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Enhancing Math-class Experience throughout Digital Game-based Learning, the case of Moroccan Elementary Public Schools

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Abstract: There is a growing interest in integrating active learning and computer-based approaches in the teaching and learning of mathematics in elementary schools. In this study, we introduce Digital Game-Based Learning (DGBL) of Mathematics targeting students in the 5th and 6th grades following a design-to-implementation strategy. We first developed an edutainment Mathematics game and then tested it with 196 pupils from 9 public elementary schools in Morocco. The rationale of the study is to probe the effect of DGBL in lessening pupils' mathematical anxiety and improving classroom experience.

Students in our study were more engaged and less anxious towards learning Mathematics. Our designed pedagogical edutainment game made students more comfortable when dealing with numerical arithmetic assignments. The study suggests that edutainment games lead to positive individual attitudes towards mathematics and to a better math classroom experience, thus more effective teaching and learning of mathematics.

Index Terms: Mathematics Education; Mathematics Anxiety; K-12 education; Elementary education; DGBL; serious-games; digital games; edutainment games; computer games; instructional design; ADDIE, Classroom Experience.

1. Introduction

Several authors consider the learning and teaching of mathematics quite difficult due to a number of factors which can exhibit math difficulties at different learner's level and age [1, 2]. Some researchers have been interested in *school-to-knowledge* relationship-related factors, e.g., the *emotional* and *psychological* dimensions, *attitude* toward the subject, and *classroom experience* [3]. Special and cautious attention focused on *mathematics anxiety* (MA) [4] which is a special type of general anxiety [5]. MA could be defined as a *suffering from an irrational fear of mathematics where learners are paralyzed in their thinking which inhibits their performance, and subsequently prevent them from learning* [6]. Students with MA *feel tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations* [7]. *MA is also defined as the feeling of helplessness and panic, that a pupil may experience when trying to solve a mathematical problem or tasks* [8]. It is a *dread and nervousness feelings associated with physical symptoms while dealing with mathematics* [9]. A Number of studies claim the existence of a negative correlation between anxiety and performance or success in mathematics [10, 7, 11, 12, 13, 14, 15, 16]. Anxious learners often hate the subject, resist learning, and deviate from any course that requires mathematical skills and knowledge [17, 18, 19]. MA is a notable phenomenon, among K-12 pupils, and all levels and curriculums requiring mathematics [14]. Some studies suggest that MA origins may trace back to elementary education

[20], appearing as early as 3rd and 4th grades [21]. MA origins are more likely connected to "negative classroom/teaching experience". Experiencing a negative teaching/learning experience at early grades may affect the long-term learner's experience [21, 22]. Although many studies claim that MA and "negative classroom experience" are correlated [23, 14, 24], but how these "negative experiences" accrue, their context, and which ones are relating to MA, remain loosely undescribed.

Over the last decade, with the advent of new technologies, active learning approaches have become widely popular in education research. Khan and Madden [25] have emphasized how active learning could significantly reduce students' anxiety during tests. Digital Game-Based Learning (DGBL), in particular, can bring a lot to the learning process, thanks to digital games' *motivational* and highly *engaging* intrinsic characteristics, [26, 27, 28], *motivating-immersive* features [29, 30], and unique *interactive player experience* [31]. In education, DGBL became one of the wide contemporary approaches that emerged [32, 33, 34, 35, 36, 37, 38, 39, 40]. It refers to any "*approach that combines fun-activity into a digital environment, with educational content, it tends to make uninteresting or difficult learning subject, more accessible, attractive, engaging, and pleasant*" [41, 42]. DGBL is considered active learning for many reasons. Alvarez, Kafai, Malone and, Oblinger [43, 27, 41, 44] explained how digital-games could be employed as effective educational tools to enhance or backup learnings, e.g., they favour active learning, absorb the player, maintain his concentration, promote intellectual functions, memory, and skills; sustain communication, support, train, present, explain, simulate, motivate, evaluate/self-evaluate, introduce/reintroduce information in a "fun" way. They assess team/social work, creative thinking, analysis, problem-solving, and other 20th century skills [34], including many required mathematics skills. Nevertheless, DGBL approaches remain generally difficult to adopt, as videogames could not be used *alone* to achieve specific learning/educational goals. A great part of research on digital games focuses on the effectiveness *outside* classrooms (e.g., exercisers or homework) [45] . Few studies carefully introduced DGBL into limited didactical sequences, introduction, and simulations [39, 38]. Incorporating DGBL into economically undeveloped countries' elementary classrooms may be challenging [46].

