THE EFFECT OF THE INTEGRATION OF ONLINE GAMIFIED MATHEMATICS PRACTICE ACTIVITIES ON LEARNERS' ENGAGEMENT, MOTIVATION AND ACADEMIC ACHIEVEMENT

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ABSTRACT_ *This is a mixed method concurrent research study set-out to explore the integration of online gamified activities, within the context of mathematics education, specifically focusing on lower primary grade level (Grade 2). The results indicated the integration of online gamified learning activities to practice mathematics contributed positively to learners' engagement, motivation and to their academic performance. Moreover, it further found that gamification elements, including the award of points and certificates, along with provision of facilities that enabled learners to engage competitively, receive feedback and publicly share their achievements, had a direct effect on increasing engagement and motivation of learners in mathematics education. The research ended by developing a 'bolt on' model. The recommendations of the study included ascertain whether the 'bolt-on' online Mathematics Practice model used in this study could be up-scaled to increase transitions towards technology integration in mathematics education.*

KEYWORDS: *Primary learners, gamified learning, gamification.*

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I. Introduction

The study of mathematics as a discipline began in the 6th century AD with Pythagoras who coined the term 'mathematics' from Greek, meaning 'subject of instruction' Heath [1]. Before the modern age, mathematics was primarily used for trade and commerce. By the twentieth century, mathematics had become an independent curriculum in developed countries. In the early 21st century, 'mathematical proficiency' became a key focus in many countries [2].

The focus of mathematics education in general is not just to engage learners in mathematics thinking but rather to enable them to view mathematics as way of thinking Pratt [3] and a subject of growth in which their role is to learn and think about new ideas Boaler [4]. Therefore, all learners should be taught within a culture that values their ability to think, engages them in the breadth of mathematics, and encourages them to achieve more Boaler [4]. Learners must be taught to be power thinkers who make connections, think logically, and use numbers creatively.

Technology, particular games provide a useful method of learning, and furthermore game mechanics and dynamics are increasingly used by educators to motivate, engage and change users' behaviour Deterding et al [5]. Computer games have furthermore provided an innovative approach to enhancing learners' interest Ebner & Holzinger [6]; Papastergiou [7], increasing learners' motivation (Burguillo [8]; Dickey [9]; Harris & Reid [10]; Miller et al [11], reforming learners' behaviour Connolly, Boyle, MacArthur, Hainey & Boyle [12], improving learners' learning Brom, Preuss, & Klement [13], Clark, Nelson [14], fostering learners' understanding Klawe [15], fostering learners' problem-solving skills and advancing learners' ability to achieve specific goals [16].

Therefore, this study broadly sought to identify way/s in which technology could be mainstreamed within education. The potential of gamified learning in the practice of mathematics education at lower primary levels was primarily explored in this study.

I. The rationale of the research

Online gamified learning was evidence from other jurisdictions of its success in motivating learners to engage within and beyond the classroom e.g. Su and Chengt [17]. There was limited research at national and global levels on the behaviour of children aged between 6 and 9 within online gamified learning environments [18].

In order to prosper within dynamic social, cultural and economic environments of the 21st century, learners need to develop and/ or enhance skills such as critical thinking, teamwork, digital literacy, problem solving, collaboration and cooperation. In the last 30 years, a range of pedagogic approaches have been developed to foster these skills. One such approach involves the gamification of learning, which has been shown by Lee & Hammer [19] to be particularly important in supporting learners to interact, communicate and collaborate with each other, and thus can help facilitate types of learning required for 21st century living. Therefore, this study hoped to add to the body of research by exploring learners' engagement and motivation in a particular type of gamified learning (which was geared towards enabling the practice of mathematics) in an attempt to shed light on how the use of these types of activities can support learning in mathematics education at the aforementioned grade level. Moreover, this study aimed to respond to calls for improvements in the enhancement of digital literacy of learners, while recognising that the wider context of ICT integration is impacted by many and varied factors such as teachers' and learners' dispositions and skills, and the technological infrastructure. In doing so, the researcher also recognised that the evidence base for the generalizations underpinning the concept of digital natives has been contested by researchers including, Helsper and Eynon [20] and Bennett et al [21], and accepted that digital natives are perhaps better identified across a broader range of factors which move beyond the narrow generational concept, to include other impacts such as the degree of immersion in the technology and breadth of exposure to online engagement for learning purposes, as well as socio-demographic factors (gender dimensions and/ or educational levels).

This research explores the impacts of gamified learning activities practices on learning engagement, motivation and academic achievement at low level learners (Grade 2). The research question includes: *What impact, if any, does the integration of online gamified mathematics 'practice activities' have on learning engagement, motivation and academic achievement?*

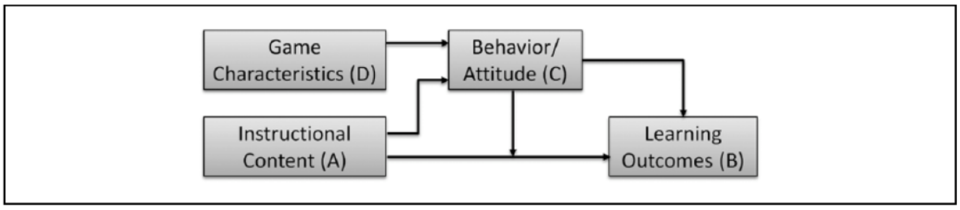
These questions divided to sub-questions:

- How do primary learners interact and perform within traditional spaces?
- Does the integration of online gamified mathematics practice activities affect learners' engagement, motivation and academic achievement? Why, why not?

