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ARTICLES

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Effect of digital game-based learning on achievement of primary school pupils in sciences in Enugu State, Nigeria

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Abstract

Considering the growing need for the infusion of digital technologies in the teaching pedagogy, the study sought to investigate the efficacy of digital game-based learning on achievement of pupils in sciences. The study adopted pretest-posttest randomized control group design with 45 participants. Science achievement test (SAT) was used to collect data for the research. The instrument was both face and content validate and as well trial tested. The internal consistency and stability indices of the SAT were estimated to be 0.87 and 0.76 respectively using Kuder-Richardson formula 20 and Pearson's product moment correlation. Mean and analysis of covariance were used to analyse the data collected in order to answer the research questions and test the hypotheses. The findings revealed that digital game-based learning significantly ($p < .05$) improved the achievement of primary school pupils at both the post-test and follow-up measures. Pupils who were exposed to DGBL, participated actively during the teaching learning situation than those who were exposed to the traditional method of teaching.

Keywords: *Achievement. Digital game-based learning. Primary school pupils. Sciences.*

Introduction

Improving the academic achievement of learners especially at primary school level has been the efforts of researchers in this twenty first century. Modern teaching strategies are important and most preferred in the technological age. A modern education system uses technology to impart education especially in this twenty first century world. The growing usage of digital games and applied sciences into learning environments has affected both the teaching by educators and the learning of students. The integration of digital games in the educational environment has shown positive results in enhancing the learning process (Trybus, 2014). The emergence of computers and multimedia technologies have led researchers to develop digital content and systems for teaching various subjects at different levels of education. According to Turner, Johnston, Kebritchi, Evans and Heflich (2018), strategically designed and integrated digital games have the potential to increase academic and learning effectiveness.

Several research have examined the effect of digital game-based learning for non-traditional students enrolled in postsecondary education and the implication games can have on achievement and learning outcomes (Chia-Li, Ting-Kuang & Chun-Yen, 2016; Turner, Johnston, Kebritchi, Evans & Heflich, 2018, Ming-Hsiu, Shih-Ting & Chi-Cheng, 2019). Chia-Li *et al*. (2016) found that through the fun and enjoyment of the self-developed instructional RPG, students could engage in an active and effective learning process even when they were not aware of an upcoming test. However, based on the result of Chia-Li, Ting-Kuang and Chun-Yen's study, the effectiveness of RPG as a supplementary reviewing tool for grade 10 geological instruction fell short of researchers' expectations. This is contrary to other several studies that suggested that students learned effectively with instructional games (Chen, Wang & Lin, 2015; Hwang, Wu & Chen, 2015)

Besides, Ming-Hsiu, Shih-Ting and Chi-Cheng (2019) found that after exposing students to game-based instruction intervention, the improvement rate of the students in the low-score group was clearly greater than that of the high-score group, thereby indicating that the game-based instruction increased concentration. Morales (2005) developed mathematical lessons on a website for engaging student in self-learning and found that the time for remedial instruction was significantly reduced. Application of multimedia could assist students in mathematical learning (Damian & Duguid, 2004). According to Nguyen, Hsieh and Allen (2006), web-based learning allowed students to enhance their mathematical learning attitude and promote their learning motivation. The interactive and instantly responsive instructions which are the major aspects of web-based learning help students or learners to construct knowledge (Steen, Brooks & Lyon, 2006; Moyer, Salkind & Bolyard, 2008).

Similarly, Hennessy, Deaney, Ruthven and Winterbottom (2007) opined that the interactive records of information technology instructions could allow teachers to reflect and improve the curriculum design, as well as cultivate student capabilities of independent thinking and problem-solving. Discussions between teachers and students through technology allowed the curriculum to be closer to students' thinking and further promoted their learning quality (Jewitt, Moss & Cardini, 2007). The foregoing indicates the potentials of technology-supported learning such as digital game-based learning (DGBL) in enhancing learners understanding of scientific concepts.