The present work explores the outcomes of implementing an edutainment game inside the classroom. The rationale of the study suggests repositioning pupils' MA and improving classroom experience throughout DGBL. Whilst a great deal of research has been accumulated in developed countries, only few comprehensive studies about the topic, have been done yet in Morocco. MA remains an unfamiliar and new concept for most in-service and preservice teachers, especially in elementary schools. Likewise, DGBL remains loosely explored in the Moroccan field. Besides that, the environment and culture of the Moroccan public classrooms are different and unfamiliar. Hence, the following research questions are raised in guiding this study:

- RQ1: "What impact does DGBL have on elementary pupils' MA and classroom experience?"
- RQ2: "What are the outcomes of edutainment digital games' integration, into elementary math-class of Moroccan public schools?"

We established arithmetic devoted game, created throughout the *five* phases of instructional design process: Analyze, Design, Development, Implementation and, Evaluation (ADDIE) [47]. This paper summarizes the main game design and development phases and discusses the game implementation findings. Our experiment involved 196 pupils from different regions and elementary public schools in Morocco. This study not only provides insights for teachers and educators to create and employ effective methods that may improve future classroom teaching practices and learning experience, but it also suggests a methodic structure of edutainment games' design and implementation.

2. Materials, Method, and Experiments

The present work has consisted of a chronological flow of phases and experiments, designed according to the ADDIE instructional design model. ADDIE suggests dynamics and flexibles guidelines for educational projects' management, throughout a set of five systemic chained processes: Analysis, Design, Development, Implementation, and Evaluation. ADDIE is meant to save effort and time, caused by contagious problems, while it is still easy to fix them [47]. In the following, we summarize the five methodologic phases in our ADDIE-based strategy, elaborated throughout three studies, referenced as *study 1, study 2,* and *study 3.* Fig.1 outlines the method, studies, and ADDIE phases considered in this work.

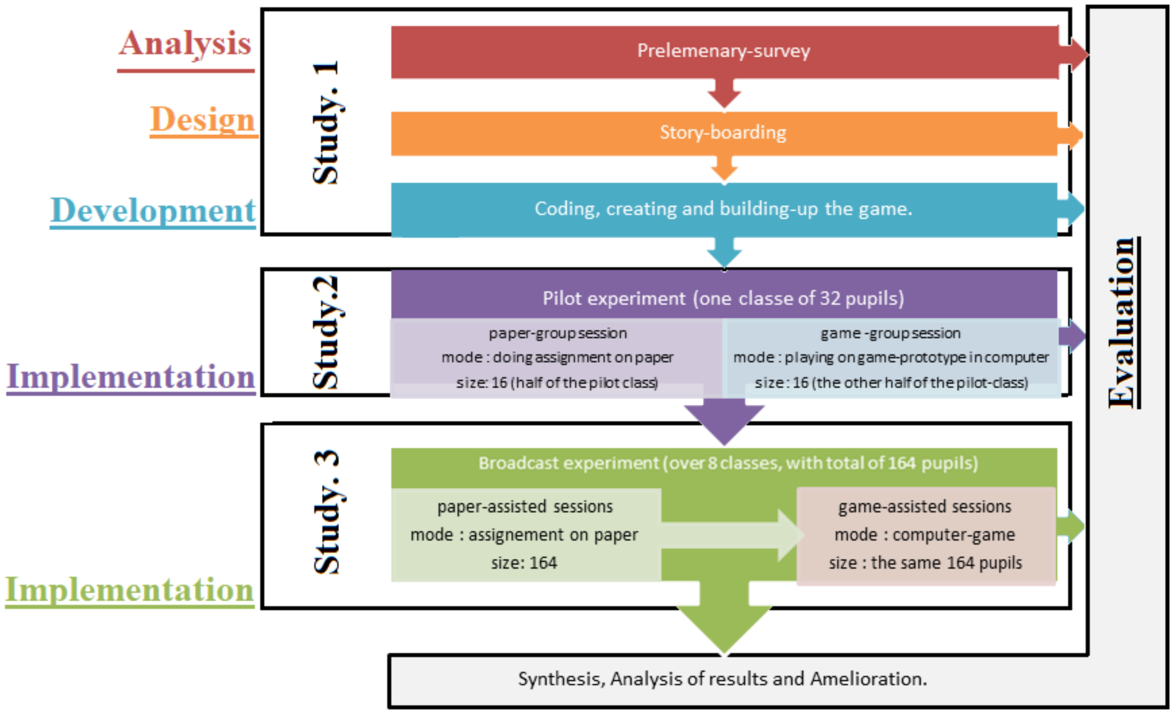

Fig.1. Main Experimental Phases.