II. Gamification of Learning

The gamification of learning involves the use of game features in a non-game context Deterding [5], and focuses on developing skills, changing behaviours and driving innovation [22]. In fact, "*gamification is about engaging people on an emotional level and motivating them to achieve their goals*" Burke [22]. The use of gamification has been increasingly applied to different fields, including politics, health and marketing. Gamification of learning involves the application of individual game elements or combinations of those elements within a learning context [23]. Numerous scholars have attempted to create a gamification element framework. For example, Werbach, and Hunter [24], proposed a framework of gamification in which the gamification elements form a pyramid with three main groupings as follows: *components* (i.e., achievements, levels, avatars, points, badges, leaderboards, virtual goods, content, and gifting); *mechanics* (i.e., challenge, competition, cooperation, feedback, resources, rewards, and chances); and, *dynamics* (i.e., constraints, emotions, narrative, progression, and relationships). In addition, Bunchball [25] presented a list of common game mechanics that could be applied to gamification: points, levels, challenges, virtual goods, rewards, status, accomplishments, self-expression and competition. In educational contexts, Kapp [26] further added to that list, with: "*goals, rules, conflict, competition,* *cooperation, time, reward structures, feedback, levels, storytelling, interest level and aesthetics*" as elements that can be applied within a learning context. Moreover, in a systematic mapping study to investigate the gamification elements that can be applied in education, Dicheva, Dichev, Agre & Angelova [27] acknowledged that the most popular game mechanics were: points, badges and leader boards, and further identified gamification principles, including: visual status, social engagement (competition), freedom of choice, freedom to fail, and rapid feedback. More specifically, in primary education, Simões, Díaz Redondo and Fernández Vilas [28] constructed a framework of gamification elements that could be applied to an online social learning environment for primary education learners (aged 6 to 12), which included: feedback; rewards (e.g., badges and points); levels; a progress bar; student participation; and, performance.

Landers [23] tried to develop a theoretical model to explain how gamification affected learning. He used nine game attributes to define game elements including: action language, assessment, conflict/challenge, control, environment, game fiction, human interaction, immersion and rules/ goals that can apply outside of game context to increase engagement and improve learning. Landers defined gamification as the use of these game elements to facilitate learning and related outcomes. In his theory, he stated that game elements will affect learners' behaviour and by default their learning. In this regard, Landers articulated two main processes by which game elements can affect learning (see Figure 1), which form the foundation of the theory of gamified learning.



Note. D → C → B and A → C → B are mediating processes. The influence of C on A → B is a moderating process. Directional arrows indicate theorized path of causality.

Figure 1
Theory of gamified learning adapted from Landers [23]

The first process is a more direct 'mediating process' and the second process is a less direct 'moderating process'. Gamification can affect learning via the mediating process, i.e. when game characteristics affect behaviour and/or attitude and the behaviour and/or attitude affects learnings. The important implication in this process is that a game element must cause positive changes in the behaviour/ attitude of a learner, with the corollary that the change in behaviour will lead to improvement in learning. For example, the integration of a game element (e.g. points, credits) might encourage learners to visit the activities more regularly, which would likely lead to improvement in their learning. In terms of a moderating process, the learner engagement with the instructional content and experience of interacting in game (i.e. achieving or not achieving the learning outcome/s), is impacted by the learner disposition.

Previous studies found that the integration of gamification in education provides an enjoyable atmosphere that increased learners' interest and motivation Buckley and Doyle [29]; Seixas et al [30]; Hursen & Bas [31] . This contributes to increase the level of learners' engagement Hursen & Bas [31]; Seixas et al [30]; Alghamdi& Holland [32] and then improve academic performance of learners [17,30,31].

Hursen & Bas [31] for example conducted a study with 4th grade students taking a science education class, reported the positive effects of the gamification on the students' motivation and achievements. Students in their study had good level of communication

with their friends and teacher in the classroom. Alghamdi& Holland [32], in their meta review explored the effect of online game- based learning and gamification on learners' dispositions, abilities and behaviours of learners age 6-12 found that learners' intrinsic motivation has been enhanced and this had a direct effect on increasing engagement and improving academic achievement. Lin & Chiou [33], conducted a study on sixth graders school students who were taking an algebra class and determined that the use of gamification has positive effective in students' learning of algebra word problem solving and attitude toward learning.

III. Methodology

This study utilised a concurrent mixed methods approach including qualitive and quantitative tools.

4.1 Research processes

Grade 2 learners were chosen for this research study. A Control Group and an Integrated Group were formed could be used to compare and contrast engagement and performance of learners. The Control Group undertook the traditional mathematics session, and thus were taught the traditional way and used workbooks for practising mathematics. The Integrated Group was a bit more complex – it included two cohorts of learners in one classroom all of whom were taught the traditional way, however, one cohort had access to iPads or laptops and thus could engage with Mathletics in the mathematics practice part of the class this cohort became known Mathletics Group (MG), the remainder had to undertake practice activities within the workbook – this cohort became known as the Workbook Group (WG)

4.2 Research tools

4.2.1 Qualitative tools.

This section provides the tools that used to collect the data. The qualitative tools including direct class observation and interview.

4.2.1.1 Direct class observation

The observations were performed during the normal class sessions, which lasted 25 minutes; both groups (CG) and (IG) experienced traditional teaching while (CG) practicing the new mathematical concepts with traditional way using workbook, Integrated Group practised the material using the Mathletics platform. The same learners were observed to record their behaviour and their progression in practice sessions. Field-notes from the observed sessions were manually recorded in the researcher' diary, capturing teachers' and learners' engagement in the classroom.

4.2.1.2 Interviews

Face to face semi-structured interviews were conducted with two teachers participating in this research, to capture teachers' viewpoints regarding the use of technology for students in classrooms and an understanding of their level on using technology in classroom, each lasting between twenty and twenty-five minutes. The interview has seventeen questions. The teachers in the interview were asked questions about the use of technology in their daily classrooms, their experience using ICT into teaching, their level of using technology, and the training courses that are provided to them. The first four questions were asked about the background information of the teachers. Question five and six were asked about teachers' ICT skills and training. Questions from seven to ten were asked about the teachers' integration of ICT in teaching. The teacher in the IG sessions were further asked about her opinions to gamified mathematics practice activities.

Furthermore, the face to face semi-structured interviews were conducted with six students. The learners' interview questions started by warm-up questions to help relax the learners. The first three questions asked about their free time at home, their favourite game and their favourite devise. The purpose of this was to create a positive atmosphere for the learner. The rest of the questions were much focused on their engagement in mathematics classrooms. learners in MG were asked about the factors that motivate them in the online gamified mathematics platform. Each interview lasted between fifteen and twenty-five minutes.

