GAMES, GAME FLOW, AND GENDER AS THEY AFFECT MATHEMATICS ACHIEVEMENT OF PUPILS IN NIGERIA

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Abstract. Game flow experience in the use of games has the potential of determining whether games used for learning would achieve the desired goal of improved achievement. With a subject like Mathematics, it is vital to ensure that if game based strategies are to be used, the games must possess this very important construct. Furthermore, the games must be able to produce the flow experience in both males and females, so that the observed gender gap in the learning of the subject would not be further widened. It is therefore important to investigate the gender differences in a game based learning environment for a subject such as Mathematics. This is the purpose of this research. This research investigated games, game flow, and gender as they affect Mathematics achievement of pupils in Nigeria. Through the use of Achievement of Pupils in Fraction-concepts Test (APFT) and Game Flow Questionnaire (GFQ), data were collected. The result was a significant difference in mathematics achievements of pupils exposed to game based strategy and those exposed to modified conventional method of teaching. However, there was no significant difference in game flow experiences, as well as in

mathematics achievement of male and female pupils exposed to game based strategy.

Keywords: gender, mathematics, game flow and achievement

Introduction

Mathematics is an important subject that serves as pivotal knowledge to many other aspects of life including employment prospects. The more mathematics people know, the greater the opportunities that are available to them. This affects everyone, from those requiring basic and financial numeracy, to those using high-level mathematics. With greater emphasis on mathematics and science, revolutions in technology have transformed the way we live, work and do business. Though the government makes mathematics a compulsory subject at the basic and secondary levels in Nigeria, there is serious challenge on national economic prosperity and technological development because performance of students in learning mathematics is undesirable and worrisome. There is need to help the learners to attain excellence in mathematics achievement and a good approach to doing this is to use strategies that would motivate the students to learn. Digital game based strategy is an example of such. It has been proved however that digital games that would produce a great effect on achievement in learners must possess what is known as "Game flow".

According to Csikszentmihalyi (1990), flow refers to a state in which someone focuses completely on a pleasant activity, with individuals perceiving a balance between skills and challenges.

Games, game flow experience and mathematics achievement

The generation of today's children grow up and use a huge range of information technology even from very tender ages and this poses attendant consequences on teaching and learning. Beyond enjoyment, playing digital games has also been found useful in teaching and learning difficult or complex concepts such as mathematics.

With heightened quest to improve pupils' achievement by exploring flow experience, it is not enough to have the new technology available to teach mathematics. Compulsorily, the teachers need to develop a teaching and learning environment that is conducive to learn mathematical ideas. The kind of software, and the way it is used are crucial to develop this environment. It should not be that the computer tools are made available to the students without instructional tasks in which students are to apply these tools. According to Kiili (2005), inappropriate challenges of the game environment and bad usability of the computer games reduce the possibility of flow experience. In order to facilitate flow experiences when teaching mathematics using game based strategy, computer games should have some characteristics. Sweetser & Wyeth (2005) stated that players' perceived skills are very important and they should match the challenge supported by the game. Both of them should be in balance in order to facilitate and maintain flow during gameplay. When flow is experienced as such, there is tendency to highly improve pupils' mathematics achievement.

From findings of Roussou (2004), playing computer games is one of the most favourite activities of children, so an environment that includes elements such as fun and entertainment might have a positive impact on their learning occurrence. Many of the diverse pleasures that people experience during recreational computing activities can be synthesised into a single concept known as flow. Flow experience is a state of intense mental focus that occurs when a person's perceptual and cognitive systems are challenged at near capacity without being exceeded. It is this positive influence of flow on task performance that engenders improving learning outcomes or performance, and this is also true of game based approach has integrated into classrooms to enhance students' mathematics achievement. In particularly, some knowledge domains are suited to computer gaming. Empirically, mathematics drill-and-practice games have also been found successful in educational environments (Rice 2007).