2.1. Study 1

a) Preliminary survey

In study1 we conducted more than 22 interviews with teachers, educationalists, and Math inspectors who have field experience ranging from 22 to 38 years. We retain the following general remarks:

- Mathematics' difficulties' causes and effects are variants and appear at any school level. The interviewed persons mostly accentuated difficulties during transient levels (i.e., $5^{th}/6^{th}$ to 7^{th}, 9^{th} to 10^{th}, and 12^{th} grades).
- The interviewed highlighted that geometry and arithmetic present serious difficulties to young pupils. In upper school levels, pupils still manifest errors related to early prerequisites in geometry and arithmetic.
- During face-to-face class-situations, the percentage of interviewed persons who witnessed signs of negative experience during mathematics' activities is as follows: e.g., lack of autonomy (24%), mathematics' skills (27%), apprehension or demotivation (33%), low concentration and commitment to the activity (26%), natural avoidance, procrastination toward the chore (27%).
- All interviewed persons confirmed dealing with at least one anxious pupil, toward mathematics subjects, per academic year, over their professional years and practices.

b) Storyboard

Before game development, we designed a storyboard in three layers (Fig.2):

- Layer 1, *the content*: incorporates learning elements and tracks treated by the game, e.g., generated dialogues, pedagogy framework, learning objectives/goals, curriculum/educational norms and criteria, evaluation modalities, difficulties, and levels' hierarchy.
- Layer 2, *the look & feel*: define the nature of graphical and sonar aspects of the game, e.g., visual elements' sketches, navigation bar, sound effects, narrators, feedbacks, motivators, avatars, backgrounds, and general environment.
- Layer 3, *the gameplay*: drafts out the game mechanics, e.g., main algorithm linking all the tracks together, challenges' flexibility, scoring system, database, login modalities.

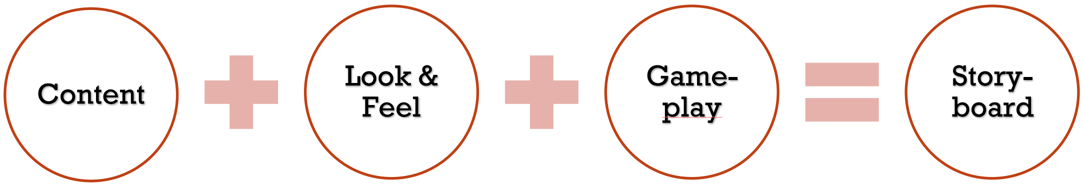

Fig.2. The game storyboard layers.

c) Building up the game.

From storyboard scratches, we developed the *prototype* in two layers:

- Layer 4 (*The skin*): Using Adobe® CS6® Illustrator and Flash, all graphics, defined in layer 2, were illustrated and animated. Sounds were made and edited via Audacity®
- Layer 5 (*The code*): based on Layers 1 and 3, via interactive coding with ActionScript3.0®, we added "life" to Layer 4 elements, open-source script code was made available for further exploitation. Fig.3 shows the game prototype components.

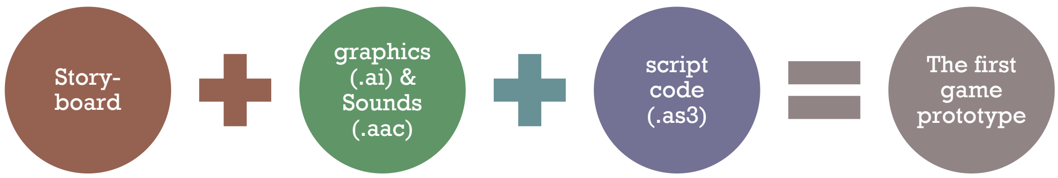

Fig.3. First game prototype: main components.

d) The gameplay

In the game, after identification/login, player chooses from four modes corresponding to, Naturals, Integers, Rational numbers, or training/tutorial mode. The fourth mode is separate and optional. At any level, by clicking the "ready" button, random arithmetic operation within the chosen mode will be generated, and the countdown begins, the player should insert the correct answer before time fades[1]. Each mode contains four hierarchical levels corresponding to: addition, subtraction, multiplication, and Euclidian division. e.g., "$\frac{1}{3}+\frac{3}{5}$" would be placed on first level in "Rational numbers" mode, while "$15 \div 5$" corresponds to the fourth level in "Natural numbers". The scoring system does not allow player to fully access all modes and levels, which specific score threshold is required (Table 1.). Leveling up requires successive correct answers, inserted in time. i.e., only the correct answer stops the countdown, and increases score by +2 points. Otherwise, +0 point for wrong answers, and −1 point if time ran out. Table 1 provides naive overview of the gameplay algorithm and scoring system:

Table 1. Gameplay overview: identification, scoring system, stages, and levels.

