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Effect of Computer-Based Concept-Mapping on Interest in Genetics among Low-Achieving Students' in Colleges of Education, North-West, Nigeria

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Abstract

Genetics is an important component of biology education; however, low-achieving students often exhibit low interest in learning genetic concepts. This study investigated the effect of computer-based concept-mapping on interest in genetics among low-achieving students in Colleges of Education in North-West Nigeria. The study adopted a pretest-posttest quasi-experimental control group design. The population comprised 2,402 students from two Federal Colleges of Education in North-West Nigeria, while a sample of 133 students participated in the study. Purposive sampling was used to select the colleges, while a simple random balloting procedure was used to assign the selected colleges to experimental and control conditions. The experimental group consisted of 74 students (31 males and 43 females), while the control group comprised 59 students (28 males and 31 females). Students in the experimental group were taught genetics using computer-based concept-mapping developed with the SimpleMind application, while those in the control group were taught using the conventional teaching method. The instrument used for data collection was the Genetic Interest Questionnaire (GITQ), which had a reliability coefficient of 0.79. Two research questions and two null hypotheses guided the study. Mean and standard deviation were used to answer the research questions, while analysis of covariance (ANCOVA) was used to test the hypotheses. The findings revealed a statistically significant difference in interest scores between the experimental and control groups, with the experimental group recording higher scores. However, no statistically significant difference was found between male and female students in the experimental group. The findings suggest that computer-based concept-mapping using SimpleMind may be a useful instructional approach for supporting interest in genetics among low-achieving students. It was therefore recommended that Colleges of Education lecturers consider integrating computer-based concept-mapping into genetics instruction.

Keywords: computer-based concept mapping, SimpleMind app, genetics, low achievement

1 Introduction

Biology is a branch of science that serves as a prerequisite for many science courses and a requirement for admission to Nigerian Universities; it is a crucial foundation for many interdisciplinary STEM fields, enabling the integration of knowledge and methods from science, technology, engineering, and mathematics (Bartlett *et al.,* 2023). This foundational role is especially evident in emerging areas like bioinformatics, systems biology, and synthetic biology. Barde *et al.* (2020) opined that biology is designed to be the necessary pillar required by all students to acquire the desirable manipulative skills and logical abilities needed for bridging the gap in human knowledge. The teaching of biology is also essential for students to develop a scientific attitude, enhance problem-solving skills, and stimulate critical thinking. Biology enables students to understand the interactions between living organisms and their environment, which is crucial for addressing global challenges such as climate change and biodiversity loss. Biology encompasses diverse fields including botany, conservation, ecology, evolution, marine biology, medicine, microbiology, molecular biology, physiology, zoology, biochemistry, ecology, embryology, taxonomy, palaeontology, histology, physiology and genetics etc. Genetics is one of the fundamental fields of biology which frequently intersects with many other life sciences. It has been widely recognized as the conceptual framework for the understanding of biology itself.

Genetics is the branch of biology concerned with the study of genes, genetic variation and heredity in organisms. It is a core topic in the biology curriculum and in the Minimum Standards for Colleges of Education (National Commission for Colleges of Education [NCCE], 2012), which cover variation, mitosis and meiosis, monohybrid crosses, sex determination, co-dominance and mutation, among other areas. Many of these concepts have been identified as difficult and abstract for students. The knowledge of Genetics is vital, and significant advances in recent decades have dramatically increased the impact of genetic information and technologies on society. The rapid advances in genetic research, which include DNA

testing, discovery of new therapies for genetically related diseases, cloning, gene editing, stem cell research, and genetic disorder testing, the popularity of the topic and the direct role that genetics plays in human health and reproduction make it a scientific discipline that everyone needs to understand because it is crucial to the scientific and technological development of any society (Choden and Kijkuakul, 2020).

However, despite the crucial role genetics plays in society, various reports among learners and teachers, such as Ogunniyi *et al.* (2020), Adelana and Akinyemi (2021) and Odufuwa *et al.* (2022), state that understanding and teaching the concepts of genetics and their mode of operation appear to be difficult to teach and learn. According to Aivelo and Uitto (2021), the sheer volume of specialized terminology in genetics can be confusing. The subject requires a high level of reasoning and ability to integrate concepts from multi-scientific disciplines, such as biochemistry and mathematics. This cognitive demand can be overwhelming for low-achieving students, thereby leading to low interest in the subject. A low-achieving student, according to Ogunniyi *et al.* (2020), is a candidate who consistently scores below the set standard in a test or an examination. In this regard, Dahliani and Rahmatan (2020) posit that when the learning strategies are not suitable and are not enjoyable, it makes the students feel bored, lose strong desire and enthusiasm to achieve the goals of good learning outcomes and cannot concentrate on participating in learning, which can cause decreased interest in learning. Kurniawan and Pravitasari (2023) stated that students' interest in science subjects cannot be separated from their academic achievement, since poor or good academic achievement depends greatly on interest in science subjects and that students' high level of interest and learning performance is inseparable from how teachers teach, which can excite students to learn, affecting their learning results. Studies by Rahim *et al*. (2020) reported that the adoption of conventional teaching methods, which are believed to enable the coverage of more content in less time, has an impact on students' interest in learning genetics.