Many researchers (such as Moreno & Mayer, 2007; Kiili & Lainema, 2008) propose that there is a direct relationship between flow and learning. Gaines (1997) describes flow as "an optimum learning state"; and Nakamura (1988) demonstrated that the difference in performance between two equally capable groups of mathematics students was related to the fact that during periods of study the high achievers experienced flow twice as often as the low achievers. Despite the fact that digital games are today among the favourite leisure activities of billions of pupils around the world, there could be preferences with respect to gender, flow experience and achievement of the pupils.

Gender gaps in the learning of mathematics

It is a wrong mindset that the observable differences between male and female automatically translate to superiority of male gender over the female counterpart in all situations. As opined by Gilbert (2008), it makes sense to assume that since boys and girls behave very differently from each other in and out of the classroom, they must be made of different things. Scientifically, this is not exactly true, but research does show that the brains of boys and girls devote different amounts and specific locations of space to the same skills. This dynamic applies to a vast variety of subjects including mathematics. Meaning that boys and girls actually do see the world differently and they learn from it differently as well.

In the society, a very large stratum of educated people and the teeming illiterates ordinarily project mathematics as a very difficult subject and that it is not meant for just any student. Interestingly, mathematics is yet another field in which societies and cultures expect boys to excel but Geist & King

(2008) noted that females are also often overlooked or socialized to dislike mathematics. To Popham (2008), this negative attitude toward mathematics is a growing barrier for many children to learn mathematics. Because of this common stereotype, parents often unknowingly encourage boys to work earlier, harder, and more often at math based activities, which reinforces the stereotype in the next generation (Geist & King, 2008). Due to the lack of encouragement, support or praise that their male counterparts receive, girls enjoy mathematics less and less the further they advance in the subject while boys, on the other hand, often demonstrate high confidence in their abilities and continue with mathematics, even voluntarily deepening their participation in and commitment to the subject (Geist & King, 2008). However, mathematics is a science subject and some gender-based science researchers have reported that what both the 'feminist empiricists' and the 'liberal feminist critics' seem to agree is that females in principle will produce exactly the same scientific knowledge as males, provided that sufficient rigour is undertaken in scientific inquiry (Sinnes, 2005).

Even, the "math is for boys" stereotype has been used as the definition of why girls do not pursue science and mathematics as their careers (Cvencek et al., 2011). Also, the "math is not for me" is a cultural stereotype with girls which can affect which career choices and classes they choose to take (Cvencek et al., 2011). The latter portrays feminine gender as being less confident compared to masculine gender in mathematics abilities, the implication of this is that there are so few women pursuing careers in mathematics, science and technology. Cooper (2006) reported that although the gender gap in the use of technology and knowledge about it has diminished, there are still indications that the use of technology in education affects girls and boys differently. While Interactive Digital Software Association industry research[1)] found a female gamer population of nearly 50%, Jones[2)] explained that another source documented 60% of college females playing computer games compared to 40% of males. These research findings contradict evidence that males play more than females, so more investigation is necessary.

Almost all the sex differences documented in electronic game studies confirm the social gender roles. Ray (2003a) elucidated that as they grow older, boys are more likely to be sent to computer classes and have new computers. Girls are more likely to receive productivity-oriented software i.e. “Learn to Type”, reinforcing that mastering computers is not important to a girl’s life. Gradually, girls learn to see computers as tools that facilitate work, instead of a source of entertainment (Ray, 2003a; Turkle, 1988). As a result, using computers to have fun is less natural for females than for males. This possibly portrays a negative psychological affect for female and eventually the male could readily enjoy positive psychology in which flow experience is rooted.

Furthermore, traditionally, stereotypes and archaic role models are applied to portray female game characters – they are weak victims that need to be protected or rescued by powerful males and their visual design exaggerates female sexuality, Ray (2003b). This under-representation and misrepresentation of game characters may be one of the reasons for the low attraction to computer games by females (Hartmann & Klimmt, 2006). With this understanding, a lot of games are now being developed to suit the female as well as the male pupils. However, taking care of stereotypes may not be the only issue to be addressed with the use of digital games. Achievement being contingent upon game flow experience behooves that games used in learning environments be investigated for game flow, as well as if there would possibly be gender differences in the Game flow experience. It becomes therefore necessary to investigate whether there are differences in the game flow experiences of both males and females as they learn mathematics in a game based learning environment.

