Are serious games a good strategy to improve students' level knowledge?

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Abstract

This article is interested in the integration of serious games in the classroom. Serious Games are computer applications that combine fun and serious aspects, and they are designed with a primary objective that is not entertainment. They are increasingly used in education as an educational tool. For this reason we developed five serious games for primary school student of CM1 and sixth grade, in order to acquire the mental calculation skill. This skill plays a very important role in the educational curriculum of learners in all education stages. We are also interested in assessing the potential effects that Serious Games can have on student learning. One promising approach is to use the playful video culture of students to motivate them in order to invest time in mathematics' practice, especially mental calculation. We compared two scenarios: a group of participants used the classic method "Control group", and another group of participants used our Serious Games "Experimental group". A t-test using SPSS statistical software was carried out to test the existence of significant change in students' performance based on the marks they scored on a test for a mental calculation before and after the introduction of serious games in students learning process. Based on the analysis carried out, the results of this study showed that the improvement of the experimental group was greater than the control group. The main conclusion of this study is the superiority of the experimental group over the test of learning outcomes and those serious games influence positively the motivation of learners. We can therefore say that the use of Serious Games in the classroom is more effective than the traditional method in our study.

Keywords: *Serious Games, Primary school, Mental calculation, Motivation.*

1. Introduction

Nowadays, a growing interest is focused on Serious Games and their uses as learning tools for the teaching. A Serious Game is a computer application that combines both fun and serious aspects whose primary purpose is other than just entertainment.

There are many studies showing the benefits of Serious Games for children and adults in terms of providing motivation, engagement, developing skills and encouraging collaboration. Wood and Stewart(1987) asserted that incorporating digital games into instructional design improves students' skills in practical reasoning, complex problem solving (Hayes,1981) transfer of learning (Crisafulli &Antonietti,1993) making inferences and engaging in inductive reasoning (Mayer &Sims,1994) and using Metaphorical Maps to generate alternative solution paths(Quinn,1996).Other researchers that explored this area includes Prensky (2001),who discussed the potential of educational serious games and listed the elements as to why games engage people. Those reasons includes: games motivate players (to achieve goals), gratify the ego (when winning), are fun (through enjoyment and pleasure) and spark the players' creativity (to solve the game problem). The use of interactive games has impacted the mode of learning. (Foreman et al., 2004). Wood (2001) investigated the use of learning serious games as a learning tool and concluded that game could be more effective at capturing learner's attention than traditional media such as textbooks. Looking at all these claims on the potential of game based learning, we decide to use the serious games to motivate and engage the primary schools students to develop their mental calculation skill.

The desire to harness this motivational power to encourage students to want to learn is the main drive behind an interest in serious games for learning. The objective of this study, is to find out how well Serious games can motivate and engage the Moroccan pupils to learn mathematics efficiently and to identify the necessary factors that may hinder the students motivation in learning with serious games as it supplements the traditional teaching. And to determinate the impacts of these serious games on students learning.

2. Purpose of the study

This study was conducted in fifth and sixth grade of primary school in Morocco. Our Serious Games have been designed to develop mental calculation skills among students. We wanted to enrich the traditional learning of this subject by the use of these serious games and study the contribution of these on the learning of students. To do this, we propose an evaluation grid and the students have passed two tests (Pretest and Posttest). They serious games will be evaluated to measure the performance and impact of this tool on student learning.

3. Research questions

This paper present feedback on the use of serious games developed for learning mathematics, specifically mental calculation. The central research questions that this study aimed to answer are:

- Do the serious games lead to better mental calculation learning than the traditional method?
- Are they efficient in developing learners' learning?

Our hypotheses are:

- The learning level of Experimental group will be greater than the learning level of control group for addition, subtraction, multiplication and division.
- The control group will make more error than experimental group.
- The experimental group will enjoy more than the control group.

