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Effect of Computer Simulation Instructional Strategy on Students' Attitude and Academic Achievement in Genetics

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Abstract. Concepts in genetics have been perceived to be very difficult by Nigerian students in recent times. This study therefore investigated the effect of computer simulation instructional strategy on senior secondary students' attitude and achievement in genetics. This was coupled with the moderating effects of gender and ability levels. The design of the study was quasi experimental, while 209 students drawn from four intact classes using purposive sampling techniques constituted the sample size. Six research questions guided the study and emerging hypotheses were tested at .05 level of significance. Quantitative data were collected using questionnaires and achievement tests. The results revealed that the use of computer simulation as a pedagogical tool significantly improve the achievement of students and bolsters their attitude towards biology. Similarly, findings revealed that the instructional use of computer simulation significantly improve the achievement of low ability learners who recorded higher mean gains than the medium and high ability groups respectively. Gendered difference in attitude and achievement did not yield any significant result thereby implying that the instructional use of computer simulations bridges the gap in attitude and achievement of male and female students respectively. The educational implications of these findings were extensively discussed.

Keywords: Computer Simulation, Science Attitude, Achievement, Ability Level and Genetics Concepts.

1. Introduction

Genetics has been identified as one of the most difficult and abstract concepts in high school biology. This is due to the invincible processes of cell divisions i.e. mitosis and meiosis (Brown, 1990; Stewart, Hafner & Dale, 1990). The abstractness of genetic concepts contributes to students' difficulties in understanding the concepts (Albaladejo and Lucas, 1988; Johnstone and Mahmoud, 1980) and the misconceptions they hold as regarding these concepts (Banet and Ayuso, 2003; Albaladejo and Lucas, 1988). In Nigeria, these problems escalate because an analysis of the performance of students paints a gloomy picture that reveal high failure rates in biology (Sakiyo and Badau, 2015). The poor performance of students in biology, especially in difficult conceptual areas such as genetics, ecology and energy transformation in nature etc. have been adjudged to poor teaching and learning approaches which often times require students learning by rote and a regurgitation of the teachers' idea among others (Ozcan, Yildrin & Ozgur, 2012; Agboghoroma and Oyovwi, 2015). These teacher-centered instructional approaches also contribute to compounded students' misconceptions of these particular conceptual areas (Brown, 1990; Kindfield, 1991; 1994; Ozcan et al., 2012).

Computer aided instructional media such as computer simulation have been identified as an effective instructional media for enhancing students' learning of difficult and abstract concepts (Cheung, Slavin, Kim & Lake, 2016). Computer simulation incorporates multimedia elements such as graphics, animation, static pictures, simulation, photos, videos, text and narration on the computer screen (Akpan, 2001; Elangovan and Ismail, 2014). It is a software program that can be used to facilitate the teaching and learning of abstract concepts because it is specifically designed to help students visualize abstract concepts and create mental models of an observed phenomenon due to the integration of new knowledge gathered in the simulation learning environment with the previous ones (Ali and Zamzuri, Ndioho and Mumuni, 2016). Simulation also mimics the behavior of an ideal system, thus presenting abstract concepts in biology to students in a simplified manner (Hulya, Aslan & Rifat, 2011; Chinenye, Abraham & Willaims, 2019). Computer simulation-based learning modules thus have potentials for improving students' conceptual understanding of difficult and abstract concepts in biology (Goff, Reindl, Johnson, Mc Clean, Offerdahl, Schroeder & White, 2017). Biology teachers can also leverage on the use of this multimedia platform to effectively design classroom instructions that are interactive and time efficient (Deloizer and Rodes, 2016).