Statement of the problem

Difficulty in learning Mathematics is a national problem in Nigeria and disparity in gender achievement in this subject is another problem, due to teaching method and gender stereotype in the society. Game based strategy that can produce game flow experience in the pupils has the potential to motivate the students with interesting fun to improve achievement. However, teachers as well the pupils have not explored enough benefits of game based strategy using digital technology tools. Hence, this study investigated games, game flow, and gender as they affect mathematics achievement of pupils in Nigeria.

Research hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance.

1. There is no significant difference in mathematics achievements of pupils that are exposed to game based strategy and those exposed to modified conventional method of teaching.
2. There is no significant difference in game flow experiences between male and female pupils that are exposed to game based strategy.
3. There is no significant difference in mathematics achievement of male and female pupils that are exposed to game based strategy.

Research design

This study adopted a quasi-experimental research design with the use of pre-test, post-test, control group, quasi experimental research design.

Purposive sampling method was used to select two schools with functional computer laboratory facilities, within two of the six Education Districts of Lagos state, Nigeria. Participants comprised 50 primary three pupils in coeducational, public schools. The two schools were randomly assigned to experimental and control groups.

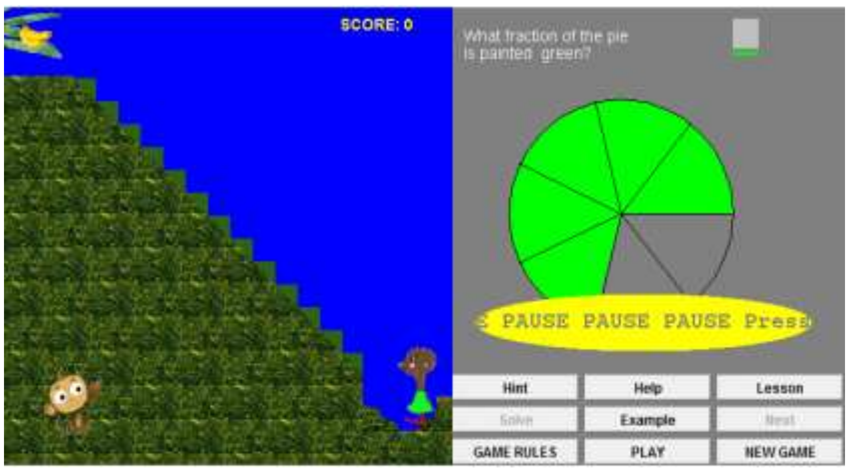
Two instruments were used for data collection in the study, namely- Pupil Fractions Achievement Test (PFAT) and Game Flow Questionnaire (GFQ). The PFAT is a fifteen (15) multiple-choice test with four options. It was designed to measure pupils' achievement in solving common fractions, ordering of fractions and equivalent fractions problems; while GFQ is a nine (9) item questionnaire on 4-Likert scale. It was designed to measure pupils' level of flow experience in playing instructional games. The required face and content validities were conducted. After these, using rational equivalence method of estimating internal consistency for individual items, Kudar Richardson formula 21 (KR 21) and Cronbach alpha were used for reliability computations for PFAT and GFQ to give reliability coefficients of 0.86 and 0.82 respectively.

TABLE OF SPECIFICATION FOR "PFAT"

OBJEC-JEC-TIVE	**KNOWL EDGE**	**COM-PRE-HEN-SION**	**AP-PLI-CAT-ION**	**ANAL YSIS**	**SYN-THESIS**	**EVALU-ATION**	**TO-TAL**
1		**1** (12)	**1** (7)	**2** (3, 13)	-	-	4
2	**2** (1, 6)	**2** (2, 10)	-	-	-	-	4
3	-	-	**1** (8)	-	**2** (9, 14)	-	3
4	-	-	-	-	**1** (4)	**3** (5, 11, 15)	4
Total	2	3	2	2	3	3	**15**