4. Research method and Design

This paper present feedback on the use of serious games developed for learning mathematics, specifically

4.1. Population and sampling

The original set of participants were 54, 5 th and 6th grade primary school students from private school in Morocco. Fifty five (54) participants are divided into two groups (control group (n = 27), experimental group (n = 27)). The two groups were not randomly assigned to the Game and Non-Game groups. Instead, they were assigned to balance low performing and high performing students between the experimental and Control group.

A pretest and posttest was administered to both groups. The experimental group underwent an intervention where they learnt mental calculation using our Serious Games for eight weeks, while the control group learnt mental calculation using traditional method.

After a pretest we divided the students into two groups: Control and Experimental group.

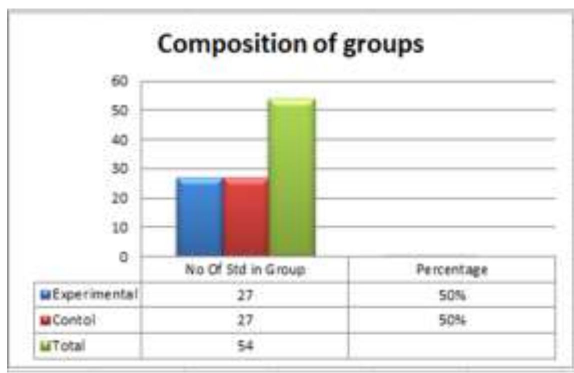

Fig. 1 Composition of groups.

4.2. Our serious games

The serious games were designed and developed to train primary school students and improve their mental calculation skills. We wanted to enrich the traditional learning of this subject with the use of these serious games, and to study the contributions of these on the development of the learning of the students. These games are single-player in which the learner-player can learn, understand and apply his skills.

IJCSI International Journal of Computer Science Issues, Volume 17, Issue 6, November 2020
ISSN (Print): 1694-0814 | ISSN (Online): 1694-0784
www.IJCSI.org https://doi.org/10.5281/zenodo.4431074

4.3. Materials

In order to evaluate the potential effects that serious games can have on the learning of primary school students in mental calculation, we compared two cases: a group of participants used the traditional method to acquire the mental calculation skills; another group of participants used our Serious Games previously described. The first group is called the control group and the second group is called the experimental group. Each group consisted of 27 participants recruited from fifth and sixth grade of primary school students.

We want to make it clear now that we did not consider gender in our study given the small size of the samples. A larger study would be needed to draw conclusions at this level. All participants of both conditions had not used serious games. A one-hour training was therefore conducted a week before the experimental session to give them the basic knowledge necessary for the use of our serious games.

For each group, the experimental session was conducted in 54 hours with three distinct stages: 1) Short presentation of the research project and pretest to assess the state of knowledge of the participants on mental calculation; 2) the actual game session and 3) a posttest to assess the state of knowledge after the use of serious games.

As previously mentioned, the evaluation of the experiment was conducted using a questionnaire and two tests. They called the pretest and posttest, the first was used before the game session and then immediately afterwards we use the posttest to measure the evolution of knowledge. It has been designed to respond to research hypotheses.

The beginning of the questionnaire concerns some general information about the participant. It was organized around three groups of items: "evaluation framework of learning with serious games": playability, learning, reality. It was used to measure the user experience, the usability of serious games and the perception of participants about their learning.

The data used for this research are based on Lickert scales from 1 to 10 (0 = disagree at all; 1 = rather disagree; 2 = rather agree, 3 = completely agree) and the closed questions.

It was important to guide the participants in their practice of the serious games without biasing the information necessary for the study conducted: a very good knowledge of the serious game, the instructions of them was mandatory to help students with some difficulties to complete the games. At the end of the test, each student completed the questionnaire of each serious game. I observed students and I assisted them in case of difficulties.

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5. Results

Statistical Package for the Social Sciences (SPSS) was used to answer the objectives of this study. Achievement test scores were analyzed. The test was used to test for the Mean score, Students' knowledge of the addition, subtraction, multiplication and division between the pretest and posttest exam for the control group and experimental group. And SPSS was used to test the independent t-test for pretest and posttest for both groups.