Furthermore, evidences synthesized from previous studies suggests that computer simulation is an effective pedagogical tool for learning difficult concept such as genetics e.g. (Elangovan and Ismail, 2014; Adebayo and Oladele, 2016; Asogwa, Muhammed, Asogwa & Ofoegbu, 2016) etc. A majority of these studies also document findings which reveal that the instructional use of computer simulation significantly improved the achievement and retention of students in genetics e.g. (Elangovan and Ismail, 2014, Asogwa et al., 2016'; Chinenye et al., 2019). Although, literatures that examine the pedagogical impact of computer simulation on students' learning outcomes such as achievement and retention are well established. Notwithstanding, studies that examine the effect of computer simulation instructional approach on students' attitude towards science and motivation to learn science are relatively scare. Also, only few studies have incorporated gender as a moderating variable e.g. (Asogwa et al., 2016; Amedu, 2015). This is because gender is a factor that influences students' achievement in sciences at the secondary school level (Gambari, Yusuf & Thomas, 2015). However, findings from previous studies that examined gendered influence on the performance of students in genetics are inconclusive.

In another dimension, high cognitive functioning is required for students to engage themselves in meaningful educational task. Witkin, Moore, Goodenough & Cox, (1977) termed this cognitive functioning as 'Ability level'. Witkins et al., (1977) further classified ability levels into low, medium and high ability levels respectively. Findings from previous studies suggests that technology enhanced learning bridges the gap in the performance of low, medium and high ability level students e.g. (Chen, Wang, Dede & Grotzer, 2017; Belland, Glazewski, & Richardson, 2011; Liu, Chen, & Chang, 2010). Nevertheless, we do not have enough empirical evidence with regards to the effect of computer simulation instructional strategy on students from low, medium and high ability groups respectively.

2. Theoretical Framework

The Cognitive Theory of Multimedia Learning (CTML) by (Paivio, 1986; Baddeley, 1986, 1999; Chandler & Sweller, 1991; Mayer, 1999a, 1999b) underpins the use of computer simulation instructional strategy. In the study, a collection of simulation learning module named "Virtual Cell Animation" was utilized. The development of the virtual cell (V cell) animation collectives incorporates research-based principles of multimedia instructional design. V cell animation presents a dynamic display of the multiple stages in intricate biological processes in a step-wise, moving series of on-screen events (Goff, Reindl, Johnson, Mc Clean, Offerdahl, Schroeder & White, 2016). The exposure of students to the computer simulation instructional strategy has potentials in fostering students' learning of abstract and difficult concepts in biology. It presents students with multisensory pathways. First of all, students select relevant words and images from the simulation learning environment; after which they carry out a deep cognitive processing of the words and images and translate them into information which are later transferred to their long-term memory through the effective integration of this information with their prior knowledge. This helps students build a coherent mental structure of the concepts hence meaningful learning takes place. Based on these preconceptions, it is assumed that the computer simulation instructional strategy would facilitate students' learning outcomes because students can transfer knowledge acquired from the simulation learning environment to a real-world context.

3. Purpose of the Study

The study therefore explores the pedagogical effect of animated Computer Simulation Instructional Strategy (CSIS) on students' attitude towards biology and achievement, coupled with the moderating effects of gender and ability levels. In the study, computer simulation instructional media was utilized as a milieu for the teaching and learning of genetic concepts in Nigerian senior secondary school biology curriculum.

4. Research Questions

The study aims to provide answers to the following research questions:

RQ1: Is there any difference in attitude of students taught using CSIS and the Conventional Teaching Method (CTM)?
RQ2: Is there any difference in the achievement of students taught using CSIS and the CTM?
RQ3: What is the gendered difference in the attitude of students taught using CSIS and the CTM?
RQ4: What is the gendered difference in the achievement of students taught using CSIS and the CTM?
RQ5: Does ability levels influence the attitude of students taught with the CSIS and the CTM?
RQ6: Does ability levels influence the achievement of students taught with the CSIS and the CTM?

5. Research Methodology

5.1 Participants and Design

The study adopted the pre-test, post-test, non-randomized control group, quasi-experimental design. The participants in the study were recruited from four co-educational public senior secondary schools in Lagos metropolis. A purposive convenient sampling technique was used to select four senior secondary schools that have a well-equipped computer laboratory and ICT gadgets installed in all the classrooms. Intact classes drawn in the selected schools were thereafter randomly assigned to the experimental (N=95) and the control group (N=114) respectively. The sample comprised of 209 (127 males and 82 females).