According to Prensky (2001), DGBL refers to the development and use of computer games for the purpose of classroom instructional delivery. Hwang, Sung, Hung & Huang (2012) found that adding instructional objectives and materials into digital games increases students' learning motivation due to the challenging and enjoyable nature of the games. Hung, Huang and Hwang (2014) found that DGBL significantly increased the students' self-efficacy in learning mathematics than the traditional instruction group. Wang and Chen (2010) showed that, with the DGBL approach, students were highly involved in programming activities, which have been recognized as being difficult and boring tasks to most students. Yien, Hung, Hwang, and Lin (2011) revealed positive effect of computer games on students' learning achievement in a nutrition course. Hung, Hwang, Lee, and Su (2012) found that with proper design, digital games could improve students' spatial cognition ability. From the literature, it is found that DGBL could be a good approach for improving students' learning motivation

and achievement. However, none of the studies reviewed considered the effect of DGBL on pupils' achievement in science at primary school level in Nigeria. Thus, the need for the present study. The researchers therefore sought answers to the following questions

1. What is the effect of DGBL on pupils' achievement in sciences at the posttest measure?
2. What is the effect of DGBL on pupils' achievement in sciences at the follow-up measure?
3. What is the interaction of time of measures and treatment on pupils' achievement in sciences?

Materials and methods

Ethical considerations

The researcher strictly followed the ethical standard specifications of the American Psychological Association (APA, 2017).

Design of the study

Pre-test post-test randomized control trial experimental design was adopted by the researchers for the study. Subjects were randomized into experimental and control groups.

Participants

The sample for the study was 45 primary five pupils in primary schools in Enugu State Nigeria. Besides, the accuracy of the sample size was determined using *G-Power*, version 3.1 which gave 0.91.

