GAMIFICATION AS AN INSTRUCTIONAL APPROACH UNDER COLLABORATIVE AND COMPETITIVE MODES: AN ANALYSIS OF STUDENTS LEARNING OUTCOMES IN BIOLOGY

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Abstract

Gamification of learning experiences is an evolving research paradigm in Africa and Nigeria in the diaspora. Thus, this study investigated the use of a designed and developed Biology Concept Game via mobile phone under individualize (I), individualize competitive (IC), collaborative (Col) and collaborative competitive (Col-C) learning modes. This design experimental research was conducted with two hundred and forty-two (242) senior secondary school students who were drawn from five intact classes in schools from Lagos Island local government area of Lagos State, Nigeria. Data collected were analysed using descriptive statistics and inferential statistics of Analysis of Covariance (ANCOVA) and Multiple Analysis of Covariance (MANCOVA) respectively. Empirical findings from the study revealed that the incorporation of game elements such as leader board, points, badges and game challenge significantly improved students learning engagement, achievement and attitude towards learning biology respectively. The effectiveness of gamification was also statistically significant on the combined dependent variables of engagement and achievement, engagement and attitude, engagement, achievement and attitude respectively. Furthermore, the study revealed that competition and collaboration play a significant role and interplay to moderate the learning outcomes associated with the gamified biology learning environment. The main effect of gender and its interaction with gamification on students learning outcomes was not significant. Hence, both male and female students were able to achieve equitable learning outcomes in the gamified learning environment. The study therefore recommend gamification as an effective pedagogical strategy that provide a scaffold for students learning and co-construction of knowledge in the biology classroom.

Keywords: Gamification, Collaboration, Competition and Learning outcomes.

Introduction

There is a growing level of awareness among teachers and administrators on the use of digital games in educational contexts (Millstone, 2012). The gamification of learning experiences has shown promising results to improve learning outcomes. Gamification is a process that involves the use of game elements in non-game context (Deterding, Dixon, Khaled & Nacke, 2011; Dominguez, Saenz-de-Navarrete, De-Marcos, Fernández-Sanz, Pagés, & Martínez-Herráiz, 2013). This encompasses the process of creating gamely learning via the introduction of game elements in the design of learning experiences (Hamari, Koivisto & Sarsa, 2014). In gamifying learning experiences, specific attributes from games are targeted, extracted and adapted to non-game contexts. These attributes, otherwise known as game elements are used in isolation or in meaningful combination to improve learning (Landers, 2015; Deterding et al., 2011). Zichermann and Cunningham, (2011) classified game elements as Points: points are used to reward users actions; Levels: this is used to indicate players progression in the game; Leader board: serves to motivate players to fully participate in the gaming experience; Challenge: the game challenge specifies a task player must undertake in other to progress in the game; and Badge: badges are given to players as a reward for completing a given challenge.

Furthermore, Werbach and Hunter, (2012) classified the gamified learning environment into dynamic, mechanics and components categories respectively. Dynamics is the highest conceptual level in a gamified environment. This refers to the narrative, progression, construct, emotions and relationships that exists in a

gamified system. Mechanics are set of rules that determines the outcomes of interaction in a gamified system. They are elements that result into actions. This includes challenges, chance, competition, cooperation, feedback, resource acquisition and rewards. Components refers to a specific instance of dynamics or mechanics in a gamified process. This includes achievements, avatars, badges, collection, context unlocking, gifting, leader board, levels, points, virtual goods etc. For instance, the points (component) earned in a game provides the rewards (mechanics) which in turn determines the gamers progression (dynamics) in the game.

Literature Review

Learning Outcomes Associated with Gamification

Students have positive perceptions on gamified learning and appreciates the social interactions, engagement and immediate feedbacks associated with a gamified learning experience (Cheong, Fillippou & Cheong, 2014). Gamification uses game-based mechanics and game thinking to engage student, motivate actions and promote learning (Kapp, 2012). Laine, Nygren, Dirin and Suk, (2016) also posited that game elements works harmoniously with other intervention built unto the game to impact on students learning. For instance, Cheong, Cheong, & Filippou, (2013) conducted a study that evaluated undergraduate students use of gamified quiz that incorporated leader board and points as the game design elements. Findings from their study revealed that gamified learning experiences have potential to improve students grade, enjoyment and engagement. This corroborates with findings from the study carried out by Penchenkina, Laurence, Oates, Eldridge and Hunter, (2017) in which students use of gamified mobile quizzing application resulted into an improvement on their engagement and achievement. In a similar fashion, Su and Cheng (2014) developed and implemented the use of a mobile gamification system in an elementary school science curriculum. Findings from the authors quasi-experimental research revealed that mobile gamification learning approach significantly improved the achievement and motivation of students. Furthermore, previous studies have also documented findings that exposes gamification as a developing approach for increasing learners motivation and engagement (Denny, 2013; Dominguez et al., 2013); engagement and achievement (Holman, Aguilar & Fishman, 2013; Leftheriotis, Giannakos & Jaccheri, 2017). Notwithstanding the potential of gamification as reported in the literature, a critical review of gamification in educational context revealed that studies that examines the effects of gamification in K-12 context are scanty (Dichev and Dicheva,2017). Only few studies have examined the effects of gamification within the context of biology learning (Su and Cheng, 2015). In addition, evidences to support the long-term benefits of gamification and the knowledge of how to gamify an activity in accordance with the specifics of educational context and the curriculum are limited (Dichev and Dicheva, 2017).

Competition and Collaboration in Game Based Learning

Gamification incorporate techniques that cut across a variety of contexts to motivate students engagement in a particular targeted behaviour (Landers, 2015; Deterding et al., 2011). Competition is an important feature that can be incorporated into a game-based learning environment to maximize learning goals and outcomes (Chen, Liu & Shou, 2018; Cagiltay, Ozcelik, & Ozcelik, 2015; Hwang & Chang, 2015). This is because the incorporation of competition into game design and development stimulates an environment that motivates and engages students (Burguillo, 2010; Huizenga, ten Dam, Voogt & Admiraal, 2017). Moreno, (2012) expounded that competitive elements in games provide a ground for learners to accept challenging tasks in other to fulfil their game mission. However, some researchers are of the opinion that competition in digital game should be minimal so as to increase students feeling of enjoyment, intention to use the game and to boost their self-esteem (Chen, 2014; Kazakova, Cauberghe, Pandelaere, & de Pelsmacker, 2014). A number of studies have introduced competition into game design features and documented results which indicated a significant increase in students learning achievement and attitudes (Hwang, Wu & Chen 2012; Hwang & Chang, 2015). However, studies by (Vandercruysse, Vandewaetere, Cornillie & Clarebout, 2013) suggests that the introduction of competitive elements into games have no effect on learning outcomes. While competition in games might prove to be an important game feature that bolster students engagement and motivation, there is still limited empirical research on the effectiveness of competition on learners attitude (Chen et al., 2018).