5.2 Instruments

Three instruments were utilized for data collection. They are: Attitude Towards Biology (ATB) questionnaire, Students' Prior Knowledge Test on Genetics (SPKTG) and Achievement Test on Genetics (ATG) respectively. The ATB instrument was adapted from Fraser, (1981) and Ali, Moshin & Iqbal, (2013) respectively. The adapted instrument had the subscales; enjoyment of science lessons, interest leisure in science and career interest in science. ATB questionnaire comprised of 20 items measured under five-point Likert scale response format. The Cronbach Alpha reliability co-efficient of ATB questionnaire was 0.84.

The researchers' self-developed instruments tagged Students' Prior Knowledge Test on Genetics (SPKTG) and Achievement Test on Genetics (ATG) were administered as the pre-test and post-test respectively. Test items in the instruments were constructed based on a review of previous West African Examination Council (WAEC) examination questions between the periods of 2010-2018. The revised version of Blooms taxonomy of education objectives by Anderson and Krathwohl (2001) was employed as a guide in the construction of the items under the cognitive levels of remembering, understanding and applying in other to ensure adequate coverage of the content areas in genetics. Both instruments were further subjected to experts' validation by three experienced biology teachers and two Professors of Biology education and Cell biology and genetics respectively. The reliability coefficient of the SPKTG and ATG were 0.89 and 0.78 respectively based on Kuder Richardson 20 statistics.

5.3 Procedure

The study procedure was carried out in four phases: the preparatory phase, the pretest administration phase, a learning phase and a posttest administration phase respectively. In the preparatory phase, permission was obtained from the respective school authorities while biology teachers were recruited as research assistants and trained on the procedure for delivering lessons that incorporated the computer simulation learning module. The teachers were guided by the researchers' carefully designed lesson plans for the experimental and control groups respectively. This procedure lasted for a duration of two weeks i.e. (two hours daily for ten working days respectively). The debriefing of the students and the administration of the pretest instruments i.e. (pre-ATB and SPKTG) was carried out in the pretest administration phase in the third week. Results from the Analysis of Variance (ANOVA) conducted on the pretest instruments in other to ascertain the equivalence of the treatment groups (experimental and control groups) at the beginning of the experiment did not yield any significant results ($F_{1,\ 208}$=3.45, p=0.06>.05) and ($F_{1,\ 208}$=2.204, p=0.139>.05) for the respective ATB and SPKTG pretest instruments. This implies that the groups were homogenous prior to the administration of the treatments i.e. (CSIS and CTM). The scores of students obtained from SPKTG was used to group the students into low, medium and high ability levels respectively.

In the learning phase, an enriched 80 mins per week lesson plan that incorporated the computer simulation learning module was use to deliver lessons to students in the experimental group, while students in the control group were taught the same lesson but without the computer simulation learning module using the Conventional Teaching Method (CTM). This procedure lasted for a consecutive period of four weeks. The posttest instruments of post-ATB and ATG were administered in the posttest administration phase in the last week of the procedure. Data gathered in the pretest and posttest administration phases were captured in SPSS 25 and analyzed using descriptive statistics of mean and standard deviation while Analysis of Covariance (ANCOVA) was used to test the emerging hypotheses at .05 level of significance.

6. Results

RQ 1: Is there any difference in attitude of students taught using CSIS and the Conventional Teaching Method (CTM)?

The computed descriptive statistics from table 1 reveal that the students who were taught using the CSIS had a more positive attitude towards biology (Mean gain=12.19) than those who were taught using the CTM (Mean gain =5.94). An Analysis of Covariance (ANCOVA) on the treatment groups with the pre-attitude as the covariate as indicated in table 2 below reveal that this mean difference was statistically significant ($F_{(1,208)}$ =38.657; P=.000< .05).