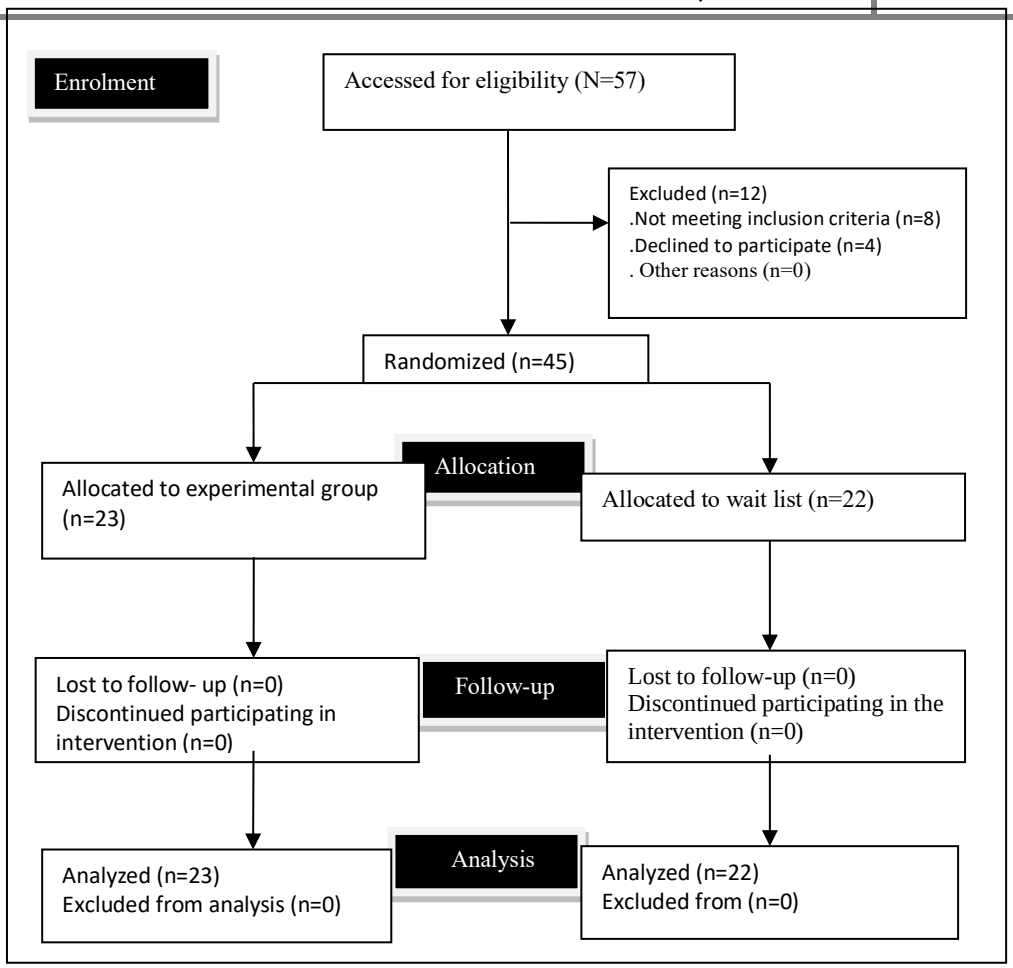

Figure 1: Sampling Distribution for the Study

The demographic statistics of the participants are presented in Tables 1.

Table 1: Demographic information of the participants

Variables	Categories	Treatment group	Control Group	Total
Gender	Male	11(47.83%)	10 (45.45%)	21(46.67%)
	Female	12(52.17%)	12 (54.55%)	24(53.33%)
	Total	23 (100%)	22 (100%)	45(100%)
Mean Age	M±SD	10.13±1.21	10.00±1.09	
Location	Urban	14(60.87%)	12 (54.55%)	26(57.78)
	Rural	9(39.13%)	10 (45.45%)	19(42.22)
	Total	23(100%)	22 (100%)	45(100%)

Measures

The instruments for data collection were Pupils' Demographic Questionnaire (PDQ) and the Science Achievement Test (SAT). PDQ was administered to the pupils before the commencement of the treatment. That helped the researchers to gather the demographic characteristics of the participants. SAT comprised 30 multiple-choice questions of response options A, B, C & D. SAT was developed by the researchers using table of specification to ensure adequate contents coverage. The items of SAT

were generated for content areas of basic science and technology for primary schools. SAT was face validated by three test development experts. An internal consistency reliability index of the SAT was estimated as 0.87 using Kuder-Richardson 20 (KR-20) formula. Temporal stability index of the SAT was found to be 0.73 using Pearson's product moment correlation coefficient.

Procedure

The researchers visited the headmasters of each of the schools in Enugu state Nigeria to notify and obtain permission for the conduct of the research from them. At the course of the visits, the researchers explained to the school authorities what Digital Game-Based Learning (DGBL). Out of a total of 57 pupils screened for participation in the study, 45 indicated interest for the study. Thereafter, Inform Consent Form (ICF) were distributed to them. Prior to that, the researcher wrote the parents informing them about the intervention program which was conducted during 2019 long vacation (July and August). After that, the students who filled ICF were randomly assigned to experimental (23 participants) and control (22 participants) groups conditions using a simple randomization procedure (participants were asked to pick 1 envelope containing pressure-sensitive paper labelled with either E-experimental group or C-control group) from a container by the researchers.

A demographic questionnaire was administered to the eligible participants to access their age, gender, and location as students. In order to remove randomization bias, information from the demographic questionnaire were concealed from the person who randomized the participants to experimental and control conditions. Prior to the commencement of the treatment sessions, pre-treatment assessment (pre-test) was conducted using the SAT in order to collect baseline data (Time 1). Thereafter, the experimental group was exposed to 45 minutes instruction with Digital Game-Based Learning while the control group were exposed to the traditional method of teaching. The program lasted twice a week for a period of 8 weeks. The treatment took place between July and August 2019. Post-test (Time 2) assessment was conducted at the end of the last treatment session. One month after the intervention program, regular follow-up assessment measure (Time 3) was conducted by the researchers. Data collected from the experimental group at each evaluation were compared to that from the control group.

Data analysis

Analysis of covariance (ANCOVA) was used to analyze the data collected. The effect size of the treatment on primary school pupils' achievement in sciences was reported using Partial Eta square and adjusted R^2 values. The assumption of the sphericity of the test statistic was tested using Mauchly test of sphericity which was not significant (Mauchly W=0.874, p=.732), implying that the assumption was not violated. Thus, the variances of the differences between all combinations of the related measures are equal. The analysis was done using statistical package for social sciences version 18.0.

