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PAPER

The Effectiveness of the Application of Game-Based E-Learning on Academic Achievement in Mathematics for Students in Jordan

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ABSTRACT

Mathematics is an abstract and complex subject for children that needs new ways of teaching. Therefore, this study explores the effectiveness of a computer game application called "My Math Academy" for learning mathematics on the academic achievement of early learning students in Jordan. My Math Academy computer game app is educational content through games that are adaptable to the curricula. The study sample consisted of ten students from kindergarten, first and second grades from eight schools in the city of Amman during the academic year 2022/2023 during the first and second semesters. They were divided into two groups: the treatment group, which consisted of 505 students, and a control group consisting of 481 students. The students of the treatment group were gradually trained to use the My Math Academy application, and the results showed through the data obtained that the treatment group that was taught with the support of My Math Academy obtained higher academic scores in mathematics compared to the control group that was taught in the traditional way. It was observed that the effect of the application of computer games to the academic achievement of students with severe arithmetic weaknesses is much greater than the effect of other students who excelled in mathematics.

KEYWORDS

game-based e-learning, mathematics, the academic achievement

1 INTRODUCTION

All over the globe, the form of education is changing from traditional methods to modern technology to comply with the rapid technological revolution [1]. Nowadays, technological games are used through mobile phones, digital assistants, tablets, and computers to support all those working in the field of education [2]. The use of learning based on adaptive electronic games through mobile phones in the education process is fun for children [3]. It enhances motivation to learn among students and is effective in

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the field of problem solving in mathematics [4]. Mobile learning can be defined as the process of acquiring information and skills through electronic applications [5]. There is no doubt that education through play in the early stages of special education for young children facilitates knowledge because it considers the age stage and corresponds with it [6]. The main objective of this paper is to investigate the impact of a game-based e-learning application on academic achievement in mathematics for students in Jordan.

2 RELATED WORK

2.1 Game-based e-learning

Mobile gaming technologies have transformed the teaching process in and out of the classroom [7]. It is noticeable in this era that the use of mobile phones is widespread, and mobile phones contain a variety of settings, giving students a wide range of modern and advanced uses of gaming technology in learning [8]. Learning through games is represented by individuality, and it is personal learning that is characterized by a response to the personal requirements of the student and is also characterized by the possibility of mobility and communication through global electronic platforms and networks [9]. Learning through games shapes students' knowledge and skills [10]. A great deal of research has led to the fact that learning through games has a real and positive effect on students' learning and development, especially in some subjects such as Arabic, mathematics and science [11–12]. That children learn well when the question in mathematics is in the form of a puzzle in a game and they are mentally active through games, especially questions in mathematics that need counting and thinking [13–16]. Learning through games builds social ties between learners and creates links for communication and learning between them with ease [17–20]. In addition, learning through games stimulates children's minds and increases their acceptance of learning [21–23]. Play is not only a great source of fun, but it can also be a source for children to learn and develop, because learning through games encourages students to show their intellectual abilities through play [25]. When the student plays, he experiences new knowledge [28]. Play is the field in which the child learns. The teacher can conduct experiments, by giving each child a role in the story while playing [26]. At the end of the story, all the child memorizes the equation in mathematics because of memorizing it in the story or by watching his classmate, i.e. [22]. The child learns firmly in the mind [29; 30]. Play does not interfere with academic learning, and play does not slow down teaching [24]. Games can be built through real experiences that teach in a deeper way that children remember and understand faster and easier [27]. So that children move from one fun activity to another, and teachers move away from traditional activities [31].

Learning based on useful play should be in the classroom, especially in kindergarten [28]. Children's minds are deeper in focus and understanding when they play in learning [22]. The levels of interest and understanding during learning by playing are much deeper than pulling out a worksheet [29]. My Math Academy is a learning accelerator and adaptive math solution for kindergarten and first and second grades [32–33].