Table 1. Mean, standard deviation and mean gains for the treatment groups on their attitude towards Biology

Treatment Groups	N	Pre-Attitude		Post-Attitude		Mean Grain .
		Mean	SD	Mean	SD	
Experimental	95	75.36	8.20	87.55	7.10	12.19
Control	114	73.73	7.65	79.67	11.05	5.94

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Table 2. ANCOVA summary for the main and interaction effects (gender and mental ability) of treatments on attitude of students towards biology.

Dependent Variable: Post-Attitude

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6780.617[a]	12	565.051	7.382	.000
Intercept	20369.923	1	20369.923	266.106	.000
Pre-Attitude	768.795	1	768.795	10.043	.002
Treatment	2959.135	1	2959.135	38.657	.000
Gender	152.264	1	152.264	1.989	.160
Ability level	876.792	2	438.396	5.727	.004
Treatment * Gender	163.006	1	163.006	2.129	.146
Treatment* Ability level	326.939	2	163.470	2.136	.121
Gender * Ability level	516.647	2	258.323	3.375	.036
Treatment * Gender * Ability level	1255.439	2	627.720	8.200	.000
Error	15003.431	196	76.548		
Total	1470563.000	209			
Corrected Total	21784.048	208			

a. R Squared = .311 (Adjusted R Squared = .269)

RQ2: Is there any difference in the achievement of students taught using CSIS and the CTM?

Results from table 3 reveal that students who were taught genetics using the CSIS (Mean gain=2.8) outperformed those who were the same genetics concepts using the CTM (Mean gain=1.35). The ANCOVA summary with the pretest as the covariate reveals that the mean difference in the achievement of students taught using CSIS and the CTM was statistically significant ($F_{(1,208)}$ =19.384; P=.000< .05).

Table 3. Mean, standard deviation and mean gains for the treatment groups on their achievement in genetics

Treatment Groups	N	Pre-Test		Post-Test		Mean Grain .
		Mean	SD	Mean	SD	
Experimental	95	9.44	2.67	12.24	3.16	2.8
Control	114	8.79	2.40	10.14	2.54	1.35

Table 4. ANCOVA summary for the main and interaction effects (gender and mental ability) of treatments on achievement of students in genetics

Dependent Variable: Posttest

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	556.217[a]	12	46.351	6.760	.000
Intercept	224.048	1	224.048	32.677	.000
Pretest	40.010	1	40.010	5.835	.017
Treatment	132.907	1	132.907	19.384	.000
Gender	6.336	1	6.336	.924	.338
Ability level	35.951	2	17.975	2.622	.075
Treatment * Gender	6.357	1	6.357	.927	.337
Treatment * Ability level	75.260	2	37.630	5.488	.005
Gender * Ability level	74.084	2	37.042	5.402	.005
Treatment * Gender * Ability level	48.245	2	24.123	3.518	.032
Error	1343.869	196	6.856		
Total	27631.000	209			
Corrected Total	1900.086	208			

a. R Squared = .293 (Adjusted R Squared = .249)

RQ3: What is the gendered difference in the attitude of students taught using CSIS and the CTM?

Table 5 reveals that the male students (Mean gain=13.74) who were taught genetics using the CSIS have more positive attitude towards biology than their female counterparts who had a (Mean gain=9.54). Likewise, the male students from CSIS group had higher attitude towards biology than the male students (Mean gain=9.83) taught genetics using the CTM. Similarly, the female students from the CSIS group outperformed the females (Mean gain=0.38) taught using the CTM on the attitudinal scale. This indicates that CSIS improve the attitude of students towards biology with respect to their gender, favoring the males more than the females. Notwithstanding, gender differences in the attitude towards Biology as indicated in table 2 above was not significant ($F_{(1,208)}$ =1.986; P=.160>.05). In addition, the interaction effects of treatment and gender was not statistically significant ($F_{(1,208)}$ =2.129; P=.146>.05).