Results

Table 2: Analysis of variance of the effect of digital game-based learning on pupils' achievement in sciences

Time	Measures	Group	Mean (SD)	F	p	η^2	ΔR^2	95%CI
1 Pre-test	SAT	Experimental Control	28.15(3.43) 28.76(4.23)	1.15	.865	.010	.013	0.21, 1.32
2 Post-test	SAT	Experimental Control	58.20(2.12) 35.19(6.43)	24.521	.000	.802	.812	19.17, 35.04
3 Follow-up	SAT	Experimental Control	59.87(2.01) 34.54(6.76)	26.022	.000	.811	.815	19.89, 40.06

PAT = Sciences Achievement Test, Mean (SD) = Mean (Standard Deviation), p = probability value, CI – Confidence Interval, η^2 - effect size, ΔR^2 = Adjusted R^2

Table 2 reveals that there was no significant difference in the achievement scores of pupils in the experimental and control groups as measured by SAT, $F(1,42) = 1.15$, $p = .865$, $\eta^2 = .010$, $\Delta R^2 = .013$. At the post test and follow-up measures, the effect of digital game-based learning on pupils' achievement in sciences was significant, $F(1,42) = 24.521$, $p = .000$, $\eta^2 = .802$, $\Delta R^2 = .812$; and $F(1,42) = 26.022$, $p = .000$, $\eta^2 = .811$, $\Delta R^2 = .815$. The results also showed that there was a significant interaction effect of time and group on the achievement of students in physics, $F(2,42) = 16.852$, $p = .000$, $\eta^2 = .402$, $\Delta R^2 = .221$. Figure 2 shows the graph of the interaction effect of time and group.

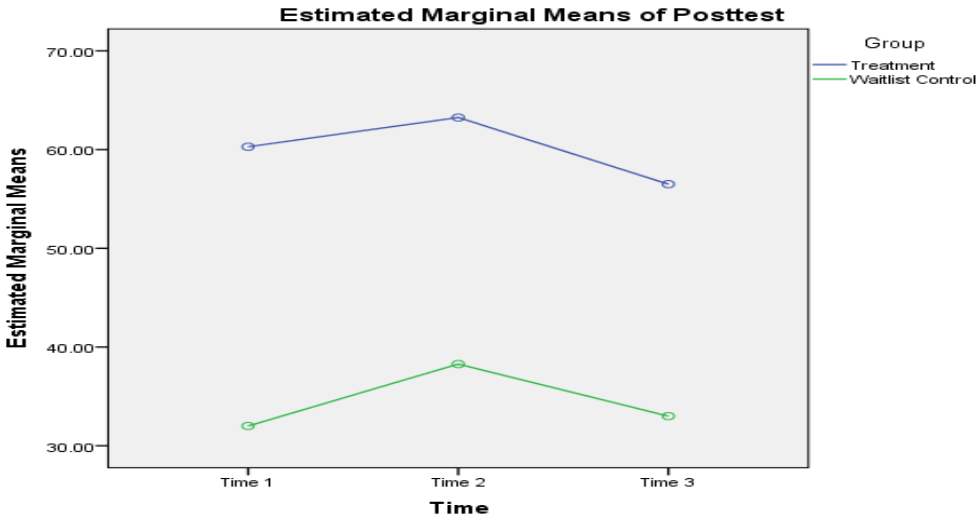

Figure 2: Interaction plot of Time x Group

Discussion of the findings

The findings of the study revealed that digital game-based learning significantly improved the achievement of primary school pupils at both the post-test and follow-up measures. It was found that the pupils who were exposed to DGBL, participated actively during the teaching learning situation than those who were exposed to the traditional method of teaching. The researchers are not surprised on the findings of the study due to the interactive nature of the DGBL which catches the attention of the

study thereby activating their interests during science classes. In line with these findings, Trybus (2014) found that the integration of digital games in the educational environment has shown positive results in enhancing the learning process (Trybus, 2014). According to Maraffi, Sacerdoti and Paris (2017), educational game improves learning processes, and at the same time, renew teaching competences of mentors integrating information and communications technology (ICT), storytelling, and digital game base learning (DGBL) with an ease to realise new didactic product.