Finally, interviews were 2 parents (mothers) in order to gain some insight into learner engagement with Mathletics beyond the school door. The interviews with parents were unstructured and focused on ascertaining from parents their child's interest in using the Mathletics platform at home and factors that motivated them to engage with platform's activities. Each interview lasted between twenty and twenty-five minutes.

All interviews were audio-taped and hand notes were also taken.

4.2.2 Quantitative tools.

This section provides the tools that used to collect the data. The quantitative tools including a mathematics performance test.

4.2.2.1 Mathematics performance tests

The tests were prepared to measure the impact on individual learner performance within the Control Groups and Mathletics Groups at each grade level. The participants completed the mathematics test twice, with approximately six weeks between the sessions (pre- and post- Mathematics Performance Test). The mathematics tests included questions from a mathematics book that has questions similar to those being undertaken in the Mathletics platform.

4.3 Data Analysis

4.3.1 Qualitative Data Analysis

In terms of data analysis, the data collected through class observations and interviews were prepared for analyses by weekly transcribing and translation of data-sets. So, all interviews and observation data were transcribed from field notes and audio transcripts into word documents and coded using thematic analysis [34].

Thematic analysis was considered for this research as that it has been proven to be an effective method of identifying themes in qualitative data-sets, that 'capture the key idea about the data in relation to the research questions and represent some level of patterned response within the data set' [34]. Braun & Clarke [34] further explain that the theme/s can be identified either in an inductive 'bottom up' or deductive 'theoretical or top down' approach. This research study followed the inductive approach which allowed 'research findings to emerge from the frequent, dominant or significant themes inherent in raw data, without the restraints imposed by structured methodologies' Thomas [35],. In this regard, the researcher read and re-read to code the data and determined theme/s without using a pre-conceived framework. The specific analysis steps were adapted in this study from Braun & Clarke [34] who present six different phases of analysis process

4.3.2 Quantitative Data Analysis Tool.

For this study, the Statistical Packages for Social Sciences (SPSS) version 24 was utilised to analyse the data obtained from Mathematics Performance Test. A paired t-test was used to compare the scores on the Mathematics Performance Test in the same group of learners pre- and post-intervention.

4.3.3 Validity and Reliability of Qualitative Data

Validity in qualitative data means that a researcher checks for the accuracy of the findings by employing some strategies such as triangulation, rich and thick descriptive data Creswell [36]. Reliability is 'consistency' or 'repeatability'. This means that if the study is repeated, it will deliver the same results. Achieving the same results from qualitative data is difficult, however, Lincoln and Guba [37] suggest that instead of *'aspiring for the same results, qualitative researchers can use triangulation, peer examination, investigator's position and audit trail to ensure dependability and consistency'*. To ensure the rigour of this study, the triangulation technique was employed, as well as using rich and thick descriptive data set, and maintaining an audit trail of all analysis processes. The qualitative data collected from the learner and teacher interviews and class observations were triangulated. In order to construct an audit trail, a diary was maintained during the process of collecting data to capture questions, ideas and decisions that were made regarding the study. This record ultimately presents evidence of how data was collected and analysed and how the research was conducted. Also, the interviews were recorded and transcriptions retained for the record.

4.4 Participants

The participants in this study were grade 2 learners in a public school setting in Saudi Arabia and their teachers and parents. The students ranged from 7 to 9 years of age. Control Group and an Integrated Group were formed at Grade 2. The Control Group undertook the traditional mathematics session, and thus Grade two Control Group had 19 students (n=19). The Integrated Group had a total of 29 learners, with 19 in the WG and a further 10 of them were in the MG.

Two teachers and two mothers involved in this study. All participants are female as the Saudi education system is non-mixed education. So, school are separated by genders.

4.5 Mathletics Platform

The Mathletics platform was the online mathematics practice form used in this research study. This platform was chosen as it was an example of an online gamified learning environment which supported some elements of gamification while allowing for the practice of mathematics. It was solely focused on enabling learners to practise mathematics, so did not include facilities to explain concepts to learners. Each participant had their own account. The platform was chosen for this study because at the time of the research, Mathletics was the only platform uses game elements that cover Saudi curriculum.

Key Findings

This section opens with a short description of the teacher and cohort of learners and then moves forward to summarise the findings on nature of learner engagement in traditional mathematics and Mathletics sessions, with the conclusion section comparing and contrasting findings relating to engagement and performance in traditional mathematics sessions, with those that integrated Mathletics to facilitate the online mathematics practice.

5.1 Control Group: Background Information

The Control Group Teacher [CT2] had four years' experience teaching at primary level (lower level), and was in her second year at this Tatweer school during the period of study. The teacher was female, and her primary subject degree was Islamic Studies. The teacher indicated that she had undertook three months ICT professional development, that was organised by Ministry of Education and considered herself to have basic level of knowledge of integration technology in education. This teacher was their class teacher; thus, she taught this cohort the majority of the curriculum (including mathematics). The mathematics sessions were taught through Arabic.

5.2 Control Group: Pedagogy of Mathematics Practice in Traditional Setting

Once the teacher explained the new topic and did some practice exercises from the mathematics textbook, she then generally directed the learners to use the workbook for more practicing in class time and this work was submitted to the teacher once completed. The teachers did not generally provide direct feedback on the learners individually within the mathematics class, she sometimes asked the learners to drop the workbooks on her desk or bring them to her the next day to check.

The teacher was observed using different approaches to engage the learners in practicing mathematics activities. She encouraged the leaners to work in groups or individually on mathematics practice activities within the workbook. She also supported cooperation in by directing one learner in a group to help her friends in solving mathematics problem or help them to read the textual questions. On several occasions, they encouraged peer assessment by directing the learners to check each other's work. The teacher also undertook a role of facilitator across all sessions by moving around and checking on their work, and by offering support and advice when needed and providing scaffolding as and when necessary.