Ala *et al*. (2022) reported that one of the most common methods of teaching genetics in Colleges of Education is the conventional method. The persistent use of conventional methods tends to render students passive rather than active learners, leading to a lack of interest in learning the concept. This declining interest presents a serious educational concern because sustained interest is closely linked to better learning outcomes and academic achievement. Interest, according to Sapaden *et al.* (2025), is a mental attitude and state of focus on a specific subject or activity, which plays a critical role in shaping how individuals engage with and perform in different fields of study. Nnorom and Ekene (2025) reported that as biology students continue to perform poorly in genetics, the students tend to lose interest in the subject and give it a difficult status.

The rapid technological advancements and significant global changes have made it evident that traditional educational paradigms are inadequate for today's needs. Hence, fostering interest among low-achieving students is widely recognized as a key strategy for enhancing their academic performance. Computer-based concept-mapping could be a suitable teaching strategy that will alleviate the problem students encounter when learning genetics concepts. Computer-based concept-mapping is a computer-assisted instructions that incorporates the use of computer instruction with concept-mapping. It is an important tool that is used in the field of education to help students understand basic concepts and the relationships between them, and has the potential to enhance meaningful learning in education (Nuru, 2023). According to Fernandes (2024), computer-based concept-mapping can significantly enhance active learning, collaborative knowledge construction, and the development of metacognitive skills, enabling students to forge meaningful connections, recognize patterns, and build mental models of the concept by visually organizing complex ideas and illustrating the relationships between concepts. The alignment of technology with pedagogical strategies fosters deeper understanding and retention, creating a more inclusive learning environment that addresses varied learning needs, especially for low-achieving students

Although computer-based concept-mapping has been associated with better academic performance among secondary school biology students in Zaria (Nuru, 2023), and technology-based strategies have been associated with higher interest in biology (Dada *et al*., 2024; Mensah *et al*., 2025), it is not known whether computer-based concept-mapping raises interest in genetics among low-achieving NCE students, or whether any effect differs between male and female students. To the best of the authors' knowledge, this has not been investigated in Colleges of Education in North-West Nigeria. The present study addresses this gap by comparing the interest of low-achieving NCE III biology students taught genetics through computer-based concept-mapping using the SimpleMind app with that of peers taught by the conventional method, and by examining whether the effect differs by gender.

1.1 Research Questions

The study answers the following research questions:

1. What is the difference between the mean interest level of low-achieving NCE students taught genetics concepts using computer-based concept-mapping and those taught using conventional methods?
2. What is the difference between the interest level of low-achieving male and female NCE students taught genetics concepts using computer-based concept-mapping?

1.2 Null Hypotheses

1. There is no significant difference in interest between low-achieving NCE students taught genetics concepts using computer-based concept-mapping and those taught using conventional methods.
2. There is no significant difference between the mean scores of interest levels between low-achieving male and female NCE students taught genetics concepts using computer-based concept-mapping.

2 Theoretical Framework

This study is anchored on Dewey's interest theory (1913) and Mayer's Cognitive Theory of Multimedia Learning (CTML) (2009). Dewey's interest theory (1913) in education is based on learning by doing. The theory emphasize that the learning process should start from the student's interests and experiences. According to Dewey, when students find a subject relevant and interesting, their motivation and engagement increase, leading to deeper learning. Computer-based concept-mapping aligns with Dewey's theory of interest by allowing students to explore and organize knowledge in a personalized and interactive way and serves as a dynamic tool that can make the complex subject of genetics more accessible and engaging for these students. By creating concept maps, students can visually represent their understanding of complex concepts and relationships, which fosters engagement and interest. This approach enables students to take ownership of their learning, making it more meaningful and relevant to their interests. Also, through constructing maps, students can actively construct knowledge, identify relationships, and develop critical thinking skills.

Mayer's Cognitive Theory of Multimedia Learning (CTML) (2009) posits that effective learning occurs when learners engage with both verbal and visual information in a way that promotes meaningful understanding. It provides a framework for designing effective multimedia educational materials that enhance learning by considering cognitive processes and how information is best presented. Mayer's Cognitive Theory of Multimedia Learning (CTML) aligns well with computer-based concept-mapping because both focus on optimizing the way learners process, organize, and integrate knowledge. Concept maps inherently combine text and visuals, aligning with the principle that learning is more effective when relevant words and images are integrated. Many computer-based tools allow for audio explanations alongside the concept map. Instead of reading large amounts of text, learners can listen to explanations while examining visual links. Computer-based concept maps avoid redundancy by integrating concise text with visuals. Tools can restrict users from adding overly detailed explanations that duplicate what's already clear from the map.

SimpleMind is framed as a multimedia learning environment because it represents knowledge through an interactive concept-map format, where students work with concept nodes (visual structure) and concise textual labels (verbal representation). This design aligns with CTML's dual-channel perspective by coordinating words and diagrams so that learners can interpret relationships visually while using labels to construct conceptual meaning. It supports CTML's relevant principles of cognitive efficiency by encouraging learners to focus on essential ideas and connections rather than extended narrative text. Because concept-map production centres on adding and linking key concepts, learners are less likely to rely on long explanatory passages that can introduce extraneous cognitive load. The map structure also facilitates organization: the explicit links between nodes provide a framework for how ideas relate, supporting deeper integration of knowledge rather than isolated recall.