2.2 My Math Academy application

My Math Academy provides math content that is interesting to the child and is available for use at home and at school [22]. It focuses on basic concepts in mathematics: counting and comparing quantities, order of numbers, relationships

in mathematics, addition and subtraction, facts in mathematics, place value of numbers [14]. My Mathematics Academy was built according to the mastery learning system (PMLS), and this system is of an individual nature in terms of use and instruction for the student. My math academy provides a guide to help with the application, to help young students to enable them to master Personal Environment Learning (PMLE). The design of My Math Academy consists of three components: face-to-face learning games for children, the second component for the parents, and the third component for the teacher [12]. Designed by My Math Academy, it contains 98 games and over 300 activities that cover concepts and skills in mathematics from kindergarten to Grade 2 [18]. My Math Academy relies on a child's diagnostic evaluation to determine appropriate games and activities for the child based on the child's prior knowledge. My Math Academy focuses on an adaptive system that uses assessment of student performance to learn the level of difficulty of the game they are assigned to [19]. Each of the six activities is designed with a graded level of difficulty according to a previously reviewed map of learning objectives [22]. According to children's skills and understanding, they move to the next game level [23]. The problem of the study revolves around that in Jordan, as in all countries, we need to know the validity of the use of computer games application of the mathematics academy to learn mathematics for early learning students in Jordan. It is one of the most important technologies that needs to highlight its impact on students, and this raises the central question in this study: Is there an effectiveness in applying My Math Academy computer games to learn mathematics on the academic achievement of early education students in Jordan?

3 METHODOLOGY

This research used the procedural model design (definition, design, development, and distancing) for the research. [20] is the basis of this developmental research and refers to using My Math Academy app development model with the goal of developing for learning and mastering.

3.1 The study sample

The components of the study sample that the researcher relied on in his study consisted of kindergarten students and the first and second grades in the city of Amman during the academic year 2022/2023 during the first and second semesters from eight schools. They were divided into two groups, the therapeutic group, consisting of 505 students, and the control group that consisted of 481 students. The study sample included kindergarten students, divided into 233 students in a treatment group and 252 students in a control group, with a total of 485 students (see Table 1).

Table 1. Components of the study sample

	Treatment	Control	Total
Kindergarten	233	252	485
1st & 2nd grades	219	182	401
Total	452	434	886

The first- and second-grade remedial group was divided into 219 students in a treatment group and 182 students in a control group, for a total of 401. Students in the remedial group were gradually trained to use My Math Academy as a resource for learning and supporting understanding of mathematics. Starting at 8% in the first month, with a monthly increase of 10%, we have reached a usage rate of approximately 80%.

3.2 Instrument and data collection

The questionnaires were used in this research, as a research tool, and were designed according to Likert scale [5]. The questionnaire of educational experts focused on two parts: the content in mathematics provided to students through electronic games, and the interaction interface of the application and the display of activities during each game. As for the questionnaires for teachers and students, they focused on measuring the applied aspect according to the following indicators: effectiveness, interaction, efficiency, and creativity index [10]. Before the data collection process, the validity of the questionnaires was verified by three experts (experts in learning mathematics, experts in learning technology, and experts in educational technologies). To test the validity of the content used, the three experts reviewed the validity of the application. To collect data, a questionnaire was distributed to the participating teachers. As for the practical test that was applied to students who It was selected by taking an experimental sample, which showed an improvement in the level of students.

Prior to implementation, participating teachers were trained in a 2-hour virtual My Math Academy application, with time-lapse videos (3 to 9 minutes) focused on students applying for the first time in My Math Academy, and on a teacher dashboard showing how to engage with the student's electronic account and the use of the electronic whiteboard by default in the first month to acquire the skill of identifying students' previous knowledge through my mathematics academic assessments, and to develop the skills of using the teacher's information board, and the method of monitoring students' progress. The researcher held an extensive discussion with the participating teachers periodically during the year to learn about developments and answer teachers' questions and observations from the field during application. Teachers participated in using My Math Academy for 45 minutes during the week spread over 5 days (9 minutes per class). The school relied on computers, students' iPads, computers, and students' cellular devices that had My Math Academy app installed on them, and students used their individual accounts to access the app while at school or at home. At the end of the 2022/2023 school year, teachers were asked to fill out a questionnaire, conduct assessments, and conduct an interview that included questions about the teachers' experiences with My Math Academy app. In the study, measures and sources were used to collect data as follows: Assessment of students' achievement in mathematics learning, where a measurement tool developed by researchers was used to evaluate students.