On the other hand, collaborative practices in game-based learning environment provides a scaffold that enhance students engagement and cognitive performance (Sanchez & Olivares, 2011). Students interaction in small groups through game play provides an avenue for teamwork so that students can learn to solve problems collaboratively which in turn improved their chances of success, effectiveness and efficiency in the game (Li &Tsai, 2013). Nevertheless, the effects of competition and collaboration in game-based learning have only been assessed within the context of real games. Studies that evaluate the effects of competition and collaboration in a gamified learning environment are scarce. Literature that also explore how different student groups react to gamified learning are understudied (Barata, Gama, Jorge & Goncalves, 2015). Landers, Bauer, Callan and Armstrong, (2015) therefore called for more empirical studies that explore the specific processes by which gamification is intended to improve learning. Furthermore, the systematic incorporation of games in education is an area untapped (Sha & Foster, 2014; Young et al., 2012). There is also a need to study the pedagogical interventions, dynamics, social contexts and classroom environments under which games can be incorporated into learning activities to achieve educational goals and outcomes (Young et al., 2012). Based on these preconceptions, this study investigated the use of a biology mobile learning application in the design of gamified learning environments under individualized (I), individualized competitive (IC), collaborative (Col) and collaborative competitive (Col-C) learning modes. These gamified systems were used to evaluate secondary school students engagement, achievement and attitude towards learning biology.

Gendered Influence in the Gamification of Learning Experiences

Studies on the impacts of gamification on different demographic groups such as gender revealed that game mechanics implemented in a virtual learning environment does not have any effect on the performance of female students (Pedro, Lopez, Prates, Vassileva & Isotari, 2015b). Koivisto and Hamari, (2014) however, opined that gamification have great effect on females only when it contains some form of social interactions while males tend to enjoy games when its sort of competitive. Findings from the study conducted by Christy and Fox, (2014) revealed that the incorporation of leader board in gamification create stereotype threats as females dominated leader board conditions demonstrate stronger academic prowess than the male dominated leader board conditions. This finding shows that the incorporation of leader board in a gamified system affects the academic performance of different demographic groups in a different way. Notwithstanding, the findings from previous studies on the influence of gender in the gamified learning environment are inconclusive. This study therefore aims to provide more insight into how gender moderate the learning outcomes of students in a gamified learning environment that incorporate competition and collaboration as gaming strategies.

Theory of Gamified Learning

The theory of gamified learning by Landers (2015) provides an instructional framework for the use of gamification in educational context. This theory posits that the use of game attributes in non-game context affects learning related behaviour/attitude which in turn results into an improvement in students learning and strengthens the relationship between instructional design qualities and learning outcomes. Landers theory specifies that gamification affect learning or stimulate related behaviour through one of two casual pathways of moderation and mediation. Gamification translates to learning by moderation when meaningfully combined game elements are introduced into instructional contents that leads to an improvement in learning outcomes. On the other hand, gamification affects learning by mediation when meaningfully combined game elements directly encourage a behaviour/attitude that will itself improve learning outcomes. Lander (2015) however clarified that the goal of gamification is to improve instruction and not to replace it. The gamification of instructional contents cannot cause learning if the instructional contents itself does not have the capacity to improve students learning. Based on this submission, Lander gave a critique of previous studies on gamification which have failed to explicitly measure the behaviour/attitude that are the direct consequence of gamification. Thus, findings from previous studies stood a risk of misinterpreting the effects of gamification in education.

Landers theory of gamified learning was utilized as an overarching framework in the study. The conceptual framework of the study in figure 1 presents a hypothetical model which shows that the introduction of game

elements into instructional contents drawn from the Nigerian Secondary School Biology Curriculum (NSSBC) in a gamified learning system will stimulate the students learning behaviour/attitude (Engagement) which will in turn improve their achievement and attitude towards learning biology.

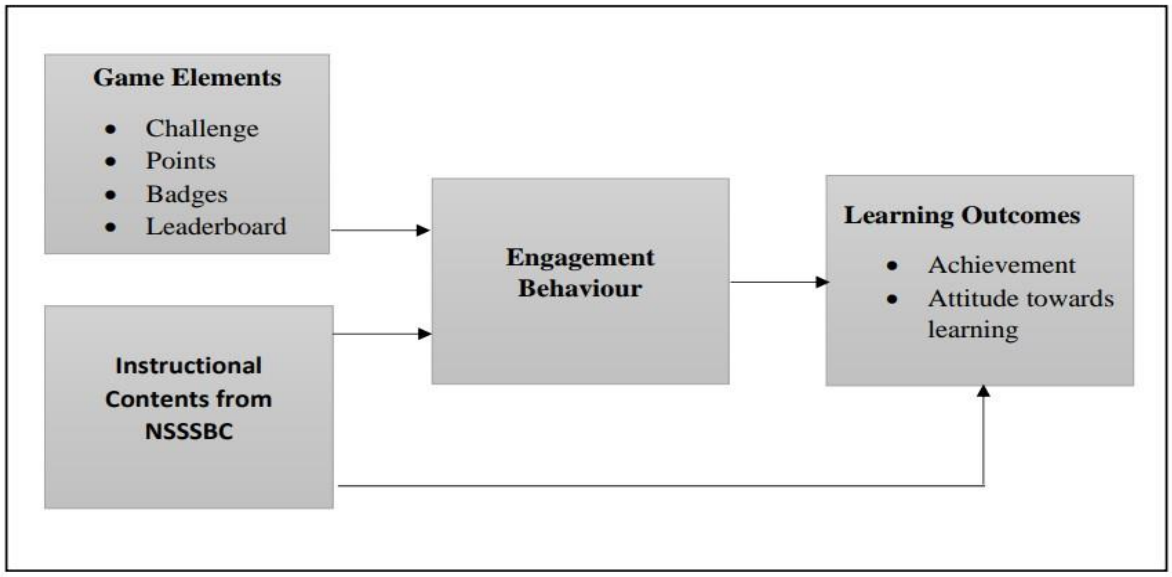

Figure 1. Gamified Learning Environment Adapted from Landers (2015)