In terms of learners' interaction in mathematics practice activities, the class observation revealed that most of the learners completed the mathematics activities. Some of the learners were observed working more cooperatively on the mathematics practice activities. They helped each other to solve the math problems. However, there were some learners who disengaged with the group work and prefer to work on mathematics practice activities by themselves. Furthermore, some of the learners displayed a lack of interest in practicing the mathematics activities. They for example closed the workbook before completing the assigned activities or copied the answer from friends and had informal chat. The learners in the interview explained that they prefer to work on easy questions only. Learner G2CC1 said that '*I like when the teacher asks an easy question. But when she gives us a hard question, I got so bored and I lose concentration…*'. In addition, there were some learners who displayed levels of anxiety [for example, learners expressing frustration by groaning or sighing, or holding head in hand accompanied by groans- observed in sessions 5 and 8, and/ or throwing down pen – observed in session 4,] with the more challenging questions in workbook. In cases such as this, learners did ask the teacher for more explanation, and frequently the teacher would lean on digital resources such as CDs to further explain mathematics activities on the white-board, where needed.

The class observation revealed that some of the learners exhibited initiative in attempting more advanced mathematics practice activities at home, and thus when teacher directed them to start the activity in the workbook, the activity had already been completed at home in advance of class – this was observed to happen with one/ two learners across all sessions. The interviewed learners said that they tried out the activities before the teacher explained in school because they felt it would help them to understand and also that they hoped to get a reward for doing so. Learner G2CC2 said that '*I like to do the activities at home before we take with the teacher because it helps me to understand fast and the teacher gives me a gift'*. Learner G2CC4 stated that '*I like to do the workbook activities when the teacher still explaining the new topic. Because when the teacher asks us to do the workbook activities, I showed her my answers, and when all answers are correct, the teacher gives me a gift like pencil or rubber. The teacher usually brings very nice gifts*'.

5.3 Integrated/ Mathletics Group.

The Mathletics Group (MG) was part of an overall grouping called the Integrated Group. Basically, the entire cohort of learners in the Integrated Group were taught the mathematics concepts together in a traditional way, but the learners within the Mathletics (sub-) group were allowed to complete the mathematics practice activities using Mathletics, whereas the others had to complete the practice activities using the workbook (hence, the latter have been named as the Workbook Group, WG).

A different teacher taught the Grade 2 Integrated/Mathletics group. This teacher [IT2] had seventeen years' experience teaching at secondary level, and was in her first year at this Tatweer school during the period of study. The teacher was female, and her primary subject degree was Home Economics. The teacher indicated that she had undertook one month of ICT professional development, that was organised by Ministry of Education, and considered herself to have basic level of knowledge of integration technology in education. This teacher was their class teacher; thus, she taught this cohort the majority of the curriculum (including mathematics). The mathematics sessions were taught through Arabic

5.4 Integrated Group: Pedagogy of Mathematics Practice in Traditional Setting

All learners in the integrated group were asked to complete at least one question from the workbook (as this is a mandatory requirement of the Saudi curriculum). However, 10 of the learners were allowed to move away from the workbook and use the Mathletics platform to practice mathematics, once this question had been completed, and the remaining 19 learners had to continue answering questions from the workbook. The section below describes what was observed during 'workbook activity' across the Integrated Group, thus it summarises for the record the interactions from the Workbook Group in their practice of mathematics problems.

The teacher encouraged cooperation across the WG, directing learners to help other group members. In session 11 for example, one group member had difficulties in 'Add Numbers: Regroup a Ten' activities. So, she asked the teacher for help, the teacher was busy with one of the learners, so the teacher asked one learner from other group to help her friend. She also encouraged peer assessment by asking the learners to exchange and correct each other's work. The teacher also played a role of facilitator and offered scaffolding when needed for those experiencing difficult in solving mathematics problems.

The learners generally engaged in cooperation within the groups and explained to each other how to solve problems. However, evidence from the class observation revealed that some of the learners disengaged in the group and prefer to work alone on solving the problem. The class observation further revealed that other learners expressed levels of anxiety with more challenging questions, and these learners asked the teacher for more explanation. In session 8 for example, the learners got frustrated in trying to measure the length of one of the shapes in the workbook. So, one of them asked the teacher, how can we use these cubes to measure something that is very long? Furthermore, the class observation revealed that some of the learners attempted workbook activities at home before it was explained in class with the teacher. Furthermore, there were some cases who expressed a lack of interest in the activities. They moved around, messing with other and had informal chatting with friends.

In terms of the learners' interaction, some of the learners completed the assigned activities and submitted to the teacher to check. In all sessions, they tried to complete the workbook activities as fast as they could and those in the MG usually would ask about the time to play Mathletics. Those who had to continue using the workbook, i.e. those 19 learners in the Workbook Group, displayed signs of frustration at not being able to engage with Mathletics software and frequently tried to informally interact with those in the Mathletics Group. The WG learners frequently stopped working on the workbook activities, and would try to engage with the Mathletics activities. In all observed sessions, most of the WG learners were observed pulling the laptop with Mathletics from a learner in the MG in an attempt to complete the Mathletics mathematics practice activity. In Session 4, one of the MG learners was observed asking for help from WG learner and became frustrated when the WG learner clicked the correct option (instead of allowing her to do so). Other WG learners cried out on occasion out of frustration and upset at not being able to engage in Mathletics (observed in session 1, 2 and 3).

5.6 Mathletics Group: Pedagogy of Mathematics Practice in Mathletics Setting

Generally, the teachers allowed those learners using the Mathletics platform to engage in self-directed learning. the teachers moved around to check on MG work and encouraged other learners to share and help their friends. The teachers also provided scaffolding when needed. For example, in one of the activities, some of the learners needed a little more help with the Mathletics practice activity, so they asked the teacher about how they can use the ruler in the game (the learners were taught to use the ruler from right to left to measure the length (Arabic mode), whereas Mathletics activities were presented to use the ruler from left to right (Western/ English mode). Grade 2 teacher when interviewed re-iterated the importance of the teacher in technology-enabled settings, such as that supported through Mathletics. She said that '*This technology (Mathletics) never replaces the teacher, 'the teacher is like a key of the box' especially for this age'* [MT2].