Table 5. Mean, standard deviation and mean gains for the treatment groups on their attitude towards Biology based on their gender

Gender	Treatment	N	Pre-Attitude		Post-Attitude		Mean Grain
			Mean	SD	Mean	SD	.
Male	Experimental	60	73.97	7.59	87.70	6.65	13.74
	Control	67	71.19	7.22	81.02	12.49	9.83
Female	Experimental	35	77.77	8.75	87.31	7.91	9.54
	Control	47	77.36	6.80	77.74	8.36	0.38

RQ4: What is the gendered difference in the achievement of students taught using CSIS and the CTM?

Table 6 shows that the male students (Mean gain=3.42) taught genetics using the CSIS outperformed their female counterparts (Mean gain=1.75). This data also indicates that the male and female students who were taught using the CSIS outwit the performance of the males (Mean gain=1.58) and females (Mean gain=1.03) students who were taught using the CTM respectively. However, mean difference in the achievement of males and female students is not statistically significant ($F_{(1,208)}$ =.924; P=.338>.05) as indicated in table 4 above. Likewise, the interaction effects of treatment and gender on the achievement of students in genetics is not significant ($F_{(1,208)}$ =.927; P=.337>.05). This imply that gender bridges the gap in the achievement of male and female students.

Table 6. Mean, standard deviation and mean gains for the treatment groups on their achievement in genetics based on gender

Gender	Treatment	N	Pre-Test		Post-Test		Mean Grain
			Mean	SD	Mean	SD	.
Male	Experimental	60	9.15	2.83	12.57	3.36	3.42
	Control	67	8.36	2.24	9.94	2.16	1.58
Female	Experimental	35	9.94	2.31	11.69	2.73	1.75
	Control	47	9.40	2.51	10.43	3.00	1.03

RQ5: Does ability levels influence the attitude of students taught with the CSIS and the CTM?

Table 7 indicates that the CSIS bolster the attitude of high ability levels (Mean gain 15.91), followed by the medium ability level (Mean gain 13.67) and then low ability level students (Mean gain=8.54) in that particular other. This performance outwits the attitude of students taught using the CTM in the high (Mean gain=3.87), Medium (Mean gain=4.0) and low (Mean gain=7.73) ability groups respectively. Table 2 above shows that there is a significant main effects of ability levels on the attitude of students towards biology ($F_{(2, 208)}$ =5.727; P=.004< .05). Likewise, there is significant interaction between gender and ability levels ($F_{(1,196}$ =3.375; P=.036< .05); treatment, gender and ability levels ($F_{(2, 208)}$ =8.200; P=.000< .05). Notwithstanding, there is no significant interaction between treatment and ability level ($F_{(2,}$

$_{208)}$ =2.136; P=.121> .05). This data reveals that the treatment, gender and ability levels jointly contribute to improve the attitude of students taught genetics using the CSIS.

Table 7. Mean, standard deviation and mean gains for the treatment groups on their attitude towards Biology based on their ability levels

Treatment Group	Ability Level	N	Pre-Test Mean	SD	Post-Test Mean	SD	Mean Grain
Experimental	Low	37	75.81	7.55	84.35	7.33	8.54
	Medium	36	74.91	8.59	88.58	6.06	13.67
	High	22	75.36	8.93	91.27	6.17	15.91
Control	Low	60	71.40	7.46	79.13	12.41	7.73
	Medium	30	75.60	5.36	79.60	9.64	4.00
	High	24	77.25	8.78	81.12	9.25	3.87

RQ6: Does ability levels influence the achievement of students taught with the CSIS and the CTM?