Based on Landers gamification theoretical framework coupled with the moderating effect of gender, the following hypotheses were tested:

H_1: the gamification of biology instruction will significantly improve students engagement behaviours.
H_2: gamification will significantly improve the achievement of students in biology.
H_3: there will be significant improvement in the attitude of students who are exposed to gamified biology instruction.
H_4: the effect of gamification on students' engagement and achievement will be significant.
H_5: gamification have a significant effect on the combined influence of engagement and attitude towards learning biology.
H_6: gamification will have a significant effect on students' engagement, achievement and attitude towards learning when combined together.
H_7: gender play a significant role in determining the engagement of students exposed to the gamified learning environment.
H_8: gender is a significant predictor of students' achievement in the gamified learning environment.
H_9: the results of students' attitude towards learning biology in the gamified learning environment will be moderated by gender.
H_{10}: the influence of gender on students' engagement and achievement will be significant.
H_{11}: gender is a significant predictor of students' engagement and attitude towards learning in a gamified environment.
H_{12}: gender play a significant role on students' engagement, achievement and attitude towards learning in a gamified environment.

Methods

Research design

The study was a design experiment which integrated pre-test, post-test, non-randomized control group, quasi experimental research design with descriptive survey research design in a single frame. Design experiment is a research methodology that incorporate multiple designs and methodologies, it is suitable for both research and the design of technology enhanced learning environment (Wang & Hannafin, 2005; Bikanga, 2018). Design experiment research is grounded in real world context where participants interacts socially with each other within a design setting (Brown & Campione, 1996; Collins, 1999). Li and Tsai, (2013) recommended the use of design experiment research for the continuous, systematic evaluation and refinement of digital games elements and design features. Hence the researcher explored the effects of different gaming strategies when simulated into a gamified learning environment on students learning outcomes in biology.

Participants were recruited from five public senior secondary schools in Lagos island local government area of Lagos state, Nigeria using purposive sampling technique. These schools were specifically selected because the biology teachers had received prior pedagogical training on the implementation of mobile enabled biology curriculum. Hence the students and teachers from these schools were vast in the adaptation and use of educational technologies in the classrooms. The sample size comprised of two hundred and forty-two (242) science students in Senior Secondary School two (SSS2) drawn in five intact classes from a total population of four thousand nine hundred and ninety-six (4996) students in Lagos island local government area. Four of the intact classes from the selected schools were randomly assigned to the experimental conditions i.e. individualized, individualized competitive, collaborative and collaborative competitive gaming strategy groups. The remaining intact class served as the control group. The figure 2 presents a demographic breakdown of the sample in the experimental and control groups respectively.

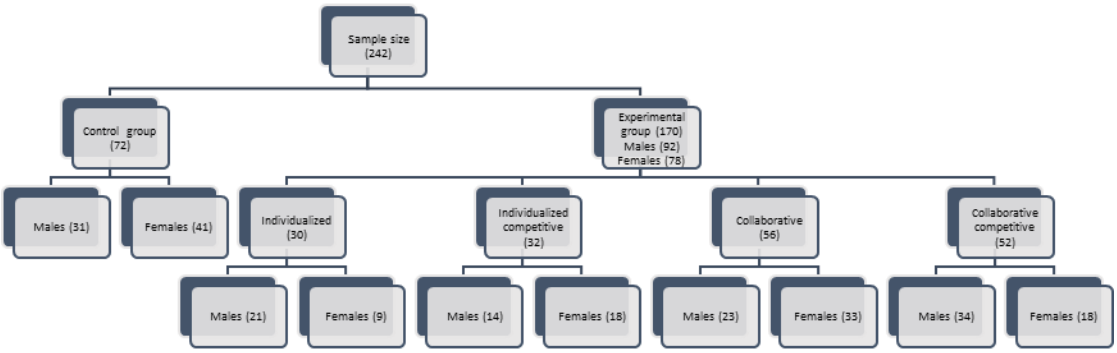

Figure 2. Demographic Distribution of Samples

Instrument for Data Collection

The Classroom Engagement Inventory (CEI), Biology Attitude Questionnaire (BAQ), Prior Knowledge Test (PKT) and Post Test (PT) were utilized as instruments for data collection. The CEI developed and validated by Wang, Bergin and Bergin, (2014) was adopted and used to measure students engagement behaviour. The CEI is a twenty-four (24) item instrument that can be used to measure fourth to twelfth grade students classroom engagement under five factors which are: affective engagement, behavioural engagement-compliance,

behaviour engagement-effortful class participation, cognitive engagement and disengagement respectively. The Cronbach alpha reliability coefficient of the CEI used in the study was 0.88.

The subscales of interest, importance and difficulty levels in the BAQ developed and validated by Prokop, Tuncer and Chuda, (2007) were adopted and used to measure students attitude towards learning biology. In the study, the BAQ comprised of sixteen items (16) which were measured under five-point Likert response format from strongly disagree to strongly agree. A pilot testing of the BAQ instrument gave a Cronbach alpha value of 0.92.

The Prior Knowledge Test (PKT) and Post Test (PT) were multiple-choice question items developed by the researchers. The items were developed based on the review of past West African Examination Council (WAEC) biology examination questions from (2010-2018). The Prior Knowledge Test (PKT) which comprised of twenty items (20) items that covered students previous knowledge in biology was administered as pre-test in other to determine if the experimental and control group differed in their knowledge level. There was no significant difference in the mean scores of the experimental and control group (t_{240}=.419, p=.199>.05). Hence, the experimental and control groups were adjudged to be of equal Knowledge level at the beginning of the experiment. The Post test was a 30 multiple choice question items that assessed students knowledge at the completion of the biology learning module. A table of specification that incorporated the revised blooms taxonomy of education objectives by Anderson and Krathwohl (2001) was used to develop the post-test items in other to ensure adequate coverage of the biology learning module. The reliability coefficients of the PKT and PT instruments using Kuder Richardson 20 statistics was 0.78 and 0.85 respectively.