The class observations revealed that the learners enjoyed playing and seemed enthusiastic with the Mathletics platform. It is interesting to note that their excitement did not appear to reduce during the overall period of the observation. Indeed, on many occasions the researcher had to shut-down the wi-fi connection to bring a close to the Mathletics sessions and/ or the teacher had to take each device from the MG learners, as learners simply refused to stop engaging with the Mathletics practice activities. The teacher in her interview noted that the level of the learners' interest towards mathematics increased when using Mathletics, '*Mathematics is one of the subjects that the learners like because it related to their life such as money, time, addition and subtraction. But the presence of the game has increased enthusiasm for Mathematics'*[MT2]. She therefore strongly recommended integrating this technology into mathematics classrooms, particularly for practising math-based activities, '*but it is good after I have explained the lesson as an additional course, so they can practice by using the game'.* The teacher however, suggested to have a separate class timetabled to use this technology because mathematics class time is not enough. The teacher stated that '*I suggested to integrate such technology as an additional course two to three time per-week because mathematics class is not enough. I take 20-30 mins to explain the new topic and the learners have to practice what they have learnt in the workbook. And also, learners need time to have access to the game'*[MT2]. So, she suggested to integrate this technology in school time, but this integration should be specifically planned, '*So, I suggest integrating this technology at school time because it really increases their enthusiasm in mathematics class. It should be integrated with clear plan.'* The teacher also highlighted the need for technology in-situ, stating that: *'It is necessary to have equipment in school such as devices, Internet and the game itself'* [MT2].

Also, the interviewed learners explained some of the benefits of using Mathletics in the classroom. Learner G2MC1 said: *'I like mathematics class, but when you bring Mathletics game, I became more concentrated when the teacher explains. I want the teacher to finish fast so I can practice by the game and understand more…The game also helps me to understand so when I have difficulty in understanding mathematics, I can play more and more'*. Learner G2MC2 stated that*:' I like mathematics class, but I became more focus with the teacher when she explains. Mathletics helps me to understand more and I became faster and smart in solving the problems because I solve them in my head and type the answers'.* Learner G2MC3 stated: '*I like mathematics class, but I like it more when we started playing Mathletics. The game makes me more focused and better at mathematics because I answer in my head and then type the answers. The most things that I like to play is addition and subtraction. These two topics were hard but now became easy because I play over and over again'*. This is in line with what one of the mothers said in the interview '*My daughter likes mathematics but this game (Mathletics) makes her better at math. She can solve the problems in head and then* *type the answer. Since this game introduced to the school, my daughter was so excited about mathematics class. She asked to charge the device before went to bed so it will be ready for the next day'* [M1].

Furthermore, the learners created challenge groups within various Mathletics activities, and expressed their enjoyment in competing and collaborating with their peers and used the activities as a chance for a challenge. The learners were observed self-organising into challenge groups in which the person who finishes first is the winner. The winner typically showed her happiness, such as by raising her voice, saying "*I won*". As previously mentioned, the learners in WG group were observed providing help to their friends so they can win the competition – sometimes this help was requested, other times it was volunteered by WG learners. During the interviews, the interviewed learners confirmed that they prefer to play at school because of the presence of their friends. Learner G2MC1 '*The most enjoyable thing is to play with my classmates'*, Learner G2MC3 *'I play at school and at home, but I like to play at school because of my friends'*. Sometimes, MG learners expressed frustration at WG interventions in their learning activity.

Additionally, the class observation revealed that the learners in this MG group exhibited a desire for collaboration. They were frequently observed explaining how to solve the problem to each other. This was confirmed by the learners in the interview. Learner G2MC1 said that '*At the beginning, I didn't know how to do the activity. When I have joined my friends, I have learnt how to play'*, Learner G2MC2 said that *'...But I like to play at school with my classmates. Because when I need help, I can ask them'*. However, there is evidence showing that there were some learners who preferred to work alone in the Mathletics activity. For example, one of the learners generally sat by herself in her seat and did the all the Mathletics activities by herself throughout the sessions [G2MC1].

The learners were also able to connect with global competitors within the 'Live-Mathematics', and this appeared to increase their excitement. This engagement was shown to be a fun learning experience for participants in this study. The learners were extremely happy when they found each other in the game 'Live-Mathematics'. The race winner showed her happiness by raising her hand, saying for example, "I won", moving around, and showing the teacher her achievement. The learners were able to move to the advanced level (second level) and challenge at this level within 'Live Mathletics'. However, in general learners played at the first level so that they could score more points and win more games.

Learners appeared to be motivated to stay on task by tracking their own progress and sharing this with their peers. The learners were also observed repeatedly returning to the activities to improve their final scores and respond with the correct answers. When the learners received their final feedback with only a few mistakes, they tried the activity again to see if they could get all correct answers. One of the mothers said in the interview, '*The game can provide the feedback so, she can play multiple times until gets the correct answers. For example, she had difficulty in one of the topics, I think 'Addition' but when she played the game it became easy because she repeated the activities over and over again and she can see her progress'* [M2]. The learners further demonstrated pride in their achievement when they completed the activity without help and without mistake - Learner G2MC1 '*Now I can play by myself – there is no need for anyone help me. But if I need help, I will ask my mother because I play most at home'*, learner G2MC2 *'I am proud of myself that I can play without help'*.

Moreover, the class observation reveals that the learners exhibited the desire to engage in the platform beyond the class. The leaners in the interview confirmed that they visited the activities at home. Leaner G2MC1 '*I played at home, I played the previous lessons such as Measurement, Geometry'*, G2MC2 *'I play Mathletics at school and at home'.* This confirmed by two different mothers interviewed: '*When my daughter came back home, she played about half an hour. she talked about the game with her siblings. She can play the game by herself, she never asks for help'* [M1], and '*Generally, my daughter is independent she never asks me for help unless she did not get the answer. But after the integration of this game (Mathletics) she never asks for help. She usually finished her homework and then played the game. She visited some of the activities that they took at the beginning of the semester and practiced something new. She talked with her brother about the excitement that she had when she played with her friends in the classroom and the activities that they played together and who won the competition. She encouraged her brother, who is a year older than her, to have an account and play the game'* [M2].