The math student assessments that used My Math Academy were determined by the math objectives for the age group of the participating students. The pre-assessment process included 31 multiple-choice choices. The duration of the test was 30–45 minutes. For the post-test, it was modified to include 7 additional items targeting the Grade 2 Math standards due to students making significant progress in the preliminary test. The duration of the post-test was 45 minutes. For kindergarten students, each student was allowed to stop after completing 31 items to consider the age group. The evaluation process took place at the beginning of the academic year 2022–2023 in the month of September 2022. After applying the use of My Math Academy in the classroom, an evaluation was conducted in the form of small groups of students (5–6 students). Technical support was provided to students, such as assistance in login and

any problems related to the use of devices, whether it is a computer, mobile phone, computer or iPad, and headphones were used for each student to give instructions. For each component of the evaluation, questions were answered by clicking to select a file on the screen. It is ensured that students have answered all questions before submitting. Code 0 (correct answer) or code 1 (correct answer) was used. Periodic visits were made during the academic year for the academic year 2022–2023. It is observed that many students have made great progress in using it. Especially in Grade 2 Math, remedial group teachers were asked to apply My Math Academy for three sessions of 20 minutes each per week (an hour per week) as a complementary resource to the math curriculum. The total educational activities were evaluated through games during the application of My Math Academy according to multiple variables that include students' performance in the game that was previously chosen and determined according to the student's abilities and age stage, and each game was associated with one or more goals to acquire skills, for example, adding and subtracting numbers from 1–9, counting skill for numbers from 1–30; in addition to measuring student performance with graded difficulty levels for each game. Teachers participating in My Math Academy app were surveyed according to monitoring of classroom practices and activities of teachers participating during My Math Academy app. Prior to the study, the participating teachers were asked to provide information regarding their practices and activities during implementation. They were limited to a survey before the study with 21 treatments associated with 19 controls, and a survey at the end of the study of 21 treatments associated with 20 controls. The teachers gave feedback about their practices and activities, including observations about the use of technological tools, and skills in mathematics such as counting 1–99, addition and subtraction two and three numbers according to the target age group.

Their observations were limited to a pre-study survey with 21 treatments associated with 19 controls, and a survey at the end of the study with 21 treatments associated with 20 controls. Teachers' feedback included monitoring students' interest in learning mathematics, using a Likert scale of 1–5, where 1 stands for very negative, 2 negative, 3 neutral, 4 positive, and 5 extremely positive. Among the teachers' observed statements were "I feel very at ease using My Math Academy as a math tutor, especially when teaching new skills to students" and "I find using My Math Academy to be a useful and supportive resource for learning mathematics, which is fun and engaging for students". These statements are translated into a questionnaire coded on a Likert scale. On a scale of 1 to 4, where 1 strongly disagree, 2 disagree, 3 agree, and 4 strongly agree, data were analyzed using SPSS software. Teachers from both the treatment groups (8) and the control group (4) were interviewed. The interview with the teacher focused on observations about the extent of my math academy application, obstacles encountered, how well students interacted during my math academy application, and inquiries about the teacher's role while applying as a mentor and evidence and supportive as well as focusing on the class environment in general. To identify the applications used in digital mathematics, the researcher used the monitoring protocol using the log file. Three areas were monitored: classroom management, teaching quality, and play quality. An inter-evaluator reliability score of 0.89 was calculated.

3.3 Data analysis

A basic equivalence test was performed using pre- and post-matched samples. There were no statistically significant differences to estimate the effect of My Math Academy on student outcomes between the treatment group and the control group at baseline. See Table 2.

Table 2. Baseline differences on the pretest scores with 31 items

Adjusted Means						
Study Sample	Treatment (SD)	Control (SD)	Difference (SE)	p-Value 95%	Confidence Interval	Unweighted Student Sample Size
Pre- and post-matched sample	15.38 (6.97)	15.53 (6.80)	–0.16 (0.60)	0.794	–1.34 to 1.02	886
Baseline sample for random assignment	15.46 (6.98)	15.54 (6.79)	–0.09 (0.59)	0.875	–1.2 to 1.07	918

4 RESULTS AND DISCUSSION

4.1 Results and discussion the effect of My Math Academy on student math achievement

The scores for student performance in mathematics showed that My Math Academy app improved student achievement in mathematics, as measured by a researcher-developed math assessment. In particular, the treatment group used My Math Academy for 12–13 weeks, compared to the control group. The difference between the treatment group and the control group was small and statistically significant (effect size = 0.11, p. = 0.026). It is the effect size that is considered moderate. This may be due to the use of digital applications by teachers of the control group other than My Math Academy, which may have been like them in influence during the three months when the application was implemented. This indicates the positive impact of using My Math Academy despite the competition with other teachers. Applications have a positive effect, subgroup analysis showed that the effect of the program varies according to the degree. It was observed in kindergarten that the treated group scored a point higher than the control group, with a statistically significant difference of 20.14 vs. 19.23, p = 0.01, effect size = 0.16. In the first grade, the difference between the treatment group and the control group decreased. My Math Academy affected a student's academic achievement in mathematics * p < .05, adjusted (see Table 3).

