Concept mapping and students' attitudes towards biology: Analysis of school location differences and attitude toward concept maps

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ABSTRACT

Many secondary school students, especially those in rural settings do not view favorably biology subject. The predominant use of the teacher-centered approach is mostly cited as the determinant. This study, therefore, investigated the effect of Concept Mapping (CM) mapping on students' attitudes based on school location and how students experienced the CM. The study used a quasi-experimental research with a pre-test and post-test control group design. The research sample consisted of 305 students from lower secondary schools. Data were collected using Biology Attitude and Attitude toward Concept Mapping Questionnaires and were analyzed using Analysis of Covariance, Multivariate Analysis of Variance, and Independent t-student test. The findings showed that the CM is more effective in fostering students' attitudes toward biology than the conventional methods of instruction. Students' attitudes towards biology when taught using the CM did not significantly differ between those in rural and urban areas. Students showed a positive attitude towards using CM as a learning tool regardless of school location. To enhance student attitudes toward biology, schools should integrate Concept Mapping (CM) into the curriculum and provide professional development for teachers to effectively implement this method. Resources and support should be allocated, especially to rural areas, to ensure equitable access to CM tools. Gathering and responding to student feedback will help refine the approach, while continuous assessment will track its effectiveness. Encouraging collaborative learning with CM can further engage students and improve their overall learning experience in biology and other science-related courses.

Keywords: *Attitude, Concept mapping, Conventional teaching, Photosynthesis, School location.*

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Highlights of this paper

- This study examines how Concept Mapping (CM) influences secondary school students' attitudes toward biology, with a focus on differences between rural and urban school locations.
- Using a quasi-experimental design, the research finds that CM significantly improves students' attitudes towards biology compared to traditional teaching methods, with no notable differences between rural and urban students.
- The study highlights that students across different locations respond positively to CM, suggesting its broad applicability as an effective instructional tool.

1. INTRODUCTION

In Rwanda, as in many developing countries, the quality of education and the effectiveness of teaching strategies are critical components in shaping student outcomes (Tsevreni, 2021). Among various educational innovations, concept mapping has emerged as a powerful pedagogical tool, particularly in science education. It is an instructional strategy that involves creating visual diagrams to represent and organize knowledge and it enhances students' understanding of complex concepts by helping them to visually and structurally connect ideas (Hsieh, Ho, Wu, & Ni, 2016). Rwanda's education system is undergoing significant reforms aiming at improving quality and accessibility, exploring how different variables impact educational outcomes. One such variable is the location of schools, which can vary widely between urban and rural settings. The geographical context of a school can influence various aspects of the educational experience, including resources available, teaching quality, and student attitudes (Okorie & Ezeh, 2016). Research into the effect of school location on students' attitudes, particularly in the context of concept mapping-based biology classrooms, is essential for understanding how to tailor educational strategies to diverse settings. In Rwanda, urban schools might benefit from better access to resources and modern teaching tools, potentially leading to different student attitudes and outcomes compared to their rural counterparts (Rubagiza, Umutoni, & Kaleeba, 2016). Conversely, rural schools might face challenges such as limited resources and infrastructure, which could impact the effectiveness of concept mapping and other innovative teaching methods.

This study aims to investigate the effect of concept mapping on students' attitudes towards biology and how the location of schools affects students' attitudes toward concept mapping in biology classrooms. By examining these dynamics in the Rwandan context, the research seeks to provide insights that could help educators and policymakers tailor educational strategies to enhance learning outcomes across different environments.

2. LITERATURE REVIEW

Biology has made tremendous developments in biotechnology, medical engineering, and microbiology worldwide (Joda, 2019). Besides, it is closely related to many science disciplines, including medicine, pharmacy, agriculture, industry, and many other subjects (Tsevreni, 2021; Umar, 2011). Again, the knowledge of biology is necessary to resolve many issues in our daily lives, especially those involving health and environmental sustainability (Acarli & Acarli, 2020; Tsevreni, 2021). Thus, learners must gain the knowledge it provides to effectively serve the community.

However, despite the significance of biology knowledge, the performance of students in the subject has remained unsatisfactory over time, particularly in the majority of underdeveloped nations, including Rwanda (Joda & Mohamed, 2017; Orora, Keraro, & Wachanga, 2014). The poor performance has led to the students' development of negative attitudes and eventually giving up learning biology (Etobro & Fabinu, 2017). This attitude is primarily the result of teachers' use of inadequate instructional practices, particularly when attempting to teach complex and abstract biology subjects (Etobro & Fabinu, 2017; Kyado, Abah, & Samba, 2019).

Attitude is defined as an individual's inclination to believe or prefer something depending on their perception and this can be positive or negative (Chrappán & Bencze, 2017; Oghenevwede, 2019). In the words of Sarmah and Puri

(2014) an individual's attitude refers to their conditioned tendency to respond positively or negatively to a situation, thing, concept, or other person. Likewise, attitude is defined as people's belief that reflects their thoughts which is sometimes reflected in their behavior (Jain, 2014). Research has demonstrated that students' academic performance is largely determined by their attitudes toward learning subjects (Bii & Chris, 2019). Therefore, having a positive attitude towards a subject is a prerequisite for success in it.

Numerous studies indicate that attitude as a psychological construct is viewed as an outcome that can be attained by learning (