The learners appeared to be motivated by some of the game elements such as points and certificates. They physically moved around the classroom to share with each other the number of points being earned. The learners in the interview confirmed that they enjoyed collecting points. Learner G2MC1 '*I like to play Mathletics to collect the points and to win the competition. I have 78 points that I have collected right now. I have only one certificate, so I have to play a lot to collect more points and have another certificate'*. Learner G2MC2 *'I have 400 points and one certificate. I have to play more to get more points'*, G2MC3 *'I like to collect points. I have 100 points and last week I had 1200 points. I have one certificate'*. So, this encouraged them to play more. Learner G2MC3 for example said that '*So, if I cannot receive a certificate, I have to play more'*. However, some of the leaners expressed sadness if they weren't able to collect points. Learner G2MC3 for example said that '*But if the week passed and I did not have a certificate, I will be so sad*'. Also, the interviewed mother supported this point, one of the mothers said that '*My daughter plays the game (Mathletics) at home because there is a challenging between her and her friends about the points that lead to the certificate. When she got a certificate at the first time, she was so excited. So, she played a lot to get more certificates'* [M2]. This mother also mentioned some of the benefits to learners when they bring their own device to school, she said that '*I am so excited about the integration of the iPads at school. This gives the kids confidence that they can take care of their own stuff. The kids are so happy to bring their own device and play with their friends at school. Also, I think bringing their own device at school will develop a good relationship between home and school. Our kids will be so excited to talk about the activities that they will do with their friends and the competition that they will make at school'* [M2].

Despite learners enjoying the Mathletics experience, some learners noted the importance of the teacher, mentioning the strategies that the teacher does to support them with more challenging questions. Leaner G2MC1 said: '*I have difficulties with the test and some of the activities. But the* *teacher helps us for example she re-explains when we need, she lets us to practice on the board, she lets us to help each other and sometimes she brings games. When we have difficulties in some of the questions such as higher order thinking question, the teacher writes the question on the board and explains it until we got it. So, the game the you gave us (Mathletics) is useful but the teacher is important because she teach us and take care of us*'. Learner G2MC5 noted: '*I had difficulties with some hard questions like higher order thinking questions, but the teacher help us. She re-explained for us individually, she lets to practice on the board, she lets us to practice the hard activities at home. So, I can say the teacher is important for us. So, the game that you gave us (Mathletics) is useful but it never replaces the teacher. We have to have a teacher to teach us reading, writing and mathematics and then practice in the game. But this game (Mathletics) helps me to revise the previous topic and I feel like I became smart because I answer in my head and then type the answer in the game'*. Learner G2MC6 further commented: '*In mathematics, there are some hard questions. but the teacher helps us. She lets us work in groups to help each other and she gives us real life examples. So, I agree with my friends that the game (Mathletics) is useful but could never replace the teacher. The game helps to practice more and revise the previous topic'*.

However, there were some learners who expressed a lack of interest of some of mathematics practice activities because of the aesthetic design of particular activities within the Mathletics platform. These learners therefore disengaged with these activities and tried to practice other activities. For example, the learners were asked to do Mathletics activity, 'Adding Three Digit Number- Regrouping'. The learners did the first few questions using pencil and paper because they could understand how to complete the question within Mathletics, and subsequently they closed the activity and tried to do other activities. Another example was when they were asked to do Mathletics activity 'Estimated Addition', the learners tried the first question only. They found this question very hard, and there was a sign (≈) that the leaners did not understand. So, they disengaged with the activity and tried to do another activity and some of them moved to play 'Live Mathematics'.

5.7 Comparison of Academic Performance in Control and Mathletics Groups:

A paired-sample t-test was performed to compare the scores on the Mathematics Performance Test in the same group pre- and post-intervention in both the Control Group and Mathletics Groups. The performance of the Mathletics Group was statistically significantly better (p=.002) at the post-test (mean 11.4) than at the pre-test (mean 8.75). In contrast, the Control Group exhibited no significant difference between the pre-test and post-test performance results (p= .63) (see Table 1).

TABLE 1

Results of Paired t-test of the differences between pre- and post- mathematics test for both Grade 2 groups.

	N	Pre-test		Post-test			
		M	**SD**	**M**	**SD**	**t**	**p**
Control Group	16	8.78	2.67	8.56	3.2	.492	.63
Mathletics Group	10	8.75	3.2.86	11.4	2.3	-4.441	.002

Furthermore, Table 2 shows that all learners (bar one who performed the same) in Mathletics Group gained better results in post-test by at least half mark, two learners (C1& C9) achieved highest result in their achievement of 14 out of 14 in the post-test.

TABLE 2

Summary results of pre- and post- mathematics for each learner in Grade 2 (Control Group and Mathletics Group)

Student's No.	Mathletics Group		Student's No.	Control Group	
	Pre- test (14)	**Post- test (14)**		**Pre- test (14)**	**Post- test (14)**
M1	11.0	14.0	C1	9.0	10.0
M2	8.0	9.0	C2	8.0	10.5
M3	10.0	12.5	C3	12.0	11.0
M4	4.0	9.5	C4	11.0	11.5
M5	9.0	13.5	C5	5.0	1.0
M6	9.5	9.5	C6	10.0	11.0
M7	6.5	11.5	C7	7.0	5.0
M8	12.5	13.0	C8	7.0	8.0
M9	12.0	14.0	C9	11.0	9.5
M10	5.0	7.5	C10	2.0	4.0
			C11	10.0	8.0
			C12	10.0	11.5
			C13	7.0	5.0
			C14	11.0	11.0
			C15	11.5	12.0
			C16	9.0	8.0

Only eight learners out of sixteen from the Control Group improved slightly their grades at the post-test compared to the pre-test, with 7 dis-improving their grade in this grouping. The highest mark was 12 (out of 14) and that was in case 15. Furthermore, the table shows that the academic performance of seven learners in the Control Group had decreased at the post-test (compared to pre-test), with one of these learners (C5) dropping from a mark of 5 out of 14, at pre-test to just 1 out of 14 at post-test .

IV. DISCUSSION

The discussion compares the key findings from exploration, in the context of developments relating to mathematics education and technology integration within and beyond Saudi Arabia.