Table 3. The effect of My Math Academy on student math achievement

Adjusted Means						
Outcome Measure	Treatment (SD)	Control (SD)	Difference (SE)	p-Value	Effect Size	Unweighted Student Sample Size
Post-test (38 items)	20.97 (8.01)	20.08 (7.84)	0.89* (0.40)	0.026*	0.11	922

Note: *p < .05.

4.2 Results and discussion: effect of My Math Academy on the most advanced skills assessed

The treatment group using my math academy gained 20.2 points compared to the control group, 19.1 points, p = 0.01, effect size = 0.16, in kindergarten as

learning gains. While there are no statistically significant differences between the treatment group for the first and second grades and the control group for the first and second grades, this confirms that the effect of the group that used My mathematics academy in kindergarten is greater than the effect in the first and second grades. Kindergarten students excelled in the most difficult skills that were evaluated. These skills were added to the post-test in kindergarten after it was noticed during the application that kindergarten children excelled until they were able to deal with second-grade games (see Figure 1).

Fig. 1. Effect of My Math Academy on the most advanced skills assessed

To see if My Math Academy was associated with math skill development as measured by assessment where we examined the relationship between math skill development and post-test score. The correlation between the post-test score and the number of cumulative skills mastered by students in My Math Academy was strong at r = 0.73 (see Figure 2).

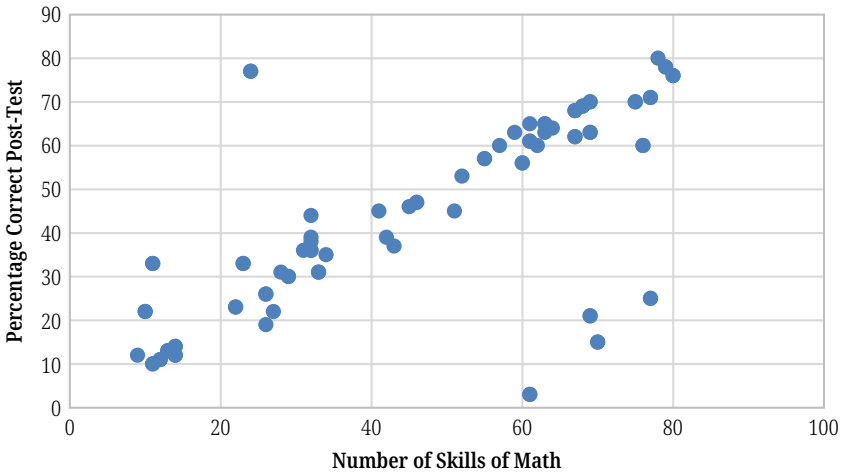

Fig. 2. Correlation, $p < 0.01$ between the skills students master through My Math Academy and their post-test scores r = 0.73

4.3 Results and discussion teachers' perception of educational technology on their students' math skills

The survey at the end of the study confirmed that the teachers in the treatment group (n = 20) and the control group (n = 20) answered questions about the positive and significant effect of using technology on the mathematical skills of their students (see Figure 3).

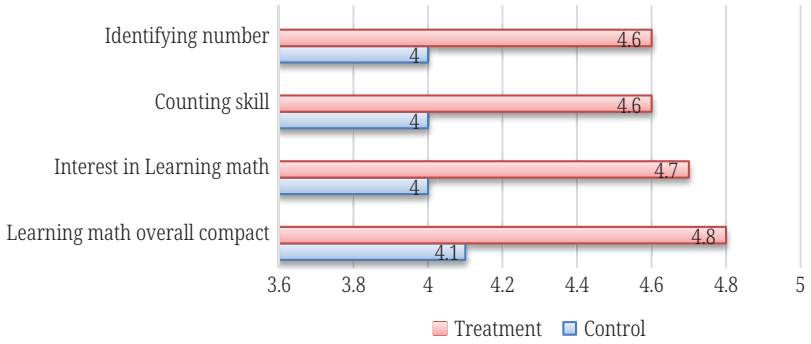

Fig. 3. Teachers' perception of educational technology on their students' math skills

In the interview, one of the teachers said: "I am a kindergarten teacher. It is great that children learn through the activities of My Math Academy, which provides them with more activity and interest in the classroom environment. Learning mathematics becomes fun and students acquire skills faster." One of the teachers explained: "The students use their mobile devices. They are professional in the activities, and they are very interested. They share their experiences by playing to learn mathematics among themselves." (See Figure 4)