Two propositions guide the study. From Dewey's interest theory: (P1) if learning is active, experience-based and built from the learner's own constructions, students' interest in the subject should rise. Constructing their own maps in the SimpleMind app is an active, learner-driven task, whereas the conventional lecture method is teacher-led. From CTML (Mayer, 2021): (P2) if verbal and visual material are integrated in a way that limits extraneous cognitive processing, learners should engage more with the content and report higher interest. SimpleMind maps place short verbal labels beside the concepts they describe (spatial contiguity), keep nodes concise (coherence) and do not duplicate the same content in text and narration (redundancy). Both propositions lead to Hypothesis One: the experimental group should have higher posttest interest than the control group after controlling for pretest interest. Neither theory predicts a gender-specific response to the treatment, so Hypothesis Two is exploratory and tests whether the effect is similar for male and female students.

3 Methodology

3.1 Research Design

The study adopted a non-equivalent control group, pretest-posttest quasi-experimental design using intact groups. A purposive sampling technique was used to select two (2) co-educational federal colleges of education from the five in North-West Nigeria. They were selected because both are co-educational, both offer BIO 323 to NCE III students, and both have comparable facilities and access to computers. The colleges were assigned by balloting to the experimental group (College A) and the control group (College B), and their names are withheld for anonymity. A pretest was administered to both groups before treatment. The Experimental Group (EG) was taught genetics using computer-based concept-mapping, while the Control Group (CG) was taught the same concepts by the conventional method for six weeks, after which a posttest was administered. Of the five colleges, FCE (T) Gusau enrols only female students and could not be selected because both study groups include male students. All the students offer biology with other science subjects, and genetics is one of the courses offered by biology students at the NCE level.

Because intact groups were used (the low-achieving NCE III biology students of each of the two colleges), students were not randomly assigned to conditions, and balloting the two colleges does not make the groups equivalent. Selection was therefore the main threat, so the groups were compared on pretest interest (Table 3). The difference was small (1.66 points) and not statistically significant, $t(131) = 1.41$, $p = .16$, and posttest scores were analyzed by ANCOVA with the pretest as a covariate. ANCOVA cannot, however, remove differences between colleges that are unrelated to pretest interest, such as location, facilities and staff, so selection remains a limitation. History was limited because both groups were taught over the same six weeks, although events specific to one college cannot be excluded. Maturation was unlikely to differ between groups because both were at the same level (NCE III) and followed the same schedule. Testing and instrumentation effects should be similar in both groups because the same questionnaire was administered under the same conditions on both occasions. Regression to the mean is unlikely to affect the interest scores because students were selected on achievement, not on interest. Experimenter effects are discussed in Section 3.5 and in the Limitations (Section 5.1).

The students were categorized on their continuous assessment and examination performance in Biol 111 (Basic Principles of Biology and Cell Biology), which is related to genetics, and on their continuous assessment in Biol 323 (Genetics), which builds on Biol 111. Continuous assessment grades were used to judge the achievement level of the subjects in line with Lakpini (2012), who stated that continuous assessment grades give a better assessment of students' academic ability than a single examination. This is because continuous assessment helps educators to measure students' understanding, track their progress, and identify areas where intervention may be necessary. Low achievement was defined using the categorization of Ajewole and Okebukola (1988) in which the top 75% were classified as high-achieving students, the middle 55% as average-achieving students, and the bottom 25% as low-achieving students. The full screening procedure is given in Section 3.3, and the population is summarized in Table 1

3.2 Population of the Study

The population of the study consist of all the NCE III Biology students offering the genetics course BIO 323 of the five Federal Colleges of Education in the North-West, Nigeria, which include FCE Bichi, FCE Gusau, FCE Katsina, FCE Kano and FCE Zaria. The total student population was 2402, which comprised 1149 male and 1253 female students.

Table **1**

Population of the Study

S/N	Colleges	No. of male students	No. female students	Total
1	FCE Bichi	220	200	420
2	FCE Gusau (T)	0	300	300
3	FCE Kano	229	300	585
4	FCE Katsina	240	122	362
5	FCE Zaria	405	591	996
	Total	1149	1253	2402

Source: Academic Secretary Office of Each College of Education (2023)

3.3 Sample of the Study and Sampling Technique

Two colleges of education were purposively selected out of the five federal colleges of education in the North-West Zone, Nigeria. The two colleges were assigned to the experimental and control conditions by balloting (the first college picked was tagged experimental, and the second was tagged control). Assignment was therefore random at the level of the college, not the student. The experimental group consisted of 31 males and 43 females, while the control group consisted of 28 males and 31 females. This amounts to a total of one hundred and thirty-three students (133) from the two colleges of education, representing the study sample. The sample size was judged adequate on two grounds. First, Gay, Mills and Airasian (2012) suggest at least 15 participants per group in experimental studies, and both groups here exceed this. Second, a sensitivity analysis for a two-group comparison with n = 74 and n = 59 ($\alpha = .05$, two-tailed, power = .80) shows that the design could detect a standardised difference of about d = 0.49 or larger (Cohen, 1988), and the pretest covariate reduces error variance further. These calculations treat the 133 students as independent observations; because only two intact colleges were used, the effective sample size for the treatment comparison is smaller (see Section 5.1).

The population comprised all NCE III biology students in the two selected colleges. Their Biol 111 examination scores and Biol 323 continuous assessment scores were obtained from college records. In total, [296] students were screened in College A and [236] in College B. A composite achievement score was computed for each student by converting both sets of scores to percentages and averaging them with equal weight. Within each college, students were ranked from highest to lowest composite score and categorised following Ajewole and Okebukola (1988). The top 25% were classified as high-achieving, the middle 50% as average-achieving, and the bottom 25% as low-achieving.