The Design of the Gamified Learning Environment

The study utilized a Biology Mobile Learning Application (BMLA) originally named Guru IGCSE biology mobile application in the design of the gamified learning environment. Guru IGCSE biology mobile application is a commercially available mobile learning applications that can be downloaded from Google play, educational application stores and other android operating system (OS) services. Guru IGCSE biology mobile application was specifically selected for this study because of its alignment with the instructional contents of the Nigerian Secondary School Biology Curriculum (NSSBC) (Udeani and Akhigbe, IN PRESS). The biology mobile application serves dual functions of been a quizzing app with over eight hundred (800) multiple choice practice questions and a learning management system that provides additional links to YouTube video tutorials, slides share, Ecards and a download centre to aid students with their learning.

In the design of the gamified learning environment, biology teachers who had received prior pedagogical training on how to incorporate mobile learning applications into biology instruction facilitated biology instruction by utilizing the biology mobile learning application in the formative, summative and diagnostic assessment of students learning. Students groups were constituted which comprised of the control and the experimental group. The control group received the regular biology instruction without exposure to the gamified learning environment. Students gaming strategies sub groups were created from the experimental group. These comprised of individualized (I), Individualized competitive (IC), Collaborative (Col) and Collaborative competitive (Col-C) groups respectively. Students in the individualized group played the biology quiz game individually while those in the collaborative group comprised of individuals who attempted the biology quizzes in small groups that provided room for peer interactions. Competition was simulated into the gamified learning environment by allowing students access to the leader board where they can compare their performance in the gamified learning environment against that of their counterparts. Hence, students in the individualized competitive group played the biology quiz game by competing individually with their peers while those in the collaborative competitive group did not only attempt the biology quizzes in small groups that allowed peer interactions but also competed with their peers from another collaborative group. The game cycle in figure 3 provides details on how the game elements prioritized in the study were implemented in the gamified learning environment. The students in the experimental group were exposed to biology quiz challenge in the BMLA after undergoing a set of instruction which was delivered by their respective biology teachers. Students earned points in the BMLA for every right answer they provided to the quizzes. After the successful

completion of a particular task, the BMLA provided a detailed review of students performance in the quiz challenge. Based on the students performance in the game, the biology teachers gave out badges to the winners for the week. The badges were redeemed for educational stationaries and souvenirs.

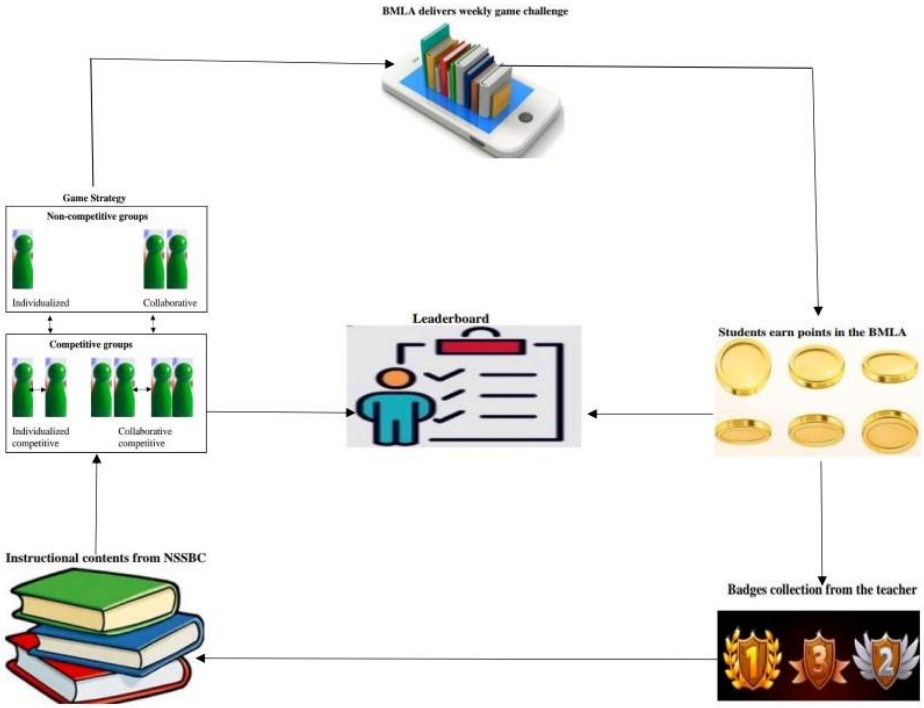

Figure 3. The Game Cycle

Experimental Procedure

An entire biology learning module for a term was gamified for over a period of three months as depicted in figure 4. The experimental procedure for the study was carried out in three phases. In the preparatory phase of the experiment, students were briefed on the purpose of the study and the role they were expected to play in the gamified environment. Students were also exposed to hands-on training on how to handle mobile devices that were pre-installed with the biology mobile learning application. The preparatory phase was rounded off with the administration of the pre-test and pre questionnaire instrument. In the learning phase, students received the regular weekly instructional biology contents as specified in the NSSBC. Students in the experimental group were further exposed to the gamified learning environment before or after receiving biology lessons from their teachers. Whereas, students in the control group were not exposed to the gamified learning environment. The learning phase lasted for a period of ten consecutive weeks. After completion of the biology learning module for the term, students were administered the post-test and post questionnaire instrument in the post learning phase of the study.

