RESEARCH ARTICLE

IMPROVING MATHEMATICAL HOMEWORK BEHAVIOR: THE ROLE OF MATH GAME APPS

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Manuscript Info	Abstract
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Homework is an essential component of teaching and learning in the school system geared towards augmenting classroom learning and enhancing performance. A growing literature on homework suggests the importance of completing homework tasks to strengthen students' academic commitment and achievement. This study investigates the effect of the math game app (Prodigy) on primary school students' math homework behavior. A quasi-experimental design was adopted, and the sample was divided into two groups: an experimental group (N=48), which was exposed to math game app, and a control group (N=45), which was not exposed to the gamification process. The experiment consisted of 24 sessions taking place over three months. Students participated in two sessions per week that lasted for 45 minutes. The findings revealed a mean difference (MD = 14.7) between the post-test study groups. Regarding the hypothesis, the result indicated a significant difference between the experimental and control group on homework behavior (91) = 6.124, p = .001. The study suggests several recommendations to integrate math game apps into the school framework.

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Introduction:-
Modern-day society appears to be gradually transmuting into a science-based ecosystem given the increasing advancements in science and technology. In particular, the trend in technological innovations and its accompanying contribution to the development of human society make this period a critical time for evolving an integrated vision for increased science education. Science-based learning is broadly considered one of the most integral parts of contemporary education (Kalogiannakis et al., 2021) and is promoted from the early learning stages (Tavares et al., 2021). Probably, there isa growing demand for reforms in the educational system of every society (Tajudin et al., 2018). Also, the global acceptance of science, technology, engineering, and mathematics (STEM) as a unified attempt to improve science education in the international educational landscape points to the importance of science-based education. So far, STEM education is increasingly becoming the foundation for a series of modifications in the school system worldwide (Liu et al., 2020). Perhaps, the emergence of STEM reflects the growing gap in science-related knowledge and the growing need to meet the demand for scientific development (Fomunyam, 2019). Notably, there are intimations that students' exposure to STEM-based content creates a pathway toa science and technology-driven environment (Banks & Barlex, 2020).

Mathematics is the key to other scientific disciplines (Widiati & Juandi, 2019), representing an essential component of science education relative to STEM (Etuk & Bello, 2016; Festus, 2014; Josiah & Olubunmi Adejoke, 2014; Musa

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& Dauda, 2014). It is a ubiquitous part of the education systems (Agashi & Adeniyi, 2021) and plays a critical role in the evolving sustainable development goals (Lafuente-Lechuga et al., 2020). Mathematical skills are fundamental for numerous professions (Li & Schoenfeld, 2019) and a crucial part of the toolset required for employability in modern society. More so, achievement in mathematics has been linked to future career opportunities (Hemmings et al., 2011). Similarly, mathematical abilities contribute significantly to the mechanization of any nation (Maloney et al., 2013).

In the Nigeria educational landscape, mathematics is central in the school curriculum (Aguele & Usman, 2007) and occupies an obligatory role in the education system (Adebule & Ayoola, 2015; Asikhia, 2021; Eze, 2013; Olaitan, 2017; Oribhabor, 2020; Oyinloye & A. Popoola, 2013; Ugodulunwa & Okolo, 2015). It provides the opportunity for learners to describe, analyze and manipulate their environment. Literature abounds that underscores mathematical relevance to the society (Ajayi et al., 2011; Akinoso, 2018; Akinsanya, 2011; Andrews, 2007; Charles-Ogan, 2015; Gengle et al., 2017; Kachapova, 2014; Kusmaryono, 2014; Obadara, 2012). However, there is growing concern about the increasing decline in student performance in mathematics (Abdullahi & Sirajo, 2020; Ayinde, 2014; Ishaq et al., 2019; Makinde & Yusuf, 2018; Maliki et al., 2009; Olatunde, 2010; Ozughalu, 2012; Sa'ad et al., 2015; Sule, 2018). The trend undermines the scientific future of the learners and the country. Thus, research is consistently required to address the phenomenon of poor mathematics performance.