* Numbers in parentheses are item numbers

Jamit Fraction Games screen shot



YoungMind Games screen shot

Game description

The digital game used in this study was an offline version of free opensource game, produced by Jamit software, "Jamit Fraction Games". The game was adapted, and using concepts that students would be familiar with in the Nigerian environment- the YoungMind Games was developed. The latter, reflected Nigeria environment by replacing some graphics and objects that were considered foreign with objects in the Nigerian environment. The concept of the game was that an avatar, which does not portray any gender characteristics, wants to climb a staircase to get a bunch of bananas. Every fraction problem solved by the game player will make the avatar to jump one step up on the staircase while a wrong answer will bring it down the staircase. A monkey is also competing to get the banana before the avatar can get there. The faster the player is able to get the avatar to the top of the staircase, the better, or else the monkey will take the bananas. The game will be won by the player if avatar gets the banana but game is lost if the monkey gets the banana. This game is played individually; also, the game has different in-built supports and scaffoldings to solve any learning challenge. The topics covered were common fractions, ordering of fractions and equivalent fractions problems.

Procedure for data collection

Necessary preliminary training on the use of the relevant tools by the appropriate experimental teachers was given. This was then followed by a pre-test conducted same day in the participating schools. The experimental group was exposed to game based learning strategy treatment while conventional method was used for the control group. Immediately after the experiment treatment, post-test was done the same manner for PFAT and GFQ was also administered appropriately on the experimental group.

Data analysis and results

The data analyses on the study are presented as follows according to the three stated hypotheses.

Hypothesis 1:

There is no significant difference in mathematics achievement of pupils that are exposed to game based strategy and those exposed to modified conventional method of teaching.

Table 1. Descriptive statistics for pre-test achievement score

Methods of teaching	N	Mean	Std. Deviation	Std. Error
Conventional Game based Total	25 25 50	24.40 24.60 24.50	8.935 8.651 8.704	1.787 1.730 1.231

Table 2. One-way ANOVA showing pre-test achievement scores between experimental and control groups

Sources of variation	Sum of Squares	df	Mean	F	P
Between Groups Within Groups Total	.500 3712.000 3712.000.500	1 48 49	.500 77.333	.006	.936 ns

ns = Not Significant at .05

From the Table 1, N=25 for each of the two groups while the means for the experimental and the control groups are almost the same. The result in Table 2 above shows that the p value of .936 is not statistically significant at the .05 level. Thus, there is no significant difference between the two groups indicating equal level of entry behaviour for both the experimental and the control groups.

Table 3. Descriptive statistics for post-test achievement score

Methods of teaching	N	Mean	Std. Deviation	Std. Error
Conventional Game based Total	25 25 50	43.60 51.40 47.50	9.950 8.723 10.064	1.990 1.745 1.423

Table 4. One-way ANOVA showing post-test achievement scores between experimental and control groups

Sources of variation	Sum of Squares	Df	Mean	F	P
Between Groups	760.500	1	760.500	8.687	.005 *
Within Groups	4202.000	48	87.542		
Total	4962.500	49			

* Significant at .05

From the Table 3, N=25 for each of the two groups while the mean of the experimental group (51.40) is greater than the mean of the control group (43.60). The result in table 4 above shows that the "p" value of .005 is statistically significant at the .05 level. So, the null hypothesis 1 that there is no significant difference in mathematics achievements of pupils that are exposed to game based strategy and those exposed to modified conventional method of teaching is rejected.

Hypothesis 2

There is no significant difference in game flow experiences between male and female pupils that are exposed to game based strategy.

Table 5. Descriptive statistics for game flow experience between male and female pupils in experimental group

Gender	N	Mean	Std. Deviation	Std. Error
Male	10	32.10	4.067	1.286
Female	15	32.47	4.549	1.175
Total	25	31.72	4.287	.857

The Table 5 shows the mean of the male pupils (32.10) and compared to the mean (32.47) of the female pupils (N=10 for male and N=15 for female). Also, the result in table 6 above shows that the "p" value of .726 is not statistically significant at the .05 level. So, the null hypothesis 2 that there is no significant difference in game flow experiences between male and female pupils that are exposed to game based strategy is not rejected.