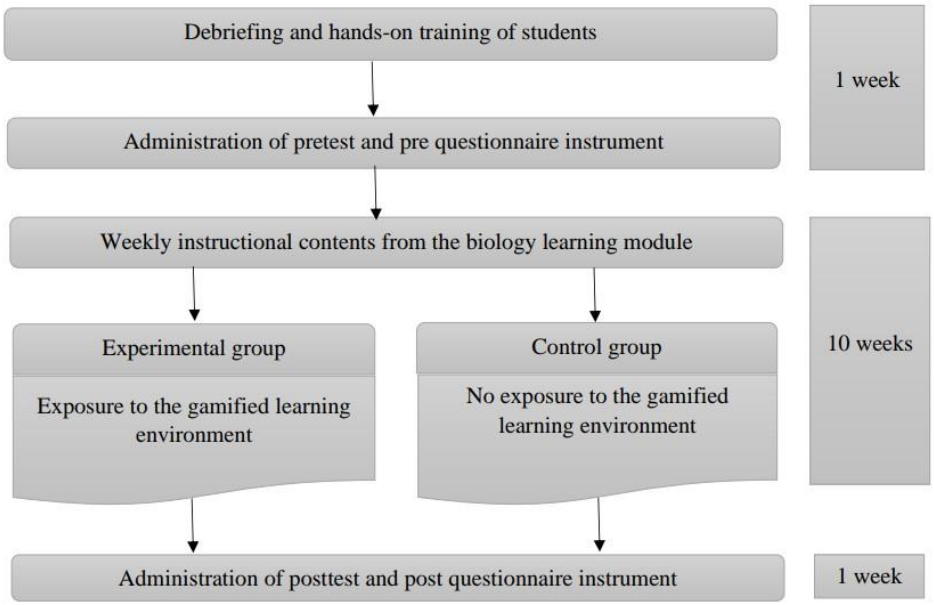

Figure 4. Experimental Procedure

Analysis of Data

Data gathered from the study was analysed using quantitative methods. Descriptive statistical tools of mean and standard deviation were used to answer the research questions while inferential statistical tool of Analysis of Covariance (ANCOVA) and Multiple Analysis of Covariance (MANCOVA) were used to test the research hypotheses at .05 level of significance. All procedures for data analysis was carried out using SPSS statistical software version 25.

Results

H_1: the gamification of biology instruction will significantly improve students' engagement behaviours.

Table 1. Descriptive Statistics for Engagement Scores of the Treatment Groups*

	Pre-Engagement		Post-Engagement		
Group(N)	Mean	SD	Mean	SD	Mean Gain
Individualized (30)	39.70	12.43	66.70	15.86	27.0
Individualize competitive (32)	39.09	12.30	73.78	14.56	34.69
Collaborative (56)	38.50	11.85	77.73	17.34	39.23
Collaborative competitive (52)	37.69	11.21	82.38	14.90	44.69
Overall (170)	38.58	11.76	76.46	16.63	37.88
Control (72)	39.19	11.94	60.86	17.22	21.67

Table 2. Combined ANCOVA Summary Result

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	POST CEI	13830.169[a]	6	2305.028	8.174	.000	.173
	POST TEST	1332.910[b]	6	222.152	4.973	.000	.113
	POST ATT	9450.704[c]	6	1575.117	5.185	.000	.117
Intercept	POST CEI	4117.388	1	4117.388	14.601	.000	.058
	POST TEST	480.822	1	480.822	10.764	.001	.044
	POST ATT	322.587	1	322.587	1.062	.304	.004
PRECEI	POST CEI	294.159	1	294.159	1.043	.308	.004
	POST TEST	.590	1	.590	.013	.909	.000
	POST ATT	.003	1	.003	.000	.998	.000
PRETEST	POST CEI	880.954	1	880.954	3.124	.078	.013
	POST TEST	11.914	1	11.914	.267	.606	.001
	POST ATT	492.411	1	492.411	1.621	.204	.007
PREATT	POST CEI	.000	1	.000	.000	.999	.000
	POST TEST	36.446	1	36.446	.816	.367	.003
	POST ATT	6734.448	1	6734.448	22.168	.000	.086
Treatment (T)	POST CEI	12237.855	1	12237.855	43.398	.000	.156
	POST TEST	1206.414	1	1206.414	27.008	.000	.103
	POST ATT	1823.764	1	1823.764	6.003	.015	.025
Gender (G)	POST CEI	78.510	1	78.510	.278	.598	.001
	POST TEST	11.836	1	11.836	.265	.607	.001
	POST ATT	736.893	1	736.893	2.426	.121	.010
T*G	POST CEI	30.042	1	30.042	.107	.744	.000
	POST TEST	1.267	1	1.267	.028	.866	.000
	POST ATT	1.498	1	1.498	.005	.944	.000
Error	POST CEI	66267.885	235	281.991			
	POST TEST	10497.260	235	44.669			
	POST ATT	71389.548	235	303.785			
Total	POST CEI	1328729.000	242				
	POST TEST	79375.000	242				
	POST ATT	2274591.000	242				
Corrected Total	POST CEI	80098.054	241				
	POST TEST	11830.169	241				
	POST ATT	80840.252	241				

a. R Squared = .173 (Adjusted R Squared = .152)
b. R Squared = .113 (Adjusted R Squared = .090)
c. R Squared = .117 (Adjusted R Squared = .094)

Students in the experimental group had higher engagement behaviour (mean gain=37.88) than their counterparts (mean gain=21.67) who were not exposed to the gamified learning environment as depicted in table 1. A synthesis of findings from table 1 also revealed that gamification technique bolstered the engagement of students in the collaborative groups i.e. collaborative (mean gain=39.23) and collaborative competitive group (mean gain =44.69), than those who individually tackled the quiz challenge with had mean gains of 27 and 34.69 for the individualized and individualized competitive groups respectively. The hypothesis which tested the effect of gamification on students engagement as depicted in table 2 was statistically significant ($F_{6, 235}$=43.398, p=.000 <.05, eta sq=.156). The partial eta squared value revealed that gamification accounted for 15.6% variance in the engagement of students. A post Hoc analysis with Bonferroni corrections showed that the significant effect of gamification on students engagement was due to the significant interactions between individualized and collaborative group (p=.03<.05), and individualized and collaborative competitive group (p=.000<.05) respectively.

H_2: gamification will significantly improve the achievement of students in biology.