Step 0	Step 1	Step 2	Step 3	Mode1: "N"	Score threshold & range	Mode2: "Z"	Score threshold & range	Mode3: "Q"	Score threshold & range

[1] https://bit.ly/3f9JaN0

If (*Login*) Go to Step 3 Else If (*New player*) Skip to Step 2	*Pseudo-Name* Insertion *Password* creation *Gender* selection M* or F* *Avatar* personalization	Login *Pseudo-Name* & *Password* Matching	Game Mode selection: N*/ Z*/ Q*/ TM* If score <101: Grants N If score <201: Grants N and Z Else Grants N, Z and Q	Lv*1 +*	0 ≤ score ≤ 25	Lv5 +	101 < score ≤ 125	Lv9 +	200 < score ≤ 225
				Lv2 -*	25 < score ≤ 50	Lv6 -	125 < score ≤ 150	Lv10 -	225 < score ≤ 250
				Lv3 ×*	50 < score ≤ 75	Lv7 ×	150 < score ≤ 175	Lv11 ×	250 < score ≤ 275
				Lv4 ÷*	75 < score ≤ 100	Lv8 ÷	175 < score ≤ 200	Lv12 ÷	275 < score

F: Female; M: Male; N: Set of natural integers; Z: Set of integers; Q: Set of rational numbers; TM* tutorial and training mode; Lv: Level; +: addition; -: subtraction; ×: multiplication; ÷: Euclidian division.

2.2. Study 2

Study 2 was a pilot study, with exploratory and prototype-evaluative purposes. Study 2 involved 32 pupils from 6^{th} grade of Al-maghrib Al-Arabi elementary public school, located at Driouch City in northeast Morocco. All chosen pupils had good use of computers and basic arithmetic knowledge (pre-test diagnostic was made). Pupils were then divided into two equivalent groups: the first 16 pupils (game-group), played and tested the game prototype for one hour, focusing on one clear given goal. The others 16 (paper-group), tried to reach the same goal via the traditional method, using paper/chalkboards. We tracked scores, the number of tries (i.e., number of received answers in a row, either correct or incorrect, before countdown stops), and motivation and, concentration levels (three levels' scale: 1-weak to 3-intense). Table 2 summarizes the pilot study main findings.

Table 2. Pilot-study main findings.

Groups	Diagnostic test mean score	Motivation	Concentration	Mean score	Max score	Min Score	Mean of tries
Game-group	95%	Intense	Intense	65.6	71	60	83
Paper-group	94%	weak	average	70.3%	90%	0%	-

2.3. Study 3

Study 3 was drawn and motivated from Study 2. Game-prototype, method, and main findings from study 1 were ameliorated. Study 3 involved 164 pupils, of 5^{th}/6^{th} grades, from eight classes, in six elementary schools, and four different regions from southern Morocco: Al-Charif Al-Idrissi (1) (N=20; 5^{th} grade), Al-Charif Al-Idrissi (2) (N=20, 6^{th} grade) and Marakat Dcheira (N=29, 6^{th} grade) in Tantan region; Tarik bnu-Ziad (1) (N=10; 5^{th} grade) and Tarik bnu-Ziad (2) (N=10; 6^{th} grade) in AssaZag region; Rebouat Essihrij (N=30; 5^{th} grade) and Tarik bnu ziad (3) (N=26; 5^{th} grade) in Guelmim Oued-Noun region; and El-Marghiti (N=19; 5^{th}/6^{th} grades) in Sidi-Ifni region.

a) Method

No selection criteria were considered. All eight class groups attended two sessions, respectively "paper-session" and "game-session":

- *Paper-session:* Pupils were given paper assignments containing similar arithmetic operations generated by the game. Draft papers were not allowed, teachers encouraged pupils to find answers through mental processes. Teachers tutored, guided, and provided explanations, and mental arithmetic "tips" as necessary. They observed, assessed, and ranked pupils' level of concentration, motivation, commitment to the assignment, intra-interaction with each other, cheating, and MA.
- *Game-session:* The game was installed on computers, rules, goals, and instructions have been explained. During this session, teachers tutored pupils, observed, and subsequently assessed, and ranked their level of concentration, motivation, connection with the game, the interaction between each other, cheating, and MA.