All students in the bottom 25% of each college (College A, n = 74; College B, n = 59) were purposively selected as the experimental and control groups, respectively. The bottom 25% rule was preferred to a fixed pass mark because it identifies students who are low relative to their own cohort. It also applies the same relative standard across colleges whose grading practices may differ.

Table **2**

Sample of the Study

School Name	Group	Male	Female	Total
School A	Experimental	31	43	74
School B	Control	28	31	59
Total		59	74	133

3.4 Instrumentation

Data were collected with the Genetic Interest Questionnaire (GITQ), a 30-item self-report instrument adapted from Farouk (2019). The questionnaire was constructed based on Likert's five-point scale. Four possible responses were given by the students, which include Strongly Agree (SA), Agree (A), Undecided (U), Disagree (D) and Strongly Disagree (SD). The questionnaire was modified to focus on five key aspects of interest, divided into five sections: A, B, C, D, and E, while the original instrument focused on two key aspects of interest. Items were scored SA = 5 to SD = 1 so total scores range from 30 to 150, with higher scores indicating greater interest in genetics. The adapted instrument was validated by two experts, each in the Departments of Educational Psychology, Guidance and Counselling, and Science Education, Ahmadu Bello University, Zaria, with qualifications of PhD and senior lecturer in addition to the validation of the instrument by the supervisory team to judge face and content validity, that is, the relevance and clarity of items and their coverage of the NCE genetics curriculum, and their suggestions were incorporated. The instruments were pilot-tested at Sa'adatu Rimi College of Education, Kano, which is part of the population but not part of the sample that was used for the study. The Cronbach's alpha was 0.79.

3.5 Data Collection Procedure

The researchers administered a pre-test to the experimental and control groups. Then, the computer-based concept-mapping software Simplemind app was introduced and explained to the students a week before the treatment. A demonstration of

the basic features and functions of the concept-mapping software was provided to ensure students understood how to navigate and utilize the software effectively. Following the computer-based concept map training, the researcher commenced the treatment by teaching the concepts for six weeks. The control group was taught the same concepts in genetics by the researcher using the conventional method of teaching. The material used for the teaching was the NCCE curriculum. A lesson plan was developed and validated by lecturers in the sampled colleges before the commencement of the treatment. The topics covered during the six-week treatment period were basic concepts in genetics; the interplay between heredity and the environment; Mendel's experiments on pea plants, including monohybrid and dihybrid inheritance; sex determination and sex linkage; and gene mutation. Each lesson lasted 120 minutes. At the end of the lessons, students in the experimental group worked collaboratively to develop their own concept maps and subsequently worked individually at their own pace.

The researcher taught both the experimental and control groups to ensure consistency in content coverage and reduce variations that might arise from the use of different teachers. However, this arrangement introduced the possibility of researcher expectancy effects, whereby the researcher's expectations might have unintentionally influenced instructional delivery or students' responses. Furthermore, students in the experimental group might have experienced a novelty effect arising from exposure to computer-based concept-mapping, potentially influencing their interest, engagement, or performance. Permission to conduct the study was obtained from the relevant college authorities. All participants provided informed consent, participated voluntarily, and were assured that their responses would be treated confidentially and used solely for research purposes.

Descriptive statistics (means, standard deviations and mean gain scores) were used to answer the research questions. The null hypotheses were tested with analysis of covariance (ANCOVA) at the .05 level of significance. For Hypothesis One, the posttest interest scores of the experimental and control groups were compared, and for Hypothesis Two, the posttest interest scores of male and female students in the experimental group were compared; in both analyses pretest interest scores were the covariate. Before running each ANCOVA, its assumptions were checked and found to be satisfied. (a) *Homogeneity of regression slopes:* the group × pretest interaction was not significant for Hypothesis One, $F(1, 129) = 0.84$, $p = .361$, and for Hypothesis Two, $F(1, 70) = 0.52$, $p = .474$, indicating that the relationship between pretest and posttest scores was similar across groups. (b) *Homogeneity of error variances:* Levene's test was not significant for Hypothesis One, $F(1, 131) = 2.35$, $p = .128$, and for Hypothesis Two, $F(1, 72) = 0.09$, $p = .766$. (c) *Normality:* the Shapiro-Wilk test on the standardized residuals was not significant for Hypothesis One, $W = .99$, $p = .412$, or for Hypothesis Two, $W = .98$, $p = .287$; skewness and kurtosis values were within ±1. (d) *Linearity:* scatterplots of pretest against posttest scores showed a linear relationship within each group. Because all assumptions were met, ANCOVA was considered appropriate. Effect sizes are reported as partial eta squared (η^2), with .01, .06 and .14 taken as small, medium and large (Cohen, 1988). Analyses were run in IBM SPSS Statistics, version 25.

4 Result

4.1 Addressing Research Question One

What is the difference between the mean interest level of low-achieving NCE students taught genetics concepts using computer-based concept-mapping and those taught using conventional methods?

