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Educational Games and Grade 11 Students' Motivation and Achievement in Algebra: The Sudoku Experience

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Abstract – The empirical study sets to unveil the influence of Sudoku Games on learners' motivation and achievement in Math's Algebra. An intact class of 11 Graders was used in the study. The study design was an experimental – control, pretest- post-test type, being quasi-experimental. Two validated and reliable instruments were deployed for the study: A Motivational Questionnaire (MQ) and a Mathematical Achievement Test (MAT), with reliability co-efficient of 0.62 and 0.64, respectively. The study confirms that Sudoku Games were not only motivational but were also high achievers than non-Sudoku Gamers. These positions influenced the recommendation that Educational Games should be integrated to make learning a thing of fun and pleasure.

Keywords – Gamification, integration, tutoring system, fun, pleasure.

I. Background of the Study

The place of mathematics games in the learning of mathematics has been proven as a powerful tool in demystifying presumed difficult concepts in mathematics. Where games are applied in a learning process, learning turns out to be a thing of fun and entertainment and easing of tension on the part of learners and even teacher.

Gamification is the integration of games while teaching or learning. In other words, it means presenting teaching and learning in games form, rather than learning the entire role in the hand of the teacher. Gamification alters the position of the teacher from the centre stage to the periphery and allows the learners to mount the centre, hence s learner-centred approach of teaching and learning (Williams, Charles – Ogan & Adesope, 2017, p.7). In gamification, games elements like competition and budgets and other elements come to bear to increase the engagement and motivation of our learners. It offers technology-friendly educators an ample opportunity to present curriculum contents with hands-on activities for maximum and desired attainment. These postures corroborate the learner-centred colouration of a gamification classroom, hence numerous games have today come to be in the field of education in general and mathematics in particular.

Mathematics offers a wide variety of games; Five, sixes, twenty-five heeds, Tetris, time dart, power TIC-TAC-TOE, LUDOmatics, Trigoludo, and over thirty (30) and others (National Mathematical Center. 2002, pp 1&2). However, the focus of the study is 'Sudoku Experience'. Sudoku itself is a mathematics game, a number place and logic-based combinational number-placement puzzle used for problem-solving skills. The main objective of the game is to enhance students' critical thinking skills, permutation combination as well elimination skills and how these play out in algebra were explored in the empirical study.

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Computers influence on human behaviour have been proven beyond all reasonable doubt. As it relates to this work, gamification motivates students in no small measure. A related study by Kirillov, Vinchenko, Melnichuk, Melnichuk and Vinogradova (2016), confirmed the improvement of learning amount through gamification and its effectiveness. The study adopted such data gathering technique as overt observation, questionnaires, interviewing and questioning. The study showed that students displayed positive emotions, alertness and alive as evidence of gamification implementation. Also, a study on Educational Gamification, Al - Azwi, Falitiand Al – Blushi (2016, pp 132 – 136) had also revealed that games can make the learning of concepts more enjoyable for students and provide a platform for their creative thought. The study also showed that games will often act as learning triggers inducing lively discussions on concepts among students following gameplay. These latest studies are not different from the outcome of a work conducted over a decade now. In an experience report on using gamification in technical higher education, IOSUP and EPCMA (2008. pp 27 – 32) had proven that gamification seems to foster interaction in the classroom as well as increases students' attention span. This was an outcome of a study that focused on two gamification-based courses, the first year B.Sc. course computer organization and an M.Sc. - level course in the emerging technology of cloud computing that involved over 450 students.

On achievement, the place of gamification has been confirmed as a correlate to improving the academic performance of gamers. Specifically, a study by Faghhi, Brautigam, Jorgenson, Martin, Brown, Measures and Maldonado – Bouchard (2014 pp 182 – 187), is a pointer in this direction. In the study, a gaming environment was used to teach mathematical topics such as addition and division in a fun manner. Video game elements and artificial intelligence Tutorial system techniques were used to teach mathematical concepts such as factoring and the quadratic formula, conceptualizing their applications, that is, learning it to their real-life relevance. In this math Dungeon experiment, the number of students who used the game had a score above the mean score on the Test of math performance greater than the number of students who used the popular math tutoring program. A related study that implicated increased students' interest cum achievement was conducted by Jagust, Boticki, Mornar and So (2016). The paper presented preliminary experiences in applying gamification in lower primary school mathematics learning and further explores how the gamification strategy influenced the level of students learning. The result, in summary, showed positive with gamers than with non-gamers. Therefore, the review attests to the fact that gamification means using game-based mechanics, aesthetics and game thinking to engage students, motivate them, promote problem-solving skills and learning in general.

II. Procedure

The study design was Pre-test Post-test Quasi-Experimental, hence two groups drawn from an intact class were used. On the whole, a total of 50 grade 11 mathematics students were used. The two type groups, Experimental Group (EG) and Control Group (CG) had 26 and 24 students respectively. The experimental group had 14 females and 12 males while there were 14 females and 10 males in the control group. The use of Sudoku game was integrated into the lessons in algebra for the experimental group and the lessons lasted for 3 weeks.

In the end, a Motivational Questionnaire (MQ) of 10-items, a 4-scale Likert-Like instrument was administered to the experimental group and a Mathematics Achievement Test (MAT) of 20-items given to the two groups. The instruments were validated by trusted colleagues, versatile in test construction and the reliability of the MQ and MAT were achieved via the Kundo Richardson 20 and 21 formulas, respectively. MQ is a scale instrument while MAT is a dichotomous one and had a reliability coefficient of 0.62 and 0.64 respectively. In the end, results were compared with the Pre-test Post-test result obtained at the beginning of the study. Hence, the following is true.