After one hour of gaming, and one hour of paper assignment, all pupils' scores have been collected. Few discussions/interviews have been engaged with pupils. Qualitative measurements were done using "standardized evaluation grids", where we provided precise directions to teachers. Each variable was given a scale of 3 (1-low to 3-high). Special attention was given to the MA assessment. The whole work was established, real-time managed, synchronized, and coordinated with teachers, via a Moodle-based platform[2].

b) MA assessment:

Assessing MA in young pupils is difficult [48]. Since 1972 researchers are trying to contribute reliable *scales* to measure MA, e.g., "*The Mathematics Anxiety Rating Scale*" (MARS) [7]. The interest in MA amongst young children is recent, e.g., "*The Mathematics Anxiety Questionnaire*" [49, 50], "*Children Anxiety in Math Scale*" [51]. However, MA scales gradually require tests/retests, analyses, and psychometric proprieties' validation [52]. Most children-target scales have been adapted or derived from adult-target scales, e.g., "*Mathematics Anxiety Rating Scale for Elementary School Children*" [53], "*Mathematics Anxiety Questionnaire*" [54, 55], "*Mathematics Anxiety Scale for Children*" [56], "*Child Math Anxiety Questionnaire*" [57], *"Mathematics Anxiety Scale for younger children"* [58, 59].

The "Abbreviated Math Anxiety Scale" (AMAS) [60], derived from MARS [7], is a reliable college/high-school-target spread MA scale [52]. AMAS distinguishes two factors: "*Learning Math Anxiety*" (LMA), i.e., learning situation related MA, and "*Evaluation Math Anxiety*" (EMA), i.e., tests, examination, and evaluation related MA. AMAS was translated, and cross-culturally tested/reviewed, and more recently was adapted for young-pupils, e.g., Persian [61], Italian [62], German [63], Polish [64], targeted 8 to11 years old children, while Italian version [65], and modified English version of the AMAS (mAMAS) targeted 8-13 years old age-range [66]. We loaded from the mAMAS the evaluation dimensional structure: EMA, and adapted their four items, to fit both, post-paper-session, and post-game-session. The Adapted *mAMAS-EMA* items we used with pupils, considering simplified vocabulary of pupils' native language (primarily Arabic, secondary Tamazight/Hassanya) and topic-related references. Table 3 shows EMA items, as originally mentioned in AMAS and mAMAS. Our Adapted mAMAS-EMA items are on the far right of Table 3.

Table 3. EMA items as cited in AMAS, mAMAS and, their corresponding adapted items in our study.

EMA items	In AMAS	In mAMAS	Items' adaptation	
			Paper-session version	Game-session version
1	Thinking about an upcoming math test one day before.	Thinking about a test the day before you take it.	Thinking about an upcoming math test.	Thinking about the game as a math test before you take/play it.
2	Taking an examination in a math course.	Taking a math test.	Taking a test in a math class.	Playing the game in a math class.
3	Being given a homework assignment of many difficult problems that is due the next class meeting	Being given math homework with lot of difficult questions that you have to hand in the next day.	Being given math operation (such as sum, multiplication etc.) with lot of difficult arithmetic calculations/operations, that you have to hand in class.	Being given in-game arithmetic operations that requires a lot of difficult calculations, that you have to hand before time runs out.
4	Being given a pop quiz in math class.	Finding out that you are going to have a surprise math quiz when you start your math lesson	Finding out that you are going to have a surprise math quiz at math class.	Finding out that you are going to have a surprise videogame about mathematics, at math class.

3. Results & Discussion

Study 2 results were fairly satisfying (Table 2). Since the goal was to (a) test the game prototype and (b) receive preliminary feedback on classroom implementation strategy. Pupils have been *conveniently* selected to best match the required criteria (good use of computers and optimal arithmetic skills: all scores in this pre-diagnostic-test were above 94%). As planned, explorative and persuasive purposes were reached: (a) pilot-study pupils raised few technical issues and bugs which were fixed and adjusted, (b) Sample was divided into two separated groups, i.e., each pilot-pupil participated either on game-session or control-group. Which may expand the error-margin in descriptive statistics, related to individual differences, personalities [31, 23], or teacher change effect [21]. In study 3, we subjected each class-pupil to both sessions, under their own teacher supervision. Where we trusted teachers with data collection, sessions' management, MA assessments, and reviews. Study 3 data are *qualitative*, which were organized, quantified, and normalized in nonparametric data (%). Fig. 4 to 11 display comparisons of classroom experience between the game session and the paper session, based on medians drawn together, from the collected MA and other variables' metrics.