Table 3: Descriptive statistics for pre-test and post test score for the treatment groups

	Pre-test		Post test		
Group (N)	Mean	SD	Mean	SD	Mean Gain
Individualized (30)	9.30	3.54	16.60	5.81	7.3
Individualized competitive (32)	9.88	4.08	16.69	7.81	6.81
Collaborative (56)	9.93	3.94	20.36	6.79	10.43
Collaborative competitive (52)	9.54	0.57	17.71	6.90	8.17
Overall (170)	9.69	3.23	18.19	6.99	8.50
Control (72)	9.86	2.06	13.19	5.69	3.33

A synthesis of empirical evidence as shown in table 3 revealed that gamification improved the academic achievement of students in biology due to the fact that the overall mean gain of 8.5 for the experimental group was higher than the mean gain of 3.33 for the control group. A test of the hypothesis from table 2 indicated that there was a significant main effect of gamification on students' academic achievement in biology ($F_{6, 235}$=27.008, p=.000 <.05, eta sq=.103) and this accounted for 10.3% variance in the achievement of students. A post hoc comparisons with Bonferroni corrections revealed that the significant main effect of gamification on students' academic achievement was due to the significance differences between collaborative and individualized group (p=.008<.05), collaborative and individualized competitive group (p=.012<.05) respectively.

H_3: there will be significant improvement in the attitude of students who are exposed to gamified biology instruction.

Table 4: Descriptive statistics for pre-attitude and post-attitude score of the treatment groups

	Pre-attitude		Post-attitude		
Group(N)	Mean	SD	Mean	SD	Mean Gain
Individualized (30)	78.00	4.06	93.17	11.96	15.17
Individualized competitive (32)	79.59	5.01	91.72	11.88	12.13
Collaborative (56)	78.95	5.19	89.73	9.55	10.79
Collaborative competitive (52)	83.15	4.67	109.67	18.11	26.52
Overall (170)	80.00	5.22	96.81	19.68	16.81
Control (72)	81.21	5.65	91.43	12.65	10.22

The descriptive statistics as depicted in table 4 revealed that the overall the mean gain (16.81) for the experimental group was higher than the mean gain (10.22) of the control group. A further testing of the hypothesis from table 2 revealed that there was a significant main effect of gamified instruction on students attitude towards biology ($F_{6, 235}$=6.003, p=.015<.05, eta sq=.025). The partial eta squared value showed that gamified instruction accounted for just 2.5% variance in the attitude of students towards biology. A post hoc analysis with Bonferroni corrections was conducted to determine the real level of significance. Result showed that the main significant effect of gamification on students attitude was due to the significant interaction between the individualized competitive and collaborative competitive group (p=.006<.05), and the collaborative and collaborative competitive group (p=.000<.05) respectively.

H_4: the effect of gamification on student's engagement and achievement will be significant.

Table 5. Multivariate Analysis of the Effect of Gamification on Students Engagement and Achievement in Biology

Effect	Wilks Value	LambdaF	Hypothesis df	Error df	Sig	η_p^2
Intercept	.530	104.042	2	235	.000	.470
PRECEI	.996	.524	2	235	.593	.000
PRETEST	.985	1.761	2	235	.174	.015
Treatment (T)	.771	34.986	2	235	.000*	.229
Gender (G)	.998	.232	2	235	.793	.002
T*G	.999	.089	2	235	.915	.001

* Significant at p<.05.

A Multiple Analysis of Covariance (MANCOVA) as depicted in table 5 was conducted to determine the effect of gamification on the combined influence of engagement and achievement. Statistical findings show that there was a significant effect of gamification on the combined engagement and achievement dependent variables ($F_{2, 235}$=34.986, p=.000 <.05, Wilks Lamda=.771, eta sq=.229). The partial eta squared value revealed that gamification accounted for 22.9% variance on the combined variables of students' engagement and achievement in biology.

H_5: gamification have a significant effect on the combined influence of engagement and attitude towards learning biology.

Table 6. Multivariate Analysis of the Effect of Gamification on Students Engagement and Attitude towards Biology

Effect	Wilks Value	LambdaF	Hypothesis df	Error df	Sig	η_p^2
Intercept	.929	9.041	2	235	.000	.071
PRECEI	.995	.591	2	235	.555	.005
PREATT	.916	10.729	2	235	.000	.084
Treatment (T)	.824	25.058	2	235	.000*	.176
Gender (G)	.987	1.546	2	235	.215	.013
T*G	.999	.066	2	235	.936	.001

* Significant at p<.05.

Empirical data gathered from the multivariate test as depicted in table 6 revealed that the gamification of biology instructional significantly improved the engagement and attitude of students towards learning when both dependent variables are combined ($F_{2, 235}$=25.058, p=.000 <.05, Wilks Lamda=.824, eta sq=.176). The partial eta squared value revealed that gamification accounted for 17.6% variance on the combined influence of students' engagement and achievement in biology.

H_6: gamification will have a significant effect on students' engagement, achievement and attitude towards learning when combined together.

Table 7. Multivariate Analysis of the Effect of Gamification on Students Engagement, Achievement and Attitude towards Biology

Effect	Wilks Value	LambdaF	Hypothesis df	Error df	Sig	η_p^2
Intercept	.905	8.173	3	233	.000	.095
PRECEI	.996	.347	3	233	.791	.004
PRETEST	.981	1.521	3	233	.210	.019
PREATT	.884	10.194	3	233	.000	.116
Treatment (T)	.772	22.913	3	233	.000*	.228
Gender (G)	.983	1.339	3	233	.263	.017
T*G	.999	.049	3	233	.986	.001

* Significant at p<.05.

MANCOVA summary result from table 7 show that there is a significant effect of gamification on students engagement, achievement and attitude when combined together ($F_{3, 233}$=22.913, p=.000 <.05, Wilks Lamda=.772, eta sq=.228). The partial eta squared value revealed that gamification accounted for 22.8% variance on the combined variables of students' engagement, achievement and attitude towards learning biology.

H_7: gender play a significant role in determining the engagement of students exposed to the gamified learning environment.