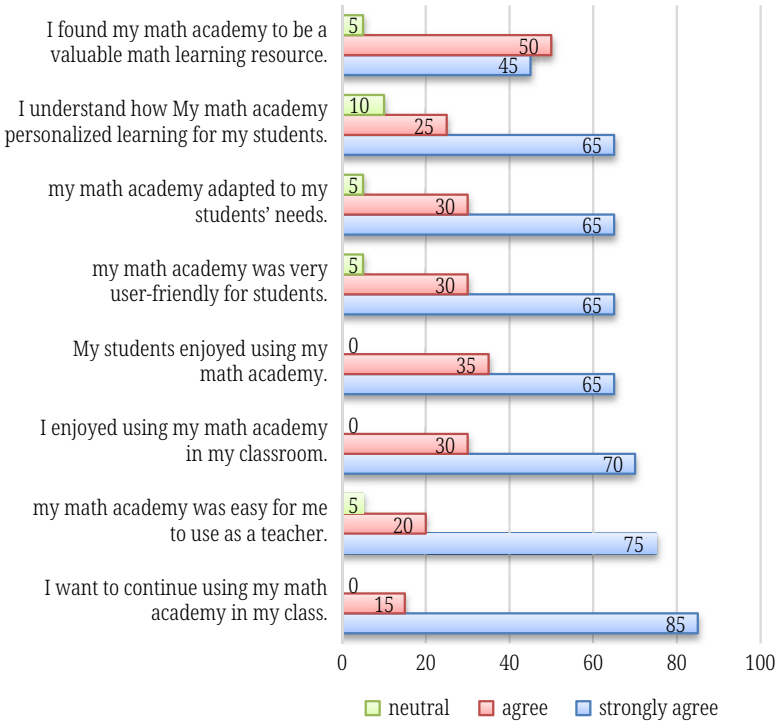

Fig. 4. Treatment teachers' experiences of using My Math Academy in their classrooms

This study stresses the need to develop early childhood education practices [19]. It emphasizes the importance of play in helping young students build personal academics based on appropriate game-based learning for young students. The results of the study indicated that students in the treatment group who used My Math Academy for a period of 12 weeks in 2022–2023 outperformed students in the control group in mathematics achievement. This result is particularly remarkable because students learn self-directed play within My Math Academy,

without the need for rote learning and memorization. Moreover, stimulation for children, learning personally and learning to master are some of the most important features of My Math Academy. Teachers confirmed that my math academy app alleviates the challenges in learning math for young children [15]. The results indicate that My Math Academy provides customized guidance to students who have problems understanding mathematics, especially in skills that are overlooked by kindergarten teachers who focus most of the time on basic skills (shape, countdown, numbers...). Finally, the findings of this study are consistent with a 2017 study of pre-kindergarten and kindergarten classrooms that used My Math Academy over a 12–14-week period [7] and increase students' interest in learning mathematics. My Math Academy is a promising and effective intervention for students from poor and low-income families, to help reduce the gap in mathematics knowledge.

4.4 Limitations and future research

The use of more than one game application for learning mathematics in kindergarten in the treatment group by teachers hinders knowledge of the real impact of using the My Math Academy application. Another limitation is time, which is overcome by the teachers' persistence and constant interaction with My Math Academy. As for the relationship between My Math Academy and the use of abstract number games, it can negatively affect it in terms of its competition and in terms of its attractiveness. This requires developing games and activities that are highly engaging and complementary to the mathematics curriculum at the same time.

5 CONCLUSIONS

The results of this study were consistent with study [22], which found positive effects of using My Math Academy for pre-kindergarten and kindergarten classes over a 14-week period. My Math Academy version of this study included games for 1st and 2nd grade content. The results of this study showed that the control group that used the second-grade content app outperformed the control group, indicating that the positive effects of using My Math Academy extend beyond kindergarten. As for teachers' positive perception of my mathematics academy in this study, this is due to the app's ease of use and students' high engagement in the app to learn math. The results of this study reinforce and clarify previous evidence [22], confirming the effectiveness of My Math Academy in teaching mathematics to young learners, as well as the app's usability in first and second semesters. It has two features, play and master the games. This app turns out to be very practical according to teachers and students. It is applicable to mathematics. This study concluded that the application of computer games in My Math Academy for learning mathematics resulted in a significant improvement in the academic achievement of early learning students in Jordan. These positive trends are not only among students, but also among teachers and parents who appreciate the positive impact of learning through electronic games. My Math Academy computer games app provides the opportunity for parents to share games and activities with their students while learning through this app. The intended future research is to test these game-based applications in different educational stages.

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