5.1 User experience rating with serious games

Table 1: Participants' thoughts on the overall design of serious games

I think that serious games are:	Mean	Deviation	Max	Min
Useful	2,92	0,27	3,0	2,0
Relevant	2,63	0,49	3,0	2,0
Amasing	2,37	0,68	3,0	1,0
Easy to use	2,48	0,64	3,0	1,0

As mentioned above, the user experience was evaluated from a questionnaire that was offered to students after the use of serious games. It consisted of closed questions with answers on a four scale (0 = disagree at all; 1 = rather disagree; 2 = rather agree, 3 = completely agree), or in the form of multiple-choice questions. Table 1 shows that students who have used serious games have rather positive opinions about usefulness, relevance, playfulness and ease of use (with mean scores of 2.92- 2.63- 2.37 and 2.48). The students' point of view is relatively homogeneous.

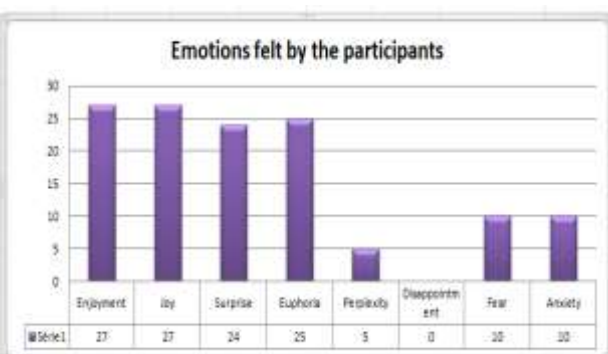


Fig. 2 Emotions felt by the participants

We then asked the participants the level of feeling of different emotions when using Serious Games. Table 2 shows the answers given. The emotions most often expressed are positive like pleasure (27 learners) and joy (27). Some students expressed a feeling of surprise (24) or euphoria (25). Most students did not express negative emotions. Some students expressed a feeling of stress at the idea of making miscalculations or failing to win in the serious game (10).

5.2 Assessment of learning

5.2.1. Feeling of learning

Participants' feelings of learning are presented in Table 2. They feel they have the ability to calculate additions (m = 2.59 for the control group vs m = 2.48 for the experimental group), calculate the subtractions (m = 1.74 for the control group vs m = 1.62 for the experimental group), calculate the multiplications (m = 2.07 for the control group vs m = 1.92 for the experimental group) , and calculate the divisions (m = 1.62 for the control group vs m = 1.48 for the experimental group). The Values are very similar in both groups. It can therefore be concluded that the perception of learning is similar in both groups.

Table 2: Participants' Learning feelings

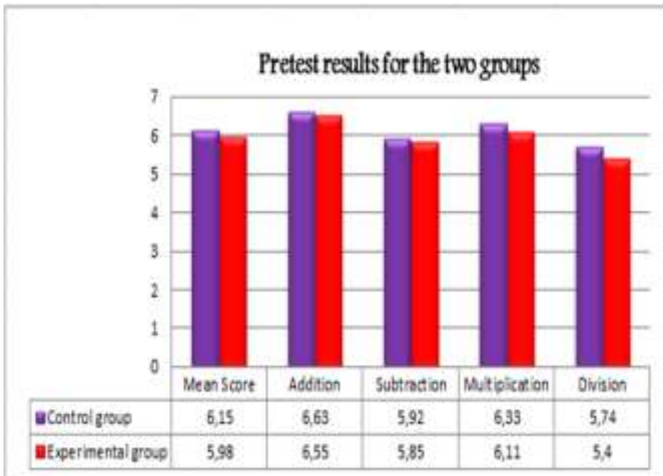
		Mean	Deviation	Max	Min
Control group	I am able to calculate the additions	2,59	0,5	3	1
	I am able to calculate the subtractions	1,74	0,52	3	1
	I am able to calculate multiplications	2,07	0,67	3	1
	I am able to calculate divisions	1,62	0,68	3	1
Experimental group	I am able to calculate the additions	2,48	0,5	3	1
	I am able to calculate the subtractions	1,62	0,56	3	1
	I am able to calculate multiplications	1,92	0,72	3	1
	I am able to calculate divisions	1,48	0,64	3	1