[2] http://www.jeu-math.technoeducative.com/

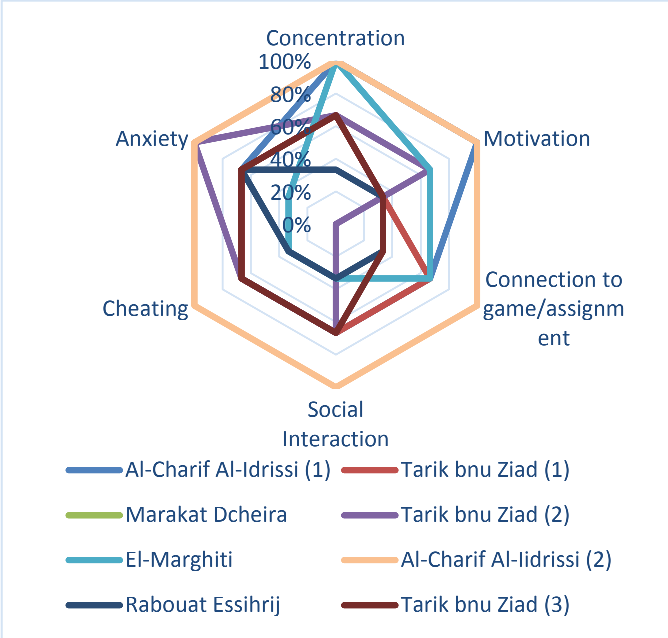

Fig.4. All elementary schools' paper session experience overview.

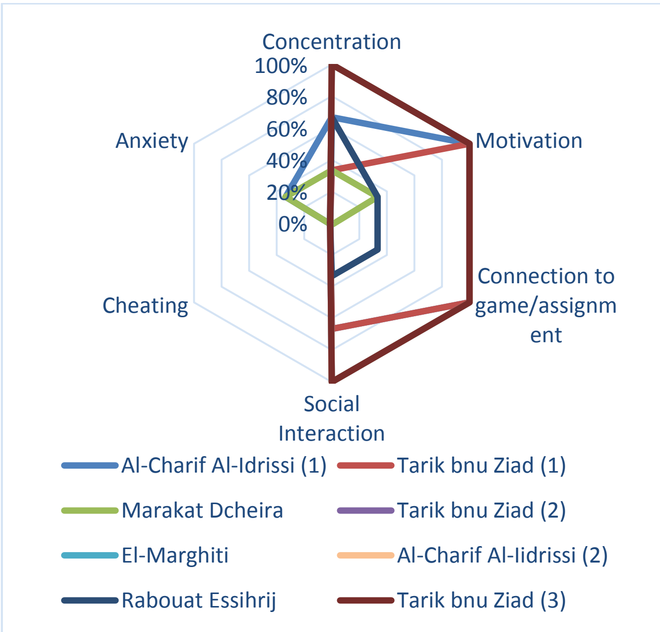

Fig.5. All elementary schools' game session experience overview.

What first catches the eye is the overall shown gain throughout most groups' game-sessions, i.e., motivation, concentration, and connection-to-game (Fig. 4 and Fig. 5). Versus low levels of cheating and MA (Fig. 4 and Fig. 5). Most pupils were in a comfortable and undistracted state of mind during game sessions compared to paper sessions. Fig. 6 shows the drop in MA levels from paper sessions to game sessions.

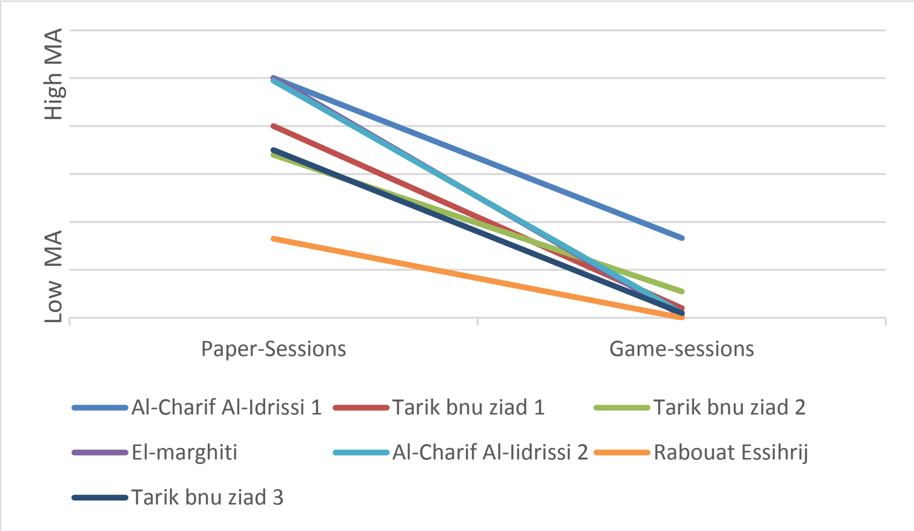

Fig.6. MA levels' retrogression from paper-sessions to game-sessions.