Table **3**

Mean and Standard Deviation of Pretest and Posttest Interest Scores for Experimental and Control Groups in Teaching Genetics Concepts

Group	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Mean Gain
Experimental	74	76.24	7.48	89.14	8.73	12.89
Control	59	74.58	5.66	77.22	5.68	2.64
Mean Difference		**1.67**		**11.91**		**10.25**

Table 3 shows that the experimental group had a pretest mean interest score of 76.24 (SD = 7.48), while the control group had a mean of 74.58 (SD = 5.66). At posttest, the experimental group recorded a mean of 89.14 (SD = 8.73), compared with 77.22 (SD = 5.68) for the control group. The experimental group therefore recorded a greater mean gain in interest (12.89) than the control group (2.64). The results indicate that students taught using computer-based concept-mapping demonstrated a greater increase in interest in genetics than those taught using the conventional method. To determine whether this observed difference was statistically significant after controlling for pretest interest scores, null hypothesis two was tested using ANCOVA.

4.2 Testing Null Hypothesis One

There is no significant difference in interest between low-achieving NCE students taught genetics concepts using computer-based concept-mapping and those taught using conventional methods.

Table **4**

ANCOVA Summary of Posttest Interest Scores of Experimental and Control Groups

Source	**SS**	**df**	**MS**	**F**	**p**
Pretest (Covariate)	1728.207	1	1728.207	39.342	.000
Group	3923.392	1	3923.392	89.315	.000
Error	5710.577	130	43.928		
Total	947190.000	133			
Corrected Total	12098.992	132			

a. R Squared = .528 (Adjusted R Squared = .521) Significant at p ≤ 0.05

Table 4 shows that, after controlling for pretest interest scores, there was a statistically significant difference in posttest interest between the experimental and control groups, $F(1, 130) = 89.315$, $p < .001$. Since the p-value is less than 0.05, the null hypothesis was rejected. This indicates that students taught genetics using computer-based concept-mapping had significantly higher interest than those taught using the conventional method, consistent with the higher posttest mean observed for the experimental group in Table 2

4.3 Addressing Research Question Two

What is the difference between the interest level of low-achieving male and female NCE students taught genetics concepts using computer-based concept-mapping?

Table **5**

Mean and Standard Deviation of Pretest and Posttest Interest Scores for Male and Female Students in the Experimental Group

Gender	**N**	**Pretest Mean**	**Pretest SD**	**Posttest Mean**	**Posttest SD**	**Mean Gain**
Male	31	80.32	8.56	90.32	8.53	10.00
Female	43	73.30	4.88	88.28	8.88	14.98
Mean Difference		**7.02**		**2.04**		**-4.98**

Table 5 shows that male students had a pretest mean interest score of 80.32 (SD = 8.56), while female students had a mean of 73.30 (SD = 4.88). At posttest, male students recorded a mean of 90.32 (SD = 8.53), while female students recorded a mean of 88.28 (SD = 8.88), resulting in a posttest mean difference of 2.04 in favour of the male students. The male students

recorded a mean gain of 10.00, while female students recorded a greater mean gain of 14.98. Thus, although male students had a slightly higher posttest interest mean, female students showed greater improvement from pretest to posttest.

To determine whether the observed difference in posttest interest between male and female students was statistically significant after controlling for pretest interest, null hypothesis two was tested using ANCOVA.

4.4 Testing Null Hypothesis Two

There is no significant difference between the mean scores of interest levels between low-achieving male and female NCE students taught genetics concepts using computer-based concept-mapping.

Table **6**

ANCOVA Summary of Posttest Interest Scores of Male and Female Students in the Experimental Group

Source	**SS**	**df**	**MS**	**F**	**p**
Pretest (Covariate)	1123.125	1	1123.125	18.255	.000
Gender	63.184	1	63.184	1.027	.314
Error	4368.300	71	61.525		
Total	593502.000	74			
Corrected Total	5566.649	73			

Significant at p ≤ 0.05

Table 6 shows that, after controlling for pretest interest scores, there was no statistically significant difference in posttest interest between male and female students, $F(1, 71) = 1.027$, $p = .314$. Since the p-value is greater than 0.05, the null hypothesis was retained. This indicates that male and female students taught genetics using computer-based concept-mapping did not differ significantly in their level of interest.

5 Discussion

The study revealed that students in the experimental group had a higher interest level than their counterparts in the control group. The difference is significant as shown by the Mean Rank of interest in Tables 3 and 4. There was a significant difference in the interest of low-achieving NCE students taught genetics concepts using computer-based concept-mapping compared to those taught using conventional methods. Students who were taught using the computer-based concept-mapping strategy exhibited significantly higher levels of interest in the subject matter than those taught using conventional methods. Mayer's (2009) cognitive theory of multimedia learning supports these results by positing that well-designed multimedia tools help learners integrate verbal and visual information more effectively. In genetics, where learners must grasp abstract and dynamic processes, computer-assisted instruction offers experiential learning opportunities that static diagrams or text cannot provide. This finding aligns with the studies of Onu *et al.* (2020) and Ochube (2021), who found that students taught the concept of tropical climates using computer animation achieved significantly higher interest levels than those in the control group, who were taught using conventional methods. Similarly, Dada *et al.* (2024) reported that students taught using technology-based strategies, including concept-mapping, demonstrated higher levels of interest in the subject matter compared to those taught using conventional methods. Their study highlighted that the interactive nature of technology fostered greater enthusiasm for learning, which is consistent with the findings of this study.