These findings aligned with the findings of Turner, Johnston, Kebritchi, Evans and Heflich (2018); Ming-Hsiu, Shih-Ting and Chi-Cheng (2019). Ming-Hsiu, Shih-Ting and Chi-Cheng (2019) found that after exposing students to game-based instruction intervention, the improvement rate of the students in the low-score group was clearly greater than that of the high-score group, thereby indicating that the game-based instruction increased concentration. According to Holzinger, Nischelwitzer and Meisenberger (2005), computer games directly support learning by giving pupils an opportunity to develop knowledge and cognitive skills in an emotional way, to make decisions in critical situations by solving problems, to learn by researching and to experience situational learning. By playing computer games pupils discover and develop their abilities and skills, gain experience, learn and create. Games develop imagination and creativity. Computer games have their meaningful context learning becomes a situation contributing to the formation of a competent and confident individual (Lee & Hoadley, 2007).

Corroborating these findings, Hung, Huang, and Hwang (2014) found that DGBL significantly increased the students' self-efficacy in learning mathematics than the traditional instruction group. Wang and Chen (2010) showed that, with the DGBL approach, students were highly involved in programming activities, which have been recognized as being difficult and boring tasks to most students. Yien, Hung, Hwang and Lin (2011) revealed positive effect of computer games on students' learning achievement in a nutrition course. Hung, Hwang, Lee and Su (2012) found that with proper design, digital games improve students' spatial cognition ability. Blanzenka and Damir (2011) equally found that using mathematical computer games for teaching contributes to more efficient and quicker realisation of educational goals at all levels of education. Blanzenka and Damir further found that using mathematical computer games for teaching influences formation of a positive attitude of pupils of different ages toward mathematics as the most difficult subject and contributes to boosting their motivation, quicker acquisition and long-term knowledge when compared to teaching without mathematical computer games.

Strength of the research

In Nigerian context, there is dearth of literature on the effect of digital game-based learning on primary school pupils' achievement in sciences. Hence, the findings derived from this study have important contribution to the scholarly discussion of the effectiveness of digital games for learning on pupils' achievement in sciences.

Limitations

The generalization of the findings of this is limited to situations with a similar population. Thus, the cultural diversity of population raises the question about whether cultural background may influence the effects of digital games on students.

Direction for further research

Replicating the study in multi-cultural settings would offer an opportunity to confirm results as well as.

Conclusion

The effectiveness of digital game-based learning in enhancing the achievement of primary school pupils in sciences has been empirically found to be significant. This may have been the case due to the fact that during the intervention period, the pupils who were exposed to DGBL were very active in the learning process than their counterparts who were not so exposed. Thus, the use of digital game-based learning enhances pupils' achievement in sciences more than the traditional method of teaching.

Recommendations

Considering the findings of this study, the researchers made the following recommendation;

1. Primary school teachers should be trained to develop the required computer literacy and skills on how to use digital game-based learning for sciences contents delivery of the classroom lessons.
2. The state government in synergy with the school authorities should provide good digital game-based learning facilities which will aid pupils' achievement and technological development to compete with the world at large.

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These must include full names, institutional affiliation and physical address, and email addresses of all participating authors. In the case of multiple authors, the corresponding author should be stated.

Publication language
English language (USA or UK English but not both in same manuscript)

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Manuscript preparation
Manuscripts must follow the most conventional approach including title, abstract (maximum of 200 words), keywords (between 5 and 7), introduction, literature review, methodology, findings, discussions and references. Note that tables, figures and appendices (if any) must be part of the main manuscript.

Ethics and conflict of interest
All forms of contributions and sponsorships must be acknowledged, and declarations must be duly reported in the manuscript.

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Minimum: 5000; maximum: 8000 including references, tables, figures and appendices.

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MS Word, Font size is 12, and Font style is Ariel

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