Table 8. Descriptive Statistics for Engagement Scores of the Treatment Groups

		Experimental group				Control group		
Gender	N	pre-eng	post-eng	Mean Gain	N	pre-eng	post-eng	Mean Gain
Male	92	34.00	90.00	56	31	45.00	60.00	15
Female	78	24.00	90.00	66	41	58.00	59.00	1.0

The descriptive statistics in table 8 revealed that gamified biology learning promote the engagement of females (mean gain=66) more than the males (mean gain=56) in the experimental group. Notwithstanding, both the male and female in the experimental group had higher engagement behaviours than their counterparts who were not exposed to the gamified learning environment. Nevertheless, the hypothesis test from table 2 above revealed that there was no significant main effect of gender ($F_{6, 235}$=.278, p=.598>.05, eta sq=.001), and interaction effect of treatment and gender ($F_{6, 235}$=.107, p=.744>.05, eta sq=.000) on the engagement behaviours of students respectively.

H_8: gender is a significant predictor of students' achievement in the gamified learning environment.

Table 9: Descriptive Statistics for Pre-test and Post Test Score for the Treatment Groups by Gender

		Experimental group				Control group		
Gender	N	pre-test	post-test	Mean Gain	N	pre-test	post-test	Mean Gain
Male	92	9.39	17.90	8.51	31	9.61	13.13	3.52
Female	78	10.04	18.54	8.5	41	10.05	13.24	3.19

Data from table 9 revealed that male students in the experimental group recorded slightly high mean gain (8.51) when compared to the females who recorded a mean gain of (8.5). Likewise, the male students in the control group recorded a slightly higher mean gain (3.52) than the females with a mean gain of (3.19). Notwithstanding, both the males and females in the experimental group outperformed the males and females in the control group respectively. The test of hypotheses from table 2 revealed that the main effect of gender on students' academic achievement in biology ($F_{6, 235}$=.265, p=.607 >.05, eta sq=.001) and the interaction effect of gender and treatment on students' academic achievement in biology ($F_{6, 235}$=.028, p=.866 >.05, eta sq=.000) did not yield any significant result. This result implies that effectiveness of gamification on students' academic achievement in biology does not depend on gender.

H_9: the results of students' attitude towards learning biology in the gamified learning environment will be moderated by gender.

Table 10: Descriptive statistics for pre-attitude and post-attitude score of the treatment groups By Gender

	Experimental group				Control group			
Gender	N	pre-attitude	post-attitude	Mean Gain	N	pre-attitude	post-attitude	Mean Gain
Male	92	80.12	89.50	9.38	31	79.90	92.35	12.45
Female	78	79.86	91.65	11.79	41	82.21	90.73	8.52

Data presented in table 10 revealed that the mean gain (11.79) of the females was relatively higher than the mean gain (9.38) of the male students in the experimental group. The mean gain of the males (12.45) was relatively higher than the mean gain (8.52) of the females in the control group. The overall influence of gender variable on the attitude of students towards biology showed mixed results because the females in the experimental group outperformed the females in the control group by recording a higher mean gain. But the reverse was the case for the males in the experimental group who were outperformed by the males in the control group. A further testing of hypotheses from table 2 on the main effect of gender on students attitude toward biology ($F_{6, 235}$=2.426, p=.121 >.05, eta sq=.010) and the interaction effect of gender and treatment on students attitude towards biology ($F_{6, 235}$=-005, p=.944 >.05, eta sq=.000) did not yield any significant result. This result implies that gamification improve students attitude towards biology irrespective of their gender.

H_{10}: the influence of gender on students' engagement and achievement will be significant.

Data from table 5 revealed that there is no significant main effect of gender ($F_{2, 235}$=.232, p=.793 >.05, Wilks Lamda=.998, eta sq=.002) and interaction effect of gender and treatment gender ($F_{2, 235}$=.089, p=.915 >.05, Wilks Lamda=.999, eta sq=.001) on the combined engagement and achievement dependent variables respectively.

H_{11}: gender is a significant predictor of students' engagement and attitude towards learning in a gamified environment.

Data from table 6 show that gender is not a significant predictor of students engagement and attitude in a gamified learning environment ($F_{2, 235}$=1.546, p=.215 >.05, Wilks Lamda=.987, eta sq=.013). Neither does the interaction of gender and treatment predict students engagement and attitude towards learning in a gamified environment ($F_{2, 235}$=.066, p=.936 >.05, Wilks Lamda=.999, eta sq=.001) respectively.

H_{12}: gender play a significant role on students' engagement, achievement and attitude towards learning in a gamified environment.

Empirical data from 7 revealed that gender do not play any significant role on students engagement, achievement and attitude ($F_{3, 233}$=1.339, p=.263 >.05, Wilks Lamda=.983, eta sq=.017). Likewise, the interaction of gender and treatment on students engagement, achievement and attitude towards learning in a gamified environment is not statistically significant ($F_{3, 233}$=.049, p=.986 >.05, Wilks Lamda=.999, eta sq=.001).

Discussion

The gamification of learning experiences shows promising results in improving students learning outcomes based on the findings from the study. Empirical findings from the study revealed that the gamification of biology learning experiences significantly improved the engagement behaviour of students ($F_{6, 235}$=43.398, p=.000 <.05, eta sq=.156), and the academic achievement of students in biology ($F_{6, 235}$=27.008, p=.000 <.05, eta sq=.103) respectively. This is because gamification initiative motivates actions that promotes students engagement in learning (Kapp, 2012). The incorporation of game mechanics such as leader board, points, badges and game challenge worked harmoniously to promote students learning engagement and achievement. Gamification also aided students' transfer of the knowledge acquired in the gamified learning environment to a real-world context. This assertion is consistent with the findings from the studies conducted by Cheong et al., (2013) and Penchenkina at al., (2017) in which the incorporation of game mechanics unto mobile quizzing applications resulted into an improvement in the engagement and achievement of students who were exposed to the gamified learning environment. Penchenkina at al., (2017) posited that gamification techniques can be deployed to consolidate for students' knowledge in a low stake learning environment. Finding from the study also revealed a significant improvement in the attitude of students who were exposed to gamified biology instruction ($F_{6, 235}$=6.003, p=.015<.05, eta sq=.025). The gamified biology mobile quizzing application thus shows promising result to bolster students' attitude towards learning. This finding is consistent with the views of Baleni (2015) and Donnelly (2014) who asserted that educators and students generally have positive attitude towards quizzes. This positive attitude towards quizzes translates to an improvement in students' attitude towards learning science.