Furthermore, the finding is consistent with the Nigerian National Policy on Education (Federal Republic of Nigeria [FRN], 2013), which advocates the integration of technology into teaching and learning. The policy emphasises the need for innovative teaching strategies that actively engage students and improve their academic performance, particularly in challenging subjects such as science. The use of computer-based concept-mapping in the teaching of genetics supports this policy, as it creates a more engaging and dynamic learning environment that has been reported to increase student interest. Appiah and Essiam (2022) reported that the perception of students towards subjects previously thought to be difficult

changed when taught using computer-assisted strategies. They stated that 95 % of the students believed that CAI aroused their interest in learning and enabled them to understand the difficult concepts. And about 87.5 % of students opined that CAI made learning more practical and enabled them to retain more information. Mensah *et al.* (2025) affirmed that students expressed that learning genetics through computer-assisted instructional strategies reignited their interest in the subject. Previously, many found genetics abstract, unrelatable, or overly difficult. However, the computer tools introduced colour, motion, interactivity, and learner autonomy, transforming the classroom from a passive to an engaging learning environment. Students reported looking forward to lessons, willingly exploring additional content, and participating actively behaviours associated with enhanced academic motivation and improved outcomes. This could be attributed to the fact that computer-based concept-mapping offers a more interactive and engaging learning experience compared to conventional teaching methods. Conventional teaching methods often rely heavily on lectures, textbooks, and rote memorization, which can lead to disengagement, particularly among students who are already low-achieving or disinterested in the subject. In contrast, computer-based concept-mapping allows students to visually organize and explore complex genetic concepts more dynamically, making the learning process more appealing and stimulating. This active engagement with the content can lead to increased interest, as students feel more in control of their learning, have the opportunity to interact with the material, and can more clearly see the relationships between various genetic concepts.

The findings of Tables 5 and 6 revealed that male students exhibited higher interest in the subject compared to the female students. The difference was not significant, as shown in the Mean Rank interest for males and females in Table 2. That there was no significant difference in interest levels between low-achieving male and female NCE students taught genetics concepts using computer-based concept-mapping suggests that both genders exhibited similar engagement and enthusiasm. This indicates that gender did not influence students' interest levels, as both groups found the computer-based concept-mapping approach equally engaging. This finding aligns with Hwang *et al*. (2020), who found that both genders showed increased engagement in science subjects through computer-based concept-mapping, though female students exhibited slightly higher enthusiasm in collaborative settings. Similarly, Wang (2022) reported no significant gender differences in interest levels when students used concept-mapping tools in a mixed-gender classroom. Vygotsky's Sociocultural Theory (1978) supports this finding, emphasizing that learning tools like computers can equalize educational experiences across genders. Also, this is consistent with the Nigerian National Policy on Education (2013), which advocates for gender-neutral teaching strategies to promote equal learning opportunities.

According to Adeboye (2022), the interactive and visual nature of computer-based concept-mapping likely contributed to this outcome, as it allows students to organise and connect complex genetic concepts, facilitating active learning. The inclusivity of this approach may also explain the absence of gender differences in interest. Because students construct and manipulate concepts according to their own understanding, both male and female students may have felt equally able to engage with the content. However, some studies report different results. Okafor and Agboghoroma (2023) and Ishaq (2024) found a significant gender difference in interest when students were taught using a metacognitive instructional strategy in Delta State. Several factors may account for the divergence. First, the instructional strategies differ: a metacognitive strategy emphasizes self-monitoring and regulation of learning, which depends on students' confidence and learning habits, whereas computer-based concept-mapping gives every student the same visual, hands-on task. Second, the contexts and samples differ: those studies involved secondary school students and a different level in Delta State, while the present study involved low-achieving NCE III students in colleges, a group that may share similar levels of prior knowledge and struggle with the same content. Third, the studies may have measured interest differently, and differences in scale content or reliability could affect whether gender gaps appear.

Kang *et al*. (2019) similarly noted that cultural and gendered expectations influence students' interest in STEM, with boys often showing greater enthusiasm. Their finding concerns broader social influences on STEM interest, rather than a response to a specific instructional intervention. It is therefore possible that such expectations shape interest in general, but that a structured, technology-supported activity like computer-based concept-mapping reduces their influence within the classroom. Given the similarity in strategy, level and population, the findings of Adeboye (2022) are more directly comparable to the present study, although the evidence base remains limited and further research is needed.

6 Conclusion

The study found a statistically significant difference in the interest levels of low-achieving NCE students taught genetics concepts using computer-based concept-mapping and those taught using the conventional teaching method, with higher interest scores recorded among students in the experimental group. This finding suggests that computer-based concept-

mapping may be a useful instructional approach for supporting interest in genetics among low-achieving NCE students. However, given the involvement of only two college clusters and the use of a self-report questionnaire to measure interest, the finding should be interpreted cautiously and should not be regarded as conclusive evidence that computer-based concept-mapping alone caused the observed difference.

The findings revealed no statistically significant difference in the interest levels of low-achieving male and female NCE students taught genetics concepts using computer-based concept-mapping. This finding suggests that computer-based concept-mapping may be a gender-inclusive instructional strategy for promoting interest in genetics among low-achieving students. The approach may provide both male and female students with opportunities to organise, connect, and manipulate genetic concepts in ways that support their understanding and engagement. However, the absence of a statistically significant difference does not establish that the strategy is equally effective for both genders, as the possibility of limited statistical power to detect an existing difference cannot be ruled out. Therefore, the finding supports the potential suitability of computer-based concept-mapping for both male and female students, rather than proving gender equivalence.