One essential strategy deployed by teachers to increase attitudes, interest, commitment, and performance in mathematics is homework. The construct of homework reflects an after-school activity used to augment classroom learning. Homework creates a relationship between home environment and school and fosters progress in all aspects of school life. Homework behavior encompasses the total amount of time spent working on a given homework and the extent to which a student commits effort to complete homework (Flunger et al., 2017). Homework is an important activity to develop different mathematics skills learned in school. Recent studies have underscored homework activities (Dettmer's et al., 2019; Rosário et al., 2019), and its association with academic achievement has been widely discussed. Students' attitude towards homework predicts homework behavior and their commitment to completing it. There is a growing concern that students often engage in off-task behaviors to escape homework demands (Hawkins & Axelrod, 2008) or fail to commit adequate effort in completing homework. In addition, many students suffer from motivational challenges to complete homework (Flunger et al., 2017). The trend poses constraint to knowledge development relative to mathematics. Previous research revealed that parental involvement in math homework increased learners' math homework behavior (Silinskas & Kikas, 2019) and well-being (Dettmers et al., 2019). However, the present study examines gamification as a technological tool to enhance math homework behavior.

Over the past two decades, researchers have highlighted the use of technology in mathematics education. The ubiquity of mobile devices, together with their potential to bridge classroom learning to the real world, has added a new angle to contextualizing mathematics learning (Fabian et al., 2018). It provides a pathway to enhancing students' motivation and interest in math (Yussop et al., 2019). Perhaps, technological devices are essential in early learning (Schenke et al., 2020). Accordingly, interactive, immersive math fun games typically have rules, goals, and competition against other players or individual scores. Perhaps, clear rules and goals are central because they let the young learners know to identify their objectives. In particular, the students face challenges and have to use strategies as they play, thus, solving a problem. Mathematics embedded gamification entails inserting math-related constructs and logical manipulations in a puzzle game-like interface (Tan et al., 2017). Numerous research has adopted gamification to improve student's mathematics performance and motivation in various domains (Bartoschek et al., 2013; Boulton et al., 2018; Coelho et al., 2019; Godejord et al., 2017; Rienow et al., 2020; Santiago et al., 2019; Sarvehana, 2019; Siew et al., 2016; Simsek, 2016; Spieler et al., 2018). Gamification has been used in numerous mathematical domains, such as reasoning skills (Bottino et al., 2007), critical geometry abilities (Yang & Chen, 2010), and arithmetic procedures (Moreno & Durán, 2004). Thus, educational math apps delivered on touch-screen tablets offer an opportunity for students' math practice.

Hypothesis:
Students exposed to math game appswould have more positive math-homework behavior than those who are not exposed

Method:-

A quasi-experimental design with pre-test and post-tests with two groups (experimental and control) was adopted in this present study. Primary school students in Enugu State constituted the population of the study. Ninety-three (n = 93) students comprising males and females within the age range of 7 – 11 years and mean age of (M=9.13) and (SD= 1.21) were randomly pooled from selected public primary schools in Enugu State as the study participants. The students were chosen mainly from the primary 5 and 6 classes and were assigned to conditions, with group A representing the experimental group and group B as the control group. Before the commencement of the main experiment, students' math homework behavior was assessed (pre-test) using the math homework behavior scale. The experimental group (group A) was exposed to a math game app (Prodigy Math) post-test. Prodigy depicts a free-to-use and adaptive game app integrating basic math concepts into a fantasy-style game. The game has been widely used in the US and has been applied as part math curriculum (NCT03706144, 2018). Participants in the control group were exposed to other mathematical activities, excluding the gamification in the post-test study. After that, the student's attitudes towards mathematics were further measured.

Math homework behavior was assessed using the Mathematics Homework Behavior Scale (MHBS), designed to measure students' homework behavior. The scale developed by Özcan and Erktin (2013) was adapted and modified to suit the present context. The instrument is a 15-items Linkert-form rating style with a 5-point answer format ranging from "Always (5), often (4), occasional (3), rarely (2), and never (1). The initial internal consistency coefficient of the scale was .92. However, .83 was recorded in this study.