IJCSI International Journal of Computer Science Issues, Volume 17, Issue 6, November 2020
ISSN (Print): 1694-0814 | ISSN (Online): 1694-0784
www.IJCSI.org https://doi.org/10.5281/zenodo.4431074

5.2.2. Level of knowledge of participants before training

Table 3: Pretest Results for the both groups

Pretest		Mean	Deviation	Max	Min
Control group	Addition	6,63	1,54	10	5
	Subtraction	5,92	1,49	8	4
	Multiplication	6,33	1,66	10	4
	Division	5,74	1,22	8	4
experimental group	Addition	6,55	1,47	10	4
	Subtraction	5,85	1,43	9	4
	Multiplication	6,11	1,62	10	4
	Division	5,40	1,15	8	3



The table 3 and figure3 show level knowledge of student', prior to training of addition, subtraction, multiplication and division. After the pretest, we divided the learners into two groups according to their initial knowledge. Control group (27 students) and the experimental group (27 students).

Table 4: Result of the Independent t-test on the pretest of both groups

Addition

Group	N	Mean	Std. Deviation	T	Sig.(2 Tailed)
Experimental	27	6,56	1,48	-0,18	0,86
Control	27	6,63	1,55		

Subtraction

Group	N	Mean	Std. Deviation	T	Sig.(2 Tailed)
Experimental	27	5,85	1,43	-0,19	0,85
Control	27	5,93	1,5		

Multiplication

Group	N	Mean	Std. Deviation	T	Sig.(2 Tailed)
Experimental	27	6,11	1,63	-0,5	0,62
Control	27	6,33	1,66		

Division

Group	N	Mean	Std. Deviation	T	Sig.(2 Tailed)
Experimental	27	5,41	1,15	-1,03	0,31
Control	27	5,74	1,29		

Total Knowledge

Group	N	Mean	Std. Deviation	T	Sig.(2 Tailed)
Experimental	27	5,98	0,58	-1,16	0,25
Control	27	6,18	0,55		

We analyzed whether the differences between the two groups were significant using a t-test. The results presented in Table 4 show that there is no significant difference in the state of initial knowledge between the two groups for addition ($p = 0.86$), subtraction ($p = 0.85$), multiplication ($p = 0.62$) and division ($p = 0.31$). And also for the total knowledge with ($p = 0,25$). We can therefore conclude that the initial level of knowledge of the participants is equivalent before the experiment for the two groups.

5.2.3. Level of knowledge of participants after training

After the experiment, the students passed a posttest exam to determine if there is any development in the learning or not.

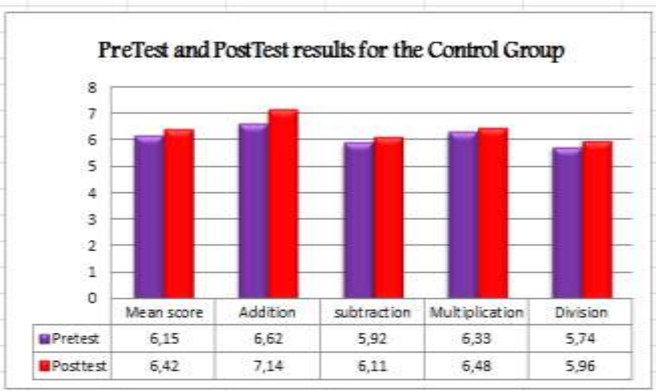


Fig 4: Pretest and Posttest Results for the control group

The Figure 4 showed that the control group obtained a mean score of 6.15 in pretest exam while they obtained 6.42 in posttest exam. The students addition skill in pretest was 6,62, while in posttest was 7,14, the students subtractions skill in pretest was 5,92, while in posttest was 6,11, the multiplication skill in pretest was 5,74, while in posttest was 5,92 Finally, the students had 5,74 in division skill in pretest and 5,96 in posttest. This means that there has been an improvement in mental calculation skills after the training.