7 Recommendations

1. Colleges of Education administrators, in collaboration with the National Commission for Colleges of Education (NCCE), should consider piloting computer-based concept-mapping in the teaching of genetics and evaluating its feasibility and educational benefits before considering its wider adoption as a recommended instructional strategy.
2. Biology lecturers in Colleges of Education may consider using computer-based concept-mapping with both male and female low-achieving NCE students when teaching genetics. This recommendation is supported by the finding that no statistically significant gender difference was observed in students' interest levels in the experimental group. However, the finding should not be interpreted as proof of equivalence between male and female students.

8 Limitations

This study has four main limitations. The first and most important concern is the design. Treatment was assigned to whole colleges, with one college per condition, so the effect of the instructional strategy cannot be separated from college-level differences such as location, facilities, staffing and student intake. The student-level ANCOVA also treated the 133 students as independent observations, which does not account for clustering within colleges and may understate standard errors and overstate statistical significance. With only one cluster per condition, a multilevel model could not be estimated, and the effective sample size for the treatment contrast is limited by the two clusters, not the 133 students. The results are therefore best interpreted as the difference in interest between the two colleges after adjustment for pretest scores, and as preliminary evidence about the strategy, not as evidence of causation.

Second, the researcher taught both groups, so expectancy and novelty effects may have favoured the experimental group. Third, interest was measured by self-report at a single point, immediately after a six-week intervention, so it is not known whether the observed gains persist. Fourth, the sample comprised low-achieving NCE III students in two federal colleges, so the findings should be generalised only to similar institutions. Future studies should assign several colleges or classes at random to each condition, analyse the data with multilevel models, use independent instructors and include delayed posttests.

9 Declaration

Ethical Statement: Ethical approval for the study was obtained. Permission to conduct the study was also obtained from the relevant college authorities. Informed consent was obtained from all participants, whose participation was voluntary. Confidentiality of participants' responses was maintained throughout the study.

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10 Reference

Adelana, O. P., & Akinyemi, A. L. (2021). Artificial Intelligence-Based Tutoring Systems Utilization for Learning: A Survey of Senior Secondary Students' Awareness and Readiness in Ijebu-Ode, Ogun State. *UNIZIK Journal of Educational Research and Policy Studies*, 9, 16–28. https://unijerps.org/index.php/unijerps/article/view/193

Adeboye, M. O. (2022). Effects of Thinking Map and Experiential Strategy on Pupils' Basic Science Academic Performance in Ilorin South Local Government Area, Kwara State. Unpublished Master's Thesis, Department of Early Childhood and Primary Education, Faculty of Education, Kwara State University, Malete, Nigeria.

Aivelo, T. & Uitto, A. (2021). Factors Explaining Students' Attitudes towards Learning Genetics and Belief in Genetic Determinism. *International Journal of Science Education,* 43(9), 1408–1425. https://doi.org/10.1080/09500693.2021.1917789

Ala, N. A., Ishyaku, A. M., Adamu, S. B., & Onojah, A. O. (2022). Computer-Animation on NCE Students' Academic Performance in Vertebrate Anatomy and Physiology in Colleges of Education. *Indonesian Journal of Educational Research and Review*, *5* (3), 449–459.

Ajewole, G. A., & Okebukola, P. A. O. (1988). The Relative Effectiveness of the Discovery and Expository Instructional Methods on Retention of Biological Concepts. In *Nigeria Educational Forum*, *11*(1), 77–82.

Appiah, S. & Essiam, C. (2022). Effect of Computer-Assisted Instruction on Students' Performance in Selected Cell Division Topics: A Quasi-Experimental Study at Adisadel College, Ghana. Ghana. *Journal of Advocacy, Research and Education*, 9(2), 86-91.

Bartlett, B., Stitt-Bergh, M., Kantar, M., & Bingham, J. (2023). A Data Science Practicum to Introduce Undergraduate Students to Bioinformatics for Research. *Biochemistry and Molecular Biology Education*, 51, 520 - 528. https://doi.org/10.1002/bmb.21762.

Barde, L. Y., Ahmed, A. A., Kabaju, I., Waru, F. Z., Waru, H. Z. & Danjuma, A. M. (2020). Academic Achievement of Non-Specialist and Specialist Biology Students in Basic Science Education. *International Journal of Research and Innovation in Applied Science* (IJRIAS) Vol. V, Issue III.

Choden, T., & Kijkuakul, S. (2020). Blending Problem-Based Learning with Scientific Argumentation to Enhance Students' Understanding of Basic Genetics. *International Journal of Instruction*, 13(1), 445-462. https://doi.org/10.29333/iji.2020.13129a

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.

Dada, F. E., Paramole, O. C., Fakokunde, J., Adewale, P., Yusuf, F. A. & Abimbola, I. O. (2024). The Motivational Efficacy of Self-Regulated ICT Resources on Interest in Biology Among High, Medium, and Low Achieving Secondary School Students. *FUDMA Journal of Sciences (FJS),* Vol. 8, No. 6, pp. 91–95.

Dahliani, E. R., & Rahmatan, H. (2020). The Correlation Between Students' Interest and Learning Outcomes in Biology. In *Journal of Physics: Conference Series* Vol. 1460, (1), pp. 012072. IOP Publishing.

Dewey, J. (1913). Interest and Effort in Education. Boston, MA: Houghton Mifflin.

Farouk, A. M. (2019). Effect of Problem-Based Instructional Strategy on Motivation, Retention and Academic Performance in Genetics Among Nigeria Certificate in Education Students in Kano State Nigeria. Unpublished Ph.D. Dissertation, Department of Science Education, Ahmadu Bello University, Zaria, Nigeria.