The practicing of mathematics concepts within the traditional context, there was a heavy reliance on textbook for guidance and workbooks for practicing mathematics. The learners typically were encouraged to practice the new mathematics concept using the prescribed workbook, during which time the teachers played the role of facilitator and offered scaffolding by supporting learners who needed assistance. The teachers also encouraged learners to cooperate in groups and peer-assess progress during the practice dimension of the class. However, the learners typically did not receive any individual feedback from the teachers on their progress or performance in completing the mathematics practice activities until later in the day. Therefore, the teachers did not generally provide individual feedback on the learners' performance in their mathematics practice session during the class time. This absence of individual feedback on mathematics practice activities during class was a cause of concern across both settings. Furthermore, the results also showed that some of the learners displayed levels of anxiety with more challenging mathematics questions, while others expressed a lack of interest in the new mathematics concept. This was particularly evident in the traditional mathematics practice setting at this grade level, while the learners did complete the mathematics practice activities by pencil and paper, generally they did not exhibit high levels of interest or excitement while practising these mathematics activities in class. Even during group activity, there were some learners who disengaged with the collaborative group work, preferring to work by themselves on the assigned activities.

Finally, there was considerable evidence of teachers using technology to present or introduce key concepts, but a dearth of evidence of technology being used to scaffold learners within the learning experience in the traditional settings .

In contrast, this research study found that the integration of the online gamified practice activities through the platform resulted in high levels of engagement and collaboration in completing the online mathematics practice activities. this finding is a line with others e.g. Hursen & Bas [31]. The findings also indicated that the learners appeared to be motivated by their own performance in Mathletics, with learners re-visiting the activities multiple time to improve their final score and visiting the main interface page to see their level of completion as displayed on the Mathletics progress bar.

Moreover, the findings from this research at this grade level further indicated that combining particular game elements such as points, certificates, progress bars, a friendly ‘competitive’ environment, direct feedback on progress and performance in completing mathematics practice activities had positive effects on increasing the learners’ interest in mathematics, and in keeping them on task. Furthermore, learners demonstrated high levels of motivation to complete the mathematics practice activities both in-school time and also completed additional mathematics activities at home.

Even though individual and group engagement could be facilitated entirely through the online Mathletics platform, learners did appear to enjoy solving the Mathletics problems in a physical class-based setting and were frequently observed calling out to friends for support within the class. Furthermore, the ‘Live Mathematics' part of Mathletics that facilitated competitive completion of mathematics practice exercises, really appeared to enthuse and engage learners – they appeared to really enjoy connecting with and challenging their classmates (and peers in other countries) in the online competition environment. The teacher was observed facilitating a high degree of self-directed and independent learning during the Mathletics practice sessions. Learners generally asked peers for assistance on those occasions that they had difficulty solving problems in Mathletics, and only rarely sought support from teachers to complete the Mathletics activity

The results from the Mathletics intervention also showed that the inclusion of game elements such as points, certificates, progress bars, a friendly ‘competitive’ environment, and immediate feedback were factors that positively impacted on learners’ engagement and motivation .

In terms of academic performance, the finding indicated enhanced academic performance the group using Mathletics to practice mathematics). This improvement comes from learners’ enjoyment and engagement within the online gamified leaning environment.

I. Conclusion

This study utilised a ‘bolt-on’ Mathematics Practice model to integrate technology in mathematics education, through which the traditional mode of practicing mathematics using a workbook was replaced by online gamified mathematics practice activities (within the Mathletics platform). This model respected the expertise of the teacher in fostering conceptual knowledge building within mathematics education, and in this regard, it was necessary for the teacher to engage directly with learners in explaining the key concepts and engaging them in related learning activities. The model differs from others in mathematics education in that it integrates online gamified activities to support the practice dimension of mathematics education. Therefore, within the ‘bolt-on’ Mathematics Practice model, learners initially engage in learning about the concept with the teacher, but progress to complete mathematics practice activities individually, collaboratively and/ or competitively within an online gamified platform with teacher acting as guide on the side.

The ‘Bolt-on Mathematics Education’ model that could be used to fast track technology adoption in mathematics education by teachers, and, in this regard, has the potential to contribute to broader transitions towards deeper integration of technology in education.

It is recommended that further research to be undertaken to ascertain the effectiveness of the ‘bolt-on’ Mathematics Practice model in supporting transitions towards technology integration in mathematics education within the broader Saudi education context. The research would need to take account of the effect of such environments on primary level learners of both genders.

II. Limitation

A limitation of this study is that as a female researcher, it was not possible for me under the Saudi education system to access boys’ single-sex schools, as Saudi rules at the time of the research only allow for interaction between teachers and learners of the same sex. Therefore, it was possible to study how boys would engage in similar interventions aiming to integrate online gamified learning practice activities .

REFERENCE

[1] Heath, S. (1921) A History of Greek Mathematics (Volume 1). Cambridge.
[2] Kilpatrick, J., Swafford, J. & Findell, B. (2001) Adding It Up: Helping Children Learn Mathematics. Washington, D.C.: National Academy Press.
[3] Pratt, N. (2002). Mathematics as thinking. Mathematics Teaching, 181, pp. 34-37

[4] Boaler, J. (2016) Mathematical Mindsets: Unleashing Students' Potential through Creative Math, Inspiring Messages and Innovative Teaching. San Francisco, CA: Jossey-Bass.

[5] Deterding, S., Sicart, M., Nacke, L., O'Hara, K., & Dixon, D. (2011, May). Gamification: Using game-design elements in non-gaming contexts. Proceedings of the 2011 Annual Conference on Human Factors in Computing Systems (pp. 2425–2428). Available at http://dx.doi.org/10.1145/1979742.1979575.

[6] Ebner, M., & Holzinger, A. (2007). Successful implementation of user-centered game based learning in higher education: An example from civil engineering. Computers &Education, 49(3), 873–890. Available at http://dx.doi.org/10.1016/j.compedu.2005.11.026.

[7] Papastergiou, M. (2009). Digital game-based learning in high school computer science education: Impact on educational effectiveness and student motivation. Computers & Education, 52(1), 1–12. Available at http://dx.doi.org/10.1016/j.compedu.2008.06.004.