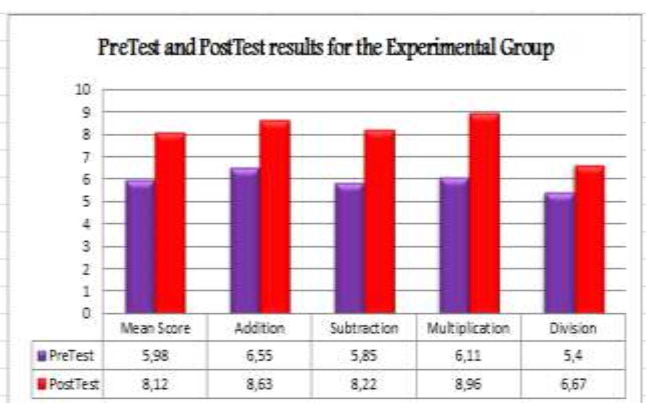


Fig 5: Pretest and Posttest Results for the experimental group

The Figure 5 showed that the experimental group obtained a mean score of 5,98 in pretest exam while they obtained 8,12 in posttest exam. The students addition skill in pretest was 6,55 while in posttest was 8,62, the students subtraction skill in pretest was 5,85 while in posttest was 8,22, the multiplication skill in pretest was 6,11, while in posttest was 8,96 Finally, the students had 5,4 in division skill in pretest and 6,66 in posttest. This means that there has been an improvement in mental calculation skills after training.

So, the two groups had an improvement in mental calculation learning after training.

Table 6: Posttest Results for the two groups

Posttest		Mean	Deviation	Max	Min
Control Group	Addition	7,14	1,41	10	5
	Subtraction	6,11	1,40	10	5
	Multiplication	6,48	1,55	10	4
	Division	5,96	1,06	8	3
Experimental Group	Addition	8,63	1,08	10	7
	Subtraction	8,22	1,53	10	7
	Multiplication	8,96	0,94	10	7
	Division	6,67	1,3	10	5

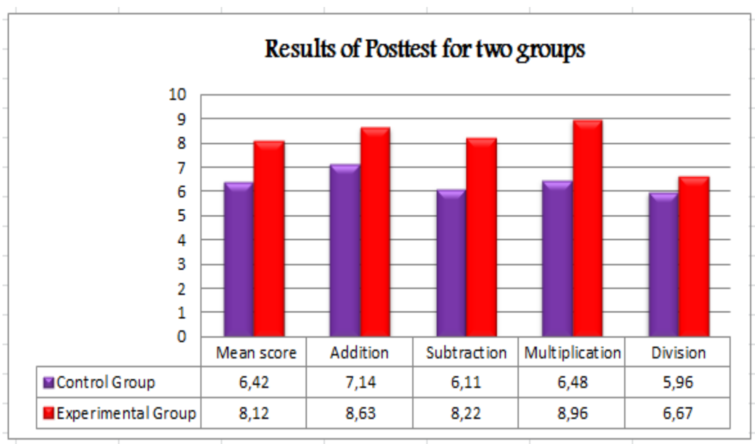


Fig 6: Posttest *Results* for the two groups

The figure 6 showed ' level knowledge of students after training. We can see that the experimental group has better results on the skill set than the control group (m = 6.42 for the control group vs m = 8.12 for the experimental group). The experimental group has in particular better results regarding subtraction (m = 6,11 for the control group vs m = 8,22 for the experimental group). The results are also better for multiplication (m = 6.48 for the control group vs m = 8.96 for the experimental group). The results are also better for the addition but much less marked (m = 7.14 for the control group vs m = 8.63 for the experimental group). The two groups didn't better score in division skill (m = 5.96 for the control group vs m = 6.67 for the experimental group).

