bachelor: Physics and Electronics, Department of Physics, Faculty of Sciences, University of Chouaib Doukkali, El Jadida, Morocco, 1993
Master: The 1st Master degree in Radiation-Matter Physics, Faculty of Science Ben M'Sik, University of Hassan II, Casablanca, Morocco, 1995 - The 2nd Master degree in Atomic Physics, University Catholic of Louvain, Louvain-la-Neuve, Belgium, 1997
Doctorate: Atomic Physics, University Catholic of Louvain, Louvain-la-Neuve, Belgium, 2000
The Last Scientific Position: Prof., Department of Physics, Faculty of Sciences, University of Chouaib Doukkali, El Jadida, Morocco, Since 2011
Research Interests: Space Weather, Atomic and Laser Physics, Education, Innovation in Science, Technology and Modeling
Scientific Publications: 76 Papers, 5 Projects, 7 Theses
Scientific Memberships: APS, SPANET, GIRGEA, AERDDS