Table 6. One-way ANOVA showing game flow experience between male and female pupils in experimental group

Sources of variation	Sum of Squares	df	Mean	F	P
Between Groups	2.407	1	2.407	.126	.726ns
Within Groups	438.633	23	19.071		
Total	441.040	24			

ns = Not Significant at .05

Hypothesis 3

There is no significant difference in mathematics achievements between male and female pupils that are exposed to game based strategy.

Table 7. Descriptive statistics for post-test achievement scores between male and female pupils in experimental group

Gender	N	Mean	Std. Deviation	Std. Error
Male	10	48.50	7.091	2.242
Female	15	53.33	9.386	2.423.
Total	25	51.40	8.723	1.745

From the Table 7, the mean for the females is 53.33 while the mean for the males is 48.50. The result in table 8 above also shows that the “p” value of .180 is not statistically significant at the .05 level. Thus, the null hypothesis 3 that there is no significant difference in mathematics achievements between male and female pupils that are exposed to game based strategy is not rejected.

Table 8. One-way ANOVA showing post-test achievement scores between male and female pupils in experimental group

Sources of variation	Sum of Squares	df	Mean	F	P
Between Groups	140.167	1	140.167	1.912	.180 ns
Within Groups	1685.833	23	73.297		
Total	1826.000	24			

ns = Not Significant at 0.05

Discussion

In this study, the experimental group performed better in achievement than the control group. This agrees with the findings of Vos et al. (2011), Kebritchi et al. (2010) and Burguillo (2010) that game based strategy is effective in improving pupil achievement in learning, However the study of Ke (2008) contradicts this. The results show that game based learning could be potent if the appropriate digital environment, in terms of technology, facilitators and software with appropriate learning tasks, are provided and maintained. This emphasizes a serious need to train teachers on how games could be integrated into the classroom practice. In this case, free open source educational materials could be used, and subsequently skill training on local production of digital games could follow. This will encourage pupils to engage in more learning and also achieve better just through playing games.

Furthermore, the male and the female pupils' game flow experiences in the experimental group recorded no difference. The finding of this current study could be as a result of the games used; which is not gender bias in anyway. The result of this study opposes the conclusion of Bakar et al. (2006) that - boys were more active than girls when playing computer games and that flow experiences occurred better among boys, because boys preferred playing games more than girls. The implication of the result however is that no gender is at disadvantage in learning mathematics as far as these games could be encouraged as instructional materials.

Finally, this study shows that irrespective of gender, achievement is improved when learners experience flow in a game based learning environment. This finding is corroborated with Papastergiou (2009) and Ke & Grabowski (2007) . The latter have explained that if both male and female are subjected to the same rigorous and purpose driven game based teaching, the problem of academic gap and poor performance will be overcome. The result of Kim & Chang (2010) disagrees with these however. The implication of the result is that the negative and wrong belief of the society on gender stereotype, regarding phobia for learning mathematics, could be changed. Hence, taking this right step of using games to teach Mathematics would spur both economic and technology advancement of a developing country such as Nigeria.

Conclusion and recommendation

As shown in this study, great benefits of digital technology could be exploited in education by using game based learning strategy, which is effective with flow experience produced by the games. This approach positively engages all the learners (irrespective of gender), motivates them to voluntarily put in their best efforts to overcome learning problems in mathematics. A subject that many people perceive as a dreadful subject. Furthermore, it has been shown that game based strategies could reduce gender gap in mathematics achievement. This finding requires formulation of enduring policy to complement conventional method of teaching with the game based strategy. This should include real training of trainers, dissemination of the skills acquisition through in-service training of teachers and its effective implementation at all levels of teacher training institutions.

NOTES

1. http://www.theesa.com/wp-content/uploads/2015/04/ESA-Essential-Facts-2015.pdf

2. http://www.pewinternet.org/files/old-media/Files/Reports/2003/PIP_College_Gaming_Reporta.pdf.pdf

REFERENCES

Bakar, A., Inal, Y. & Cagiltay, K. (2006). Interaction patterns of children while playing computer games (pp. 575-580). In: Pearson, E. & Bohman, P. (Eds.). *World conference on educational multimedia, hypermedia and telecommunications*. Orlando: AACE.