Result:-
The mean and standard deviation scores were analyzed below, following the pre-test and post-test studies. Table 1 showed that group A recorded a mean score of M = 31.17 and a standard deviation score of SD = 31.17 in the pre-test study. Meanwhile, group B scored a mean score of M = 31.11 and a standard deviation score of SD = 2.81 in the pre-test study. Thus, this indicates no significant difference between the two groups on homework behavior. Conversely, the result of the post-test study demonstrated a higher mean and standard deviation score M = 46.91, SD = 9.74 for the group A. Accordingly, a mean and standard deviation score of M = 32.21, SD = 5.17 was recorded for the group B in the post-test study as shown in table 2 below. Therefore, the result revealed a mean difference of MD = 14.7, which means that the mean and standard deviation scores of group A increased significantly following their exposure to the Prodigy Math game app.

Table 1:- Table shows mean and standard deviation scores of the students' math homework behavior for groups A and B in the pre-test study.

Group	N	Mean	SD
Group A	48	31.17	3.17
Group B	45	31.11	2.81

Table 2: -Table showing the mean and standard deviation scores of the two groups (A and B) in the Post-test study.

Group	N	Mean	SD
Group A	48	46.91	9.74
Group B	45	32.21	5.17

Table 3: -Table showing the t-test comparison of homework behavior.

Source of variation	N	Mean	SD	df	t	Sig
Group A	48	46.91	9.74			
Group B	45	32.21	5.17	91	6.12	001

Furthermore, an independent-samples t-test was conducted to determine if there were differences between the experimental and the control groups on homework behavior in the post-test study. The result demonstrated a significant difference between the groups on homework behavior t (91) = 6.124, p = .001.

Discussion:-
The present study examined the role of the math game apps in enhancing the homework behavior of students. Ninety-three participants were recruited for the study. A pre-test, post-test quasi-experimental design was employed. The experimental and control group's mean and standard deviation scores showed that the math game app significantly increased the experimental group's math homework behavior (M = 46.91, SD = 9.74) compared to the control group

(M = 32.21, SD = 5.17) with MD = 14.7. Regarding the hypothesis, the result of an independent t-test conducted to determine the differences in both groups relating to homework behavior established a positive difference between the groups on homework behavior t (91) = 6.124, p = .001. Thus, the result supported the study's expectation that there would be a significant difference between the students exposed to the gaming app and those who were not exposed to the app. The result aligns with previous findings (Hung et al., 2015; Yussop et al., 2019). For example, evidence has shown that students who participated in the game intervention group showed higher mathematics proficiency than those in the control group (Chang et al., 2015). The probable reason for this result may be attributed to the increasing advancement in mobile innovation that has reached every angle of society and has attracted the attention of many children who enjoy playing games with mobile devices. The conventional classroom teaching methods have been in use for a long and could seem monotonous to most learners. An increase in basic math skills can only be achieved by motivating the learners using technological innovations such as gaming (Batzogiannis et al., 2018). Gamification may be an opportunity for many students to compete in the mathematics environment.

Additionally, the result provided evidence that gamification in the math classroom will positively influence students' homework behavior. Indeed, positive behaviors are acquired through various means, and when formed, can direct behavior in many ways. Similarly, gaming apps have the potential to shape young learners' mathematical capabilities and change their overall perception of the subject (Schenke et al., 2020). Thus, the present result presupposes that gaming apps, especially the Prodigy math app, could be a pathway to increasing students' commitment to completing their math homework and building effective relationships with mathematics.

Limitations, strengths, and future directions
The study encountered some limitations that are necessary to report. First, due to the small sample size utilized in the study, the generalization of the result becomes a concern. More so, the self-reported homework behavior may encourage biases. Nevertheless, the present study contributes to the mathematic homework behavior literature by revealing the Prodigy math game app as an effective alternative to enhancing math homework behavior in the Nigerian primary education system. Thus, the result broadens our knowledge about the positive impact of technological devices in the learning environment. Moreover, this study seems to be the first to test the Prodigy math app on Nigerian participants. Hence, justifying the current research. Future researchers should attempt to employ more comprehensive samples and utilize data from multiple sources to minimize false reports.

Conclusion:-
The present study investigated the effect of math game apps on students' math homework behavior in a sample of primary school students. The result revealed a significant difference between students that learned with a math game app and those that did not. Thus, it was concluded that a math game app is an indispensable tool in building a more committed mathematics homework behavior in primary school students. Given the importance of math homework in enhancing performance (Fernández-Alonso et al., 2016; Maltese et al., 2012; Mousavi et al., 2012), gamification should be embedded in the school curriculum. More so, instructors should be trained to adopt technological devices in teaching.

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