Any successful gamification initiative depends on the context of its implementation and the behaviour of the users (Koivisco and Hamari, 2014). Landers (2015) theory of gamified learning also presents a conceptual framework for determining the success of any gamification initiative. This theory was operationalized by measuring the effectiveness of gamification on the combined dependent variables of engagement and achievement, engagement and attitude towards learning engagement, achievement and attitude towards learning respectively. Data gathered from the multiple analysis of variance revealed that the gamification of biology learning experiences was successful in improving students: engagement and achievement ($F_{2, 235}$=34.986, p=.000 <.05, Wilks Lamda=.771, eta sq=.229); engagement and attitude towards learning ($F_{2, 235}$=25.058, p=.000 <.05, Wilks Lamda=.824, eta sq=.176) and finally engagement, achievement and attitude ($F_{3, 233}$=22.913, p=.000 <.05, Wilks Lamda=.772, eta sq=.228) respectively. These findings show that students' engagement in the gamified learning environment was a critical factor for the improvement in their learning outcomes. The influence of gamification in promoting students engagement was not due to chance but rather depicts that students showed active engagement behaviours which were directed towards their achievement and attitude towards learning. This imply that the specific attributes of the gamified learning environment contributed directly to the significant improvement in students learning outcomes.

Competition and collaboration moderated students learning outcomes in the gamified learning environment. Empirical evidences from the study revealed that competition and collaboration interplay to promote students learning engagement behaviours, achievement and attitude towards learning. The incorporation of competition into game design and development stimulates an environment that motivates and engages students (Burguillo, 2010; Huizenga, ten Dam, Voogt & Admiraal, 2017). Competition also create a ground for students to accept challenges in the gamified environment (Moreno, 2012). Notwithstanding the effectiveness of competition on engagement, collaborative practices in the gamified learning environment also provided a scaffold that enhanced students' engagement (Sanchez & Olivares, 2011). Due to the fact that students in the collaborative competitive game strategy group recorded the highest mean gain of 44.69 when compared to the mean gains of the collaborative (39.23), individual (27) individual competitive (34.69) groups respectively. These findings thus suggest that students react to gamified learning environment differently under competitive and collaborative modes. Furthermore, the influence of competition and collaboration on the achievement and attitude of students in biology documented mixed findings. Collaboration promoted students achievement

while the reversal was the case with competition. Students in the collaborative group (mean gain=10.43) outperformed their peers in the collaborative competitive group (mean gain=8.17) on the achievement tests. Similarly, students in the individualized group (mean gain=7.3) outwit their individualized competitive counterpart who recorded a mean achievement gain of 6.81. Findings also showed that students in the collaborative groups outperformed those in the individualized groups on the achievement mean gains generally. In addition, collaboration and competition jointly promote the attitude of students towards biology because students in the collaborative competitive group had the highest mean gain (26.52) on attitudinal measure when compared with their peers from other groups i.e. collaborative (mean gain=10.79), individualized (mean gain=15.17) and individualized competitive (mean gain=12.13) groups respectively. These findings are consistent with the view that students interaction in small groups through game play provides an avenue for teamwork and collaborative problem solving which in turn improved the students learning achievement (Li and Tsai, 2013), whereas competition limits students' performance in the game (Chen, 2014). However, the findings from the study did not agree with Vandercruysse, et al. (2013) who opined that the simulation of competition into game-based learning environments have no effect on the learning outcomes of students.

Gamification improved the engagement and attitude of female students who recorded higher mean gains on their engagement (66) and attitude (11.79) when compared to their male counterparts who had mean gains of 56 and 9.38 on engagement and attitude respectively. These findings agree with Koivisto and Hamari, (2014) who asserted that gamification have greater influence on the engagement of female students than their male counterparts. Notwithstanding, the main effect of gender ($F_{6,\ 235}$=.278, p=.598>.05, eta sq=.001) and interaction effects of gamification and gender ($F_{6,\ 235}$=.107, p=.744>.05, eta sq=.000) on students engagement was not significant. Likewise, there was no significant main effect of gender ($F_{6,\ 235}$=.265, p=.607 >.05, eta sq=.001) and interaction effect of gender and gamification ($F_{6,\ 235}$=.028, p=.866 >.05, eta sq=.000) on the achievement of students. Also, the main influence of gender ($F_{6,\ 235}$=2.426, p=.121 >.05, eta sq=.010) and the interaction effect of gender and treatment on students attitude towards biology ($F_{6,\ 235}$=-005, p=.944 >.05, eta sq=.000) was not statistically significant. These separate findings suggest that gamified learning enhances students engagement, achievement and attitude irrespective of their gender. These findings corroborate with Pedro et al., (2015b) who reported that gamification does not affect the learning performances of male and female students. Hence, both male and female students achieved equitable learning outcomes in the gamified biology learning environment.

Conclusion

The gamification of biology learning serves good prospect in fostering the engagement, achievement and attitude of students towards learning biology based on the empirical evidences gathered from the study. Furthermore, gamification promotes students learning outcomes irrespective of their gender thus implying that gamification close the achievement gaps between male and female gender. Findings from the study revealed that collaboration and competition, when implemented in a gamified learning environment interplay to moderate the learning outcomes associated with the gamification initiative. The study also provided empirical evidences that reinforce collaboration as an effective strategy for improving the performance students in biology.

Recommendations

The gamification of learning experiences is an effective pedagogical strategy that can be implemented in a typical Nigerian biology classroom. This study thus recommends the utilization of gamification strategy in the design of biology instruction in other to provide a scaffold for students learning and co-construction of knowledge in the biology classroom. The biology mobile quizzing application used in this study should be adopted as a personal learning management system and a productivity tool by the students. In addition, the success of any gamification initiative depends on the contexts of their implementation. This highlights the

role of teachers in the design of gamified learning experiences for their students. Hence, the study recommends the professional grooming of in-service biology teachers in the design and implementation of game-based learning curricular. Game-based learning should also be included in curriculum of preservice biology teachers in higher institutions of learning.

The study implemented game elements and mechanics in a design experiment by simulating competition and collaboration into the gamified learning environment. Future research should rather focus on developing biology games quizzing applications with design features that embeds and provide opportunities for students to collaborate with virtual peers or to compete with a virtual anonymous or non-anonymous opponent.

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