Teachers noticed and reported on their students, an "exceptional" *engagement*-to-game, *motivation*, and *concentration* during gameplay (Fig. 5). Thereby, and contrasted to paper-session, game-session presented a better classroom *experience* for most pupils (Fig. 4 and Fig. 5). Playing videogames/digital games is characterized by abstraction from reality for a moment, and engaging in a space of freedom, related to pleasure, entertainment, and fun [33]. Such activity joins the "*flow*" theory, suggesting that the game player, may dive into the "*zone"* or the "*flow"* during the play [30], i.e., an *immersive* state-of-mind characterized by the *commitment* to an isolated mode, from real-world distraction. [67]. The *immersion* and *motivation* probed by this study can be credited to the flow phenomena, but not necessarily. Special game characteristics, like multi-sensorial feedbacks, challenges, graphics, engaging and interactive gameplay/mechanics are highly seducing, and absorbing compared to traditional methods [44]. They draw and maintain pupil attention [44], either the "ultimate" flow-state is reached, or not. However, these characteristics are double-edged. i.e., they could be a "source of distraction" or obstacle as well. e.g., Tarik bnu Ziad (1) and Al-Charif Al-Idrissi (1) both reported low levels of concentration although motivation and connection-to-game were great (Fig. 5). Though MA does not always drop to nil (Fig. 5 and Fig 6). Attitude toward computers and self-efficacy may influence students' performance and generate another type of anxiety, like "computer anxiety" [68]. Teachers reported that numerous pupils were in "struggle" before mastering the gameplay, especially pupils from *Moroccan-Sahara remote areas*[3], who are neither familiar with IT daily use, nor unaccustomed to videogames. Tarik bnu Ziad (1) and Al-Charif Al-Idrissi (1) teachers noticed amongst this category of pupils, weak autonomy and concentration using computers, which ruined their game session experience. Whilst on paper-session those pupils were more familiar with "the routine", and "the implicit didactic contract" was clear enough, and they performed better, teachers claim.

Pupils' MA during paper sessions were more intense compared to game-sessions (Fig. 12). Many authors pointed that MA negatively affects learners' *motivation* and *performance* [69, 70]. MA leads to "natural avoidance" of whatever causes suffering, "it harms" learner *concentration* when solving a mathematical problem [71]. Coping with difficulties by the challenge-reward system and suffering by the play-and-fun mechanism. Molding uneasy learning activities, into fun by *gamification*, may reduce such effect in mathematic [12, 45]. Besides, numerous pupils' attitudes toward in-class mathematics activities have positively shifted after game-sessions, thing that possibly helped ease MA and improve classroom experience [72]. We quote from some pupils' perceptions after game-session: "*not using drafts was difficult, I was worried to put wrong answers on paper, I was confused if anyone would check my mistakes, I prefer the game-way much better*", "*I did not worry about mistakes, neither tracked times I failed, I was focusing on gameplay and wining*", "*I would practice more math to win more, and achieve better scores next time*". Marton and Säljö [73] pointed out the importance of attitudes held by learners toward mathematics, and described two processes of learning approaches, "surface" and "deep". The deep approach privileges deeper and structured understanding of the studied material, while the surface approach encourages rote memorization and unmeaningful learning tasks. Numerous studies have shown the existence of a positive correlation between anxiety and surface approach, and negative correlation to deep approach [74]. Positive attitudes toward mathematics led Pupils to use a deep approach instead of a surface one when learning mathematics [75]. Although, these are not the only suspect able factors. Cooper, Downing, & Brownell [76] have emphasized that anxiety can be significantly decreased through an *active learning approach* when the approach is *well implemented*. Which is the case in our DGBL-ADDIE combined strategy? It also remains crucial to

[3] Nearly 50% of Guelmim – Oued Noun population settle in sahara/desert remote areas, statistics could be found in the HCP official website: https://www.hcp.ma/downloads/Maroc-des-regions_t18707.html

consider learners' approach and abilities to learn mathematics, alongside the teaching strategies, to help establish a better learning environment and efficient classroom experience.

Cheating was astonishingly *absent* during game sessions, and concordant to low MA levels (Fig. 4 and Fig. 5). A pupil under high tension, to free himself from the anxiety generated by the uncomfortable mathematical situation, wants to reproduce an immediate and inappropriate response, rather than pursuing a rational resolution process [77, 78]. Using paper, pupils can easily pursue such scenario, whilst through our game, "salvation" will not be granted until the good answer is given (Table 1), then immediately awarded. Mistakes are not sanctioned, but encouraged, considered as part of the game, and *normal steps* leading to winning. Thus, both MA and cheating are not privileged through such engaging game mechanics. Whilst challenges, active learning and, error-based learning are prompted instead.