Tables 7: Results of the Independent t-test on the Posttest of two groups

Addition:

Group	N	Mean	Std. Deviation	T	Sig. (2 Tailed)
Experimental	27	8,63	1,08	4,343	0,000065
Control	27	7,15	1,41		

Subtraction:

Group	N	Mean	Std. Deviation	T	Sig. (2 Tailed)
Experimental	27	8,22	1,53	5,301	0,000002
Control	27	6,11	1,4		

Multiplication:

Group	N	Mean	Std. Deviation	T	Sig. (2 Tailed)
Experimental	27	8,96	0,94	7,102	3,4028E-9
Control	27	6,48	1,55		

Division:

Group	N	Mean	Std. Deviation	T	Sig. (2 Tailed)
Experimental	27	6,67	1,3	2,183	0,033592
Control	27	5,96	1,05		

Total knowledge:

Group	N	Mean	Std. Deviation	T	Sig. (2 Tailed)
Experimental	27	8,12	0,53	12,208	6,8329E-17
Control	27	6,43	0,49		

This independent sample t-test was done to examine whether any significant differences exist between the posttest mean score of both the Control and Experimental group.

Do the serious game lead to better mental calculation learning than the traditional method?

Are they efficient in developing learners' learning?

Using SPSS to assess the posttest, with the pretest, the Experimental group performed significantly better than the Control group on the posttest. The addition learning of Experimental group (M=8,63, SD=1,08, n=27) was hypothesized to be greater than learning level in addition of control group (M=7,15, SD=1,41, n=27). This different was significant t(54)=4,343, p=3,26851E-05. The subtraction learning t of Experimental group (M=8,22, SD=1,53, n=27) was hypothesized to be greater than learning level in subtraction of control group (M=6,11, SD=1,4, n=27). This different was significant t(54)= 5,301, p=0,000002. The Multiplication learning of Experimental group (M=8,96, SD=0,94, n=27) was hypothesized to be greater than learning level in Multiplication of control group (M=6,48, SD=1,55, n=27). This different was significant t(54)= 7,102, p=3,4028E-9. The Division learning of Experimental group (M=6,67, SD=1,3, n=27) was hypothesized to be greater than learning level in Division of control group (M=5,96, SD=1,05, n=27). This different was significant t(54)=2,183, p=0,033592. The total knowledge learning of Experimental group (M=8,12, SD=0,53, n=27) was hypothesized to be greater than learning level in total knowledge of control group (M=6,43, SD=0,49, n=27). This different was significant t(54)= 12,208, p=6,8329E-17.

Findings from this study showed that the experimental group improvement is higher than the control group. The superiority of the Experimental group on test of learning is the main finding in this study. So we can conclude that using the serious games in classes is more efficient than the traditional method.

6. Discussion and conclusions

The overall results on usability and user experience are very positive. The students think that the general design of our serious games is good. In particular, they think they are useful, relevant, fun, and easy to use. They express very positive emotions like pleasure, excitement, and joy and do not experience negative emotions like embarrassment, disappointment, sadness, disgust or anger. But a few of the student express a feeling of stress linked to the fear of not winning in the game or of making calculation errors. Thus, we can conclude that the design of our serious games does not cause usability problems.

In contrast to relatively scant prior evidence that learning mathematics with a serious game is better than a conventional approach (Mayer, 2014), the results of this study show a clear benefit to learning mathematics with a serious game. Students in the Experimental group learned significantly more, enjoyed their experience more, and made fewer errors than the students in the control group. If the control group was bored or unmotivated, this may have led them to make more errors and, in turn, enjoy their experience less.

Another important finding is that low prior knowledge students learned more about mental calculation from serious games than from using traditional method. In fact, the low prior knowledge students may be precisely the best targets for mathematics serious games. These students perform less well and seem to struggle more with mathematics, perhaps because they lack self-motivation or interest. Serious Games might get such students more excited and engaged in mathematics learning.

In terms of learning, the results presented here are encouraging. Indeed, our study shows that learning is better if we use serious games rather than in a traditional method. The justification for this result is linked in our opinion that the motivation and immersion made possible by serious games allow participants to more simply make the link between the elements with which they interact in the game and the reality of the activity which is simulated. Indeed, the paradigm of action learning supposes that by placing the learner in a situation where gestures and interaction are more realistic, the situated action will be better defined and the lived experience more conducive to learning.

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