Table 8 shows that CSIS improves the achievement of low ability students (Mean gain=5.45) and medium ability students (Mean gain=1.93) where as high ability students experienced a drop (Mean gain=-0.19) on their achievement. Notwithstanding, all low and medium ability groups students taught genetics using CSIS outwit the performance of students who we taught the same concepts using the CTM who had mean gains of 2.47 and -0.6) respectively. The high ability group students (Mean gain=1.0) from the control had higher mean gains when compared with the mean gain (-0.19) of the high ability students in experimental group. Table 2 above reveals that there is no significant main effect of ability levels on the achievement of students in genetics ($F_{(1,196}$ =2.622; P=.075> .05). However, treatment and ability levels ($F_{(2, 208)}$ =5.488; P=.005< .05); gender and ability level ($F_{(2, 208)}$ =5.402; P=.005< .05) and treatment, gender and ability levels ($F_{(2, 208)}$ =3.518; P=.032< .05) does interact to produce significant results respectively.

Table 8. Mean, standard deviation and mean gains for the treatment groups on their achievement in genetics based on ability levels

Treatment Group	Ability Level	N	Pre-Test Mean	SD	Post-Test Mean	SD	Mean Grain
Experimental	Low	37	6.57	1.52	12.00	3.06	5.43
	Medium	36	10.50	0.50	12.42	3.78	1.93
	High	22	12.55	0.67	12.36	2.15	-0.19
Control	Low	60	7.00	1.87	9.47	2.96	2.47
	Medium	30	10.40	0.49	9.80	1.18	-0.06
	High	24	11.25	0.98	12.25	1.22	1.00

7. Discussion

The study is based on the instructional use of computer simulation for learning genetics. The result of the study shows that the computer simulation instructional strategy significantly improves the attitude of students towards biology ($F_{(1,208)}$ =38.657; P=.000< .05). This compares favorably with the findings of Chen and Howard, (2010) who opined that live simulation improves the attitude of students towards science and science learning. Hence computer simulation instructional approach proves to be an effective instrument for bolstering the attitude of students towards biology. Students developed positive attitude towards biology because computer simulation instructional strategy provide a drive for students to be actively involved in their own learning. It creates a feeling of enjoyment and interest among students which in turn bolster their performance in a particular subject (Dinah, 2013).

Furthermore, students who exposed to computer simulation instructional strategy significantly outperformed their counterparts who were taught using the conventional method on the achievement test ($F_{(1,208)}$ =19.384; P=.000< .05). This is because interactive computer simulations foster the visualization and active cognitive processing of abstract information due to its features that combine word, text, pictures and videos in a single frame (Goff, Reindl, Johnson, Mc Clean, Offerdahl, Schroeder & White, 2016). This help students build a coherent mental model of abstract concepts due to the integration of information gathered in a simulation learning environment with prior knowledge (Ndioho and Mumuni, 2016; Ali and Zamzuri, 2007). In addition, computer simulation is effective in scaffolding biology instruction because its systematical guides the students through the learning process (Elangovan and Ismail, 2014). This is consistent with the findings from previous studies where computer simulation has proven to be an effective pedagogical tool for improving the achievements and retention of students in abstract concepts such as genetics e.g. (Goff et al., 2016; Yang,Jen, Chang, & Yeh, 2018; Asogwa et al., 2016; Chinenye et al., 2019). For instance, Yang et al., (2018) conducted a study that compared the instructional use of animated simulation to static pictures on the performance and cognitive load of students in genetics. The researchers discovered that students who were taught using animated simulation out performed those who were taught genetics with static pictures. Similarly, Asogwa et al., (2016) investigated the effect of interactive computer simulation on the achievement and retention of students in genetics. This quasi experimental design study documented findings which revealed that interactive computer simulation significantly improves the achievement and retention of students in genetic concepts.

Likewise, the quasi experimental design study conducted by Chinenye et al., (2019) revealed that the instructional use of computer simulation significantly improves the performance and retention of students when compared to those who were taught the same biology concept using teacher demonstration method. Notwithstanding, the finding from the study did not agree with the findings of Starbak, Erjavec & Peklaj, (2010) who reported that animated simulation does not significantly improve the performance of students.