Table 1: Summary of design

Pre-Test	EG and CG
Treatment	EG -
Post Test	EG and CG
MQ	EG -

III. Interpretation of Results

Research Question 1

How motivated were students in the use of Sudoku games in learning algebra?

Table 2: Motivating Rating.

S/N		$\bar{x}$	Remarks
1.	Sudoku catches my attention	3.60	Great Extent
2.	Sudoku makes learning relevant to me	3.62	Great Extent
3.	I develop self-confidence while using Sudoku	3.80	Great Extent
4.	I feel satisfied while using Sudoku	3.00	Great Extent
5.	I spend more time while using Sudoku	3.62	Great Extent
6.	My desire for maths increased with Sudoku	3.71	Great Extent
7.	My passion for maths is influenced by Sudoku	3.73	Great Extent
8.	I solve maths puzzles with Sudoku	3.90	Great Extent
9.	It increases my critical thinking	3.81	Great Extent
10.	I am more focused while playing Sudoku	3.01	Great Extent

Table 2 shows a positive trend of students' motivation in the use of Sudoku in learning algebra. The students did attest to the fact that the game influences them to a great extent in the learning of such mathematical concepts, hence the mean scale values range between 3.00 – 3.90.

Research Question 2

What is the extent of motivational difference between male and female Sudoku Gamers?

Table 3: Motivational Rating According to Gender

Male ($\bar{x}$)	Female ($\bar{x}$)	Diff ($\bar{x}$)	Remarks
3.02	3.00	0.02	Lest Extent

Table 3 is overt on the extent of motivational difference as per gender. The table shows that motivation is gender insensitive as the mean difference ($\bar{x}$) here is less than (<) 1.

Hypothesis I: there is no statistical difference between the means of Sudoku Gamers and non-Sudoku Gamers in the learning of algebra.

Ho X1 = X2

Table 4: Mean, Standard Deviation and t-value of Experimental (E) and Control (C) groups.

Groups	n	$\bar{x}$	SD	df	α-level	t-cal	t-crit	Decision
Exp (E)	26	17.6	0.27	48	0.05	35.09	2.02	Statistically Significant
Contrl (C)	24	15.6	0.21					

Table 4 shows the mean values of 17.6 and 15.6, SD, 0.27 and 0.21 for (E) and (C) Gamers respectively. At a df 48, α – level 0.05 and t-cal 35.09 as against t-crit 2.02, the Ho is rejected.

Hypothesis 2: There is no statistical difference in the means of male and female Sukdoku Gamers in the learning of algebra.

Ho X1 = X2

Table 5: Mean, standard deviations and t-values of per gender.

Gender	n	$\bar{x}$	SD	df	α-level	t-cal	t-crit	Decision
Male	14	17.4	0.34	25	0.05	20	2.060	Statistically
Female	12	17.7	0.41					Insignificant

Table 5 shows mean values of 17.4 and 17.7, Standard Deviations of 0.34 and 0.41 for male and female gamers respectively. At a df of 25, α – level 0.05 and t-cal -20 as against t-crit 2.060, the decision revealed is that the difference is statistically insignificant and as such the Ho is accepted.

IV. Discussion of Findings

The study uncovered the influence of Sudoku, an Educational game on students' motivation to learning. This finding as in Table 2 agrees with earlier studies as reported by Vailer et al. (2017). Motivation in instructional design is a 4 – element attribute, covering attention, relevance and confidence and satisfaction (Keller, 1987). In the educational game Sudoku which is capable of offering lessons rich in these elements is bound to yield the desired results. The influence of games on students' motivation to learn is also corroborated by the outcome of relevant and related studies (Kirillov et al, 2016; Al-Azwi et al. 2016; Iosup & Epema 2008).

Thus, there is a promise of motivation through gamification. This confirms the place of video games and other related technologies among all age groups in the most recent Educational games are being explored due to their motivational values in promoting learning while also engaging learners. Educational games have been described as possessing a high level of motivational potential as in the works of Garris, Ahiers and Driskeli (2002). Hence, the idea of their integration for the real-life application cannot be described to be unreasonable (Ryan, Rigby & Przybyiski 2006). Research has also attested to the fact that game-based learning could effectively attract pupils' attention (Fan & Xiao, 2015, pp. 1212). This is in alignment with the position of an earlier study that confirmed that games as a carrier of intrinsic motivation replace with a potential cognition process to enhance not only comprehension but other higher levels objectives (Quin n, 2000). On the whole, gamification is gender insensitive as it is indicated in Table 3, meaning that motivation for games is not sex-dependent.

The study also showed that the achievement of gamers was higher than those of non-gamers, as displayed in Table 4. This finding is an attestation of the potentials of motivation, overt evidence of this key factor to learning. This finding is in tandem with those of Faghih et al (2014) on their Math Dungeon experiment that focused on addition and subtraction. It is also in alignment with the empirical study of Jagust et al. (2016), on primary pupils' achievement via video games. As it is seen, the majority of empirical studies have confirmed positive than the null influence of educational games on the achievement of learners as such the need for their exploration to enhance productively in our learning outcome should be encouraged. Like motivation, achievement is also gendered insensitive when it comes to gamers in a gamification learning environment.

V. Conclusion

Critical thinking skill, problem-solving skill and creative skill are vital in the present age and technologies has demystified learning by their numerous attributes. Learning has become a thing of fun and pleasure – courtesy (Educational games: The Sudoku for instance).

Recommendations

Going by the outcome of this study, there is, therefore, the need for the study to recommend that:

1. Sudoku Games should be integrated into mathematics lesson by teachers due to their motivational attribute to students' learning.
2. Sudoku Games should be explored to its fullest due to their overall influence on improving students' academic performance or achievement as used in this context.

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