Federal Republic of Nigeria (FRN) (2013). National Policy on Education, 6th edition: Lagos: NERDC Press.

Fernandes, R. S. (2024). Enhancing Student Learning Through Computer-Based Concept-mapping Across Academic Disciplines: A Comprehensive Review. *International Journal of Multidisciplinary Educational Research*, Vol. 13(4), pp. 46-58.

Gay, L. R., Mills, G. E., & Airasian, P. (2012). *Educational Research: Competencies for Analysis and Applications* (10th ed.). Pearson.

Hwang, G., Zou, D., & Lin, J. (2020). Effects of a multi-level concept-mapping-based question-posing approach on students' ubiquitous learning performance and perceptions. *Computers & Education*, 149. https://doi.org/10.1016/j.compedu.2020.103815

Ishaq, U. (2024). Effects of Cloud-Computing Instruction on Interest and Performance in Genetics Among Biology Students in Federal and State Colleges of Education, North-West Zone, Nigeria. Unpublished Ph.D. Thesis Department of Science Education, A.B.U, Zaria.

Kang, J., Hense, J., Scheersoi, A., & Keinonen, T. (2019). Gender Study on the Relationships Between Science Interest and Future Career Perspectives. *International Journal of Science Education*, 41(1), 80-101.

Kurniawan, E. H. & Pravitasari, D. O. (2023). Teaching Method and its Impact on English Academic performance through Learning Interest as a Moderator Variable Among the Students of MTSN 2 Kota Kediri. *Jurnal Pendidikan Bahasa Inggris*, Volume 12 (1) pp 1-11.

Lakpini, F. N. (2012). Effects of a Conceptual Change Instructional Strategy on Biology Performance of Low and Average Secondary School Students in Giwa Educational Zone. *Journal of Studies in Science and Mathematics Education*. 2(1), 47-56.

Mayer, R. E. (2009). Multimedia learning (2nd ed.). New York, NY: Cambridge University Press.

Mensah, R., Oduro-Okyireh, G., Boafo, I. K. & Gyamfi, M. (2025). From Abstraction TO Understanding: The Impact of Computer Simulations on Genetics Learning and Student Perceptions in Nzema East Municipality. *European Journal of Education Studies*, Volume 12 (11).

Nnorom, R. N. & Ekene, A. N. (2025). Test Anxiety and Self Concept as Predictors of Secondary School Students' Academic Achievement in Biology in Nnewi Education Zone of Anambra State, Nigeria. *International Journal of Social and Education* (INJOSEDU), Vol. 2 No. 1, pp. 146-162.

Nuru, A. R. (2023). Computer-Based Concept-mapping: A Cognitive Tool for Enhancing Academic Performance Among Secondary School Biology Students in Zaria, Nigeria. *Journal of the Nigerian Academy of Education*, Vol. 16 (2).

Ochube, J. O. (2021). Effects of Computer Animation on Interest, Retention and Performance in Tropical Climate Concept of Koppen's Classification among IJMB Students, North-West Nigeria. Unpublished, Department of Science Education, Faculty of Education, Ahmadu Bello University, Zaria.

Odufuwa, T. T., Adelana, O. P., & Adekunjo, M. A. (2022). Assessment of Senior Secondary Students' Perceptions and Career Interest in Science, Technology, Engineering and Mathematics (STEM) in Ijebu-Ode Local Government Area, Ogun State. *Journal of Science, Technology, Mathematics and Education*, 18(1), 147.

Ogunniyi, S. O., Akerele, J. A., & Asabi, A. O. (2020). Resource Utilization as Correlates of Students' Academic Achievement in Genetics in Adeyemi College of Education, Ondo, Ondo State, Nigeria. *Jewel Journal of Librarianship*, Vol. 15, Issue 2 45-56.

Okafor, S. N., & Agboghoroma, T. E. (2023). Effect of Metacognitive Instructional Strategy using PEEDA on Biology Student Achievement in Delta State. *International Journal of Social Science and Education Research Studies*, 3(1), 25-31.

Onu, W. O., Anyaegbunam, N. J., & Uzoigwe, A. U. (2020). Improving Biology Students' Interest and Achievement Through Collaborative Instructional Strategy. *Journal of Education, Society and Behavioural Science*, 33(2), 9-20.

Rahim, S. P. A., Samsudin, M. A., Ismail, M. E., Talib, C. A., & Amiruddin, M. H. (2020). Undergraduates' Interest Towards Learning Genetics Concepts Through Integrated STEM Problem-Based Learning Approach. *Journal of University of Shanghai for Science and Technology*, 22(11), 1125-1149.

Sapaden, K., Navoa, J., Peña, L., Sapigao, J., Armando, J., Agne, J., & Lagasca, S. (2025). Correlation of Anxiety and Interest of STEM Students in General Chemistry. Psychology and Education: *A Multidisciplinary Journal*. Vol. 34 (8), pp. 1003-1014.

Vygotsky, L. S. (1978). Mind in Society: The Development of Higher Psychological Processes. Cambridge: Harvard University Press.

Wang, Y. (2022). A Comparative Study on the Effectiveness of Traditional and Modern Teaching Methods. In 2022 5th International Conference on Humanities Education and Social Sciences (ICHESS 2022) (pp. 270-277). Atlantis Press.

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