Although findings from the study reveal that male students (Mean gain=13.74) have more positive attitude towards biology that their female counterparts (Mean gain=9.54). However, the study show that computer simulation instructional strategy bridges the gap in the attitude of male and female students towards biology. This is because there was no significant difference in the attitude of male and female students who were exposed to the treatment ($F_{(1,208)}$ =2.129; P=.146>.05). This is substantiated with the finding of Hussaini, Fong and Kamar, (2015) who also affirmed that male and female students do not differ in the attitude towards science. This view negates the claim of Chen and Howard, (2010) who posited that gender influence the attitude of students towards science after exposure to live simulation instructional approaches. The study also revealed that there is no significant effect of gender on the achievement of students who were exposed to the treatment ($F_{(1,208)}$ =.927; P=.337>.05). This finding supports the view of Asogwa et al., (2016) who posited that gender do not influence the achievement of students in genetics when exposed to computer simulation instructional strategy. Conversely, Amedu, (2015) reported that gender significantly impact on the achievement of students who are taught using simulations. It was also reported that the female students out performed their male counterparts on the achievement test.

A major finding from the study shows that there is a significant main effect of ability levels on the attitude of students towards biology ($F_{(2, 208)}$ =5.727; P=.004< .05). This implies that ability levels contribute to the attitude of students towards biology. High ability level students (Mean gain=15.91) have a more positive attitude towards biology than the medium ability level (Mean gain 13.67) and low ability level students (Mean gain=8.54) respectively. This is supported by the view of Ellah, (2016) who opined that students with high mental ability have a more positive attitude towards science than those with low and moderate mental ability respectively. Consequently, a post-hoc comparison using Bonferroni corrections revealed that the significant main effect of ability levels on the attitude of students towards biology was due to the interaction between the High ability and low ability group only at $p < .05$. There was no significant gain in attitude between high and medium, low and medium ability groups respectively. This suggests that computer simulation instructional packages bridge the gap in the differential attitude of students from low ability and high ability levels. In another dimension, the study reveals that computer simulation instructional package significantly improve the achievement of students from the respective ability groups ($F_{(2, 208)} = 5.488$; $P = .005 < .05$). Low ability group learners recorded higher mean gains on the achievement test (5.43) when compared to the mean gains of medium ability (1.93) and high ability (-0.19) groups respectively. A post-hoc comparison with Bonferroni corrections indicated that the low ability group recorded significant ($p < .05$) higher learning gains than the high and medium ability groups respectively. However, there was no significant difference in the learning gains observed between the high and medium, low and medium ability groups respectively. This corroborates with the findings of Chen, Wang, Dede & Grotzer, (2017) who reported that technology enhanced learning environment such as interactive simulation bridges the gap in the performance of students from the low ability groups. Similarly, Bellard et al., (2011) posited that cognitive tools and external representations significantly improve the learning gains of low ability students, thereby bridging the gap in the achievement of low, medium and high ability level students.

8. Conclusion and Recommendations

Computer simulations can be utilized as a pedagogical tool for maximizing the cognition of difficult and abstract concepts in biology. This ensures that learning take a paradigm shift from abstract to a more concrete reality. Findings from the study provides substantial evidence that the instructional use of computer simulations serves as a scaffold for learning genetic concepts irrespective of students' gender and ability levels. Computer simulation instructional media also have potentials for bolstering the attitude of students towards biology. Hence, computer simulation is hereby recommended for teachers in delivery of biology lessons to the students. Biology teachers can also deploy the use of computer simulations as a scaffold for the formative and summative evaluation of their students. Furthermore, preservice biology teachers should be trained on how to implement biology lessons that embeds interactive computer simulation as an instructional strategy. In addition, curriculum developers and educational technology specialists should intensify efforts aimed at developing interactive computer simulations for learning abstract concepts in biology. It is also recommended that computer simulations should incorporate design features that construct teaching and learning activities around it so that students are fully immersed in the simulation learning environment. Finally, Governmental education departments and ministry should ensure that schools are provided with the relevant technological facilities and support structures to facilitate the effective utilization of interactive computer simulations as a pedagogical tool.

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