[8] Burguillo, J. C. (2010). Using game theory and competition-based learning to stimulate student motivation and performance. Computers & Education, 55(2), 566–575. Available at http://dx.doi.org/10.1016/j.compedu.2010.02.018.

[9] Dickey, M. D. (2010). Murder on Grimm Isle: The impact of game narrative design in an educational game-based learning environment. British Journal of Educational Technology, 42(3), 456–469. Available at http://dx.doi.org/10.1111/j.1467-8535.2009.01032.x.

[10] Harris, K., & Reid, D. (2005). The influence of virtual reality play on children's motivation. Canadian Journal of Occupational Therapy, 72(1), 21–30. Available at https://journals.sagepub.com/doi/10.1177/000841740507200107.

[11] Miller, L. M., Chang, C. I., Wang, S., Beier, M. E., & Klisch, Y. (2011). Learning and motivational impacts of a multimedia science game. Computers & Education, 57(1), 1425–1433. Available at http://dx.doi.org/10.1016/j.compedu.2011.01.016.

[12] Connolly, T. M. & Stansfield, M. (2006). Using Games-Based eLearning Technologies in Overcoming Difficulties in Teaching Information Systems. Journal of Information Technology Education, 5, 460–476. Available at https://www.learntechlib.org/p/111557./

[13] Brom, C., Preuss, M., & Klement, D. (2011). Are educational computer micro-games engaging and effective for knowledge acquisition at high-schools? A quasi experimental study. Computers & Education, 57(3), 1971–1988. http://dx.doi.org/10.1016/j.compedu.2011.04.007.

[14] Clark, D. B., Nelson, B. C., Chang, H., Martinez-Garza, M., Slack, K., & D'Angelo, C. M. (2011). Exploring Newtonian mechanics in a conceptually integrated digital game: Comparison of learning and affective outcomes for students in Taiwan and the United States. Computers & Education, 57, 2178–2195. Available at http://dx.doi.org/10.1016/j.compedu.2011.05.007

[15] Klawe, M. M. (1998). When does the use of computer games and other interactive multimedia software help students learn mathematics? Paper presented at the Technology and NCTM Standards 2000 Conference, Arlington, VA.

[16] Liu, D., Ma, S., Ru, Q., Guo, Z., & Ma, S. (2009, March). Design of multi-strategic learning environment based on constructivism. Proceedings of the First International Workshop on Education Technology and Computer Science (pp. 226–228), Wuhan, China. Available at https://ieeexplore.ieee.org/document/4959298.

[17] Su, C. H., & Cheng, C. H. (2014). A mobile gamification learning system for improving the learning motivation and achievements. Journal of Computer Assisted Learning, 31(3), 268–286. http://dx.doi.org/10.1111/jcal.12088.

[18] Alghamdi, J. (2019). A mixed methods study exploring the practice of mathematics education, with a focus on the integration of online gamified mathematics practice activities in primary classroom settings in Saudi Arabia. Unpublished thesis. Dublin City University: Dublin, Ireland .

[19]Lee, J. J., & Hammer, J. (2011). Gamification in education: What, how, why bother?Academic Exchange Quarterly, 15(2), 146. Available at https://www.researchgate.net/publication/258697764_Gamification_in_Education_What_How_Why_Bother.

[20] Helsper, E. & Eynon, R. (2010) 'Digital natives: where is the evidence?', British Educational Research Journal, 36 (3), pp. 503-520.

[21] Bennett, S., Maton, K. & Kervin, L. (2008) 'The "digital natives" debate: a critical review of the evidence', British Journal of Educational Technology, 39 (5), 775-786

[22] Burke, B. (2014). Gamify: How Gamification Motivates People to Do Extraordinary Things. London: Routledge.

[23] Landers, R. N. (2015). Developing a theory of gamified learning: linking serious games and gamification of learning. Simulation & Gaming, 45, pp. 752-768.

[24] Werbach, and Hunter, 2012.

[25] Bunchball (2010). Gamification 101: An Introduction to the Use of Game Dynamics to Influence Behaviour. White paper. Available at http://www.bunchball.com/gamification101.

[26] Kapp, K. M. (2012) The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education. San Francisco, CA: Pfeiffer.

[27] Dicheva, D., Dichev, C., Agre, G., & Angelova, G. (2015). Gamification in education: A systematic mapping study. Educational Technology & Society, 18(3), 75–88. Available at https://www.researchgate.net/publication/270273830_Gamification_in_Education_A_Systematic_Mapping_Study.

[28] Simões, J., Díaz Redondo, R. & Fernández Vilas, A. (2013). A social gamification framework for a K-6 learning platform. Computers in Human Behavior, 29 (2), pp. 345-353.

[29] Buckleya, P., & Doyle, E. (2014). Gamification and student motivation. Interactive Learning Environments https://doi.org/10.1080/10494820.2014.964263

[30] Seixas et al, 2017.

[31] Hursen, C., & Bas, C. (2019). Use of Gamification Applications in Science Education. International Journal Of Emerging Technologies In Learning (Ijet), 14(01), 4. doi: 10.3991/ijet.v14i01.8894

[32] Alghamdi, J., Holland, C. (2017, June). Game-play: effects of online gamified and game-based learning on dispositions, abilities and behaviours of primary learners.

In: Tatnall, A., Webb, M. (eds.) WCCE 2017. IFIP AICT, vol. 515, pp. 55–63. Springer, Cham. Google Scholar

[33] Lin, H.-Z. S., & Chiou, G.-F. (2017). Effects of Comparison and Game-Challenge on Sixth Graders' Algebra Variable Learning Achievement, Learning Attitude, and Meta-Cognitive Awareness. Eurasia Journal of Mathematics, Science and Technology Education, 13(6), 2627–2644. Available at DOI:10.12973/eurasia.2017.01244a

[34] Braun, V. & Clarke, V. (2006) 'Using thematic analysis in psychology', Qualitative Research in Psychology, 3 (2), pp. 77-101.

[36] Creswell, J. W. (2014). Research Design Qualitative, Quantitative, and Mixed Methods Approaches. SAGE Publications, Inc .

[37] Lincoln, Y., & Guba, E. G. (1985). Naturalistic inquiry. Newbury Park, CA: Sage