On the other hand, most pupils scored better on paper session than game session. Table 4 outlines game-sessions' final scores' range, including the top highest score achieved, alongside paper-sessions' scores' mean.

Table 4. Each school pupils' performance in game and, paper sessions.

School	Game-session final scores' range (.pt)	Highest reached score	Paper-session scores' mean (%)
charif idrissi (1)	24-54	71	80 ±7
Tarik bnu ziad (1)	12-48	66	62,50 ±9,5
Marakat Dcheira	5-25	42	-
Tarik bnu ziad (2)	43-59	74	40 ±10,1
Elmarghiti	11-65	85	59,64 ±6,3
charif idrissi (2)	61-71	84	92 ±4
Tarik bnu ziad (3)	8-40	63	64 ±11

All game-sessions' final scores did not exceed 72 points, whereas paper-sessions' scores are above 40%. Even though MA levels were lower in game sessions. Most MA scales-based studies fail to distinguish a "clear" relationship between MA and mathematics performance [49], such propriety is more highlighted amongst adults/adolescents, and difficult to equate amongst children [79]. However, neither game nor paper scores are pupils' MA reliable indicators, *"MA is separate from math skill, 'typical' math performance tasks cannot be used as a MA measure"* [48]. Also, comparing pupils' performances in arithmetic, based on their raw scores, would be inaccurate, as both tests' modalities are different, and many confounding variables may have interfered in scores, e.g., we quote from teachers: "*Once pupils reach the fourth level, they are sent back to the third, the advanced game levels are more challenging, and surpass most of our pupils' capabilities.*", "*on paper, some pupils helped each other, while others claim using arithmetic techniques and hacks.*", "*some pupils are exceptionally excellent at mental arithmetic, so they did well in paper session. likewise, they quickly reached advanced levels in the game, in less than 10min, unfortunately, the game did not allow them to break through the 5th level 'easily'.*", "*the challenge maintained in the 4th level has escalated remarkably, many 'excellent' pupils have been stuck there trying and retrying*". (Tables 1 and 4). Knowing that any answer was not put on time, increments score by -1 point, and only a threshold of 75 points allows stay going beyond 4th level (Table 1), most pupils exceeded 60 points more than once, in less than one hour of play (Table 4), i.e., getting each time, successive correct answers, done throughout all 3 first levels. (Table 1). Yet, many pupils claimed to have enjoyed the game, no matter how the final score was. To them, the raised challenge in upper levels was not frustrating, rather motivating. It is crucial to maintain a balance between displayed challenges and their required abilities to avoid anxiety and boredom when designing games [30]. Any challenge should be perfectly placed beyond pupil capabilities, where he can accomplish tasks that he did not think he had the capacity to do, all through a great deal of pleasure. Respecting that criterion, through the flow, the created game leads the player to accomplish tasks that he will probably be unable to do in another state of mind [67]. Furthermore, MA and performance can reciprocally influence one another [80]. Since this study distinguishes optimal MA levels in-game sessions. Perhaps, if we gave pupils more time to play, they would have exceeded their actual scores until the the game is over.

However, measuring pupils' performance based on either the game or paper-test raw scores would be loose, and beyond the scope of this paper. This work suggests that pupils learn more efficiency, via the game than traditional paper methods, through repetition and mistakes [44, 42, 27, 26], in a comfortable state-of-mind and better class experience, with a great deal of attention and immersion, lifted by the game special characteristics [33].

4. Conclusion

This work emphasizes that implementing DGBL in classroom can improve pupils' motivation and concentration. As learning via digital-gaming activity could be highly seducing, engaging, and immersive experience to young pupils, versus traditional methods. Our study suggests that edutainment games through DGBL, can significantly ease pupils' state-of-mind during math-classes (reducing MA), involving tasks that require arithmetic calculations, in-class delivered assignments, and/or pop-up quizzes. This leads to better math-class/classroom experience. However, when conceptualizing a game, it is crucial to maintain game challenges within player's capabilities. It is also important when implementing DGBL into schools to carefully consider the instructional design process, keeping in mind that using a digital game alone cannot reach educational goals, if it is not integrated within a whole digital game-based strategy. However, it could be used as a tool for performance enhancement, but not as a reliable pupil performance assessment tool.

Using video games at school may improve students' classroom experience. In future research we may consider granting pupils the opportunity to freely play the game outside school hours and without any time constraint. Hence, gaming activity could be associated with entertainment rather than just an extra-assignment. Also, measurements like self-motivation, time a pupil would dedicate to the game before he gets bored or frustrated, and performance evolution, would be more accurate than the one-hour session post-measurements in our current experiment.

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