Burguillo, C.J. (2010). Using game theory and competition-based learning to stimulate student motivation and performance. *Computers & Education*, *55*, 566-575.

Cooper, J. (2006). The digital divide: the special case of gender. *J. Computer Assisted Learning*, *22*, 320-334.

Csikszentmihalyi, M. (1990). *Flow: the psychology of optimal experience.* New York: Harper Perennial Press.

Cvencek, D., Meltzoff, A.N. & Greenwald, A.G. (2011). Math-gender stereotypes in elementary school children. *Child Development*, *82,* 766-779.

Gaines, B.R. (1997). Knowledge management in societies of intelligent adaptive agents. *J. Intell. Inf. Systems*, *9*, 277–298.

Geist, E.A. & King, M. (2008). Different, not better: gender differences in mathematics learning and achievement. *J. Instr. Psychol.*, *35*, 43-52.

Gilbert, J. (2008). Reading between the lines: gender may matter: are girls more likely to acquire language skills at an earlier age than boys. *ESL Magazine*, Jan. 1st.

Hartmann, T. & Klimmt, C. (2006). Gender and computer games: exploring females' dislikes. *J. Computer Mediated Communication*, *11*, 910-931.

Ke, F. (2008). Computer games application within alternative classroom goal structures: cognitive, metacognitive, and affective evaluation. *Education Tech. Res. Dev., 56*, 539-556.

Ke, F. & Grabowski, B. (2007). Game playing for math's learning: cooperative or not. *British J. Educ. Technol., 38*, 249-259.

Kebritchi, M., Hirumi, A. & Bai, H. (2010). The effects of modern mathematics computer games on mathematics achievement and class motivation. *Computers & Education*, *55,* 427-443.

Kiili, K. (2005). Digital game-based learning: toward an experiential gaming model. *Internet & Higher Educ., 8*, 13–24.

Kiili, K. & Lainema, T. (2008). Foundation for measuring engagement in educational games. *J. Inter. Learning Res., 19*, 469–488.

Kim, S. & Chang, M. (2010). Computer games for the math achievement of diverse students. *Educ. Technol. & Soc., 13,* 224–232.

Moreno, R. & Mayer, R. (2007). Interactive multimodal learning environments. *Educ. Psychol. Rev., 19*, 309–326.

Nakamura, J. (1988). Optimal experience and the uses of talent (pp. 319-326). In: Csikszentmihalyi, M. & Csikszentmihalyi. I.S. (Eds.). *Optimal experience: psychological studies of flow in consciousness.* Cambridge: Cambridge University Press.

Papastergiou, M. (2009). Digital game-based learning in high school computer science education: impact on educational effectiveness and student motivation. *Computers & Education*, *52*, 1-12.

Popham, W.J. (2008). Timed tests for tykes? *Educ. Leadership, 65*(8), 86-87.

Ray, S.G. (2003a). *Gender inclusive game design: expanding the market*. Hingham: Charles River Media.

Ray, S.G. (2003b). *Gender inclusive game design: expanding the market.* Independence: Cengage Learning.

Rice, J.W. (2007). New media resistance: barriers to implementation of computer video games in the classroom. *J. Educ. Multimedia & Hypermedia*, *16*, 249-261.

Roussou, M. (2004). Learning by doing and learning through play: an exploration of interactivity in virtual environments for children. *Computers in Entertainment*, *2*(1), 1-24.

Sinnes, A.T. (2005). *Approaches to gender equity in science education: two initiatives in sub-Saharan African seen through a lens derived from feminist critique of science – PhD thesis*. Oslo: University of Oslo.

Sweetser, P. & Wyeth, P. (2005). GameFlow: a model for evaluating player enjoyment in games. *Computers in Entertainment*, *3*(3), 1-24.

Turkle, S (1988). Computational reticence: why women fear the intimate machine (pp. 41-61).. In: Kramare. C. (Ed.). *Technology and women's voices: keeping in touch*. New York: Routledge & Kegan Paul.

Vos, N., Van der Meijden H. & Denessen, E. (2011). Effects of constructing versus playing an educational game on student motivation and deep learning strategy use. *Computers & Education*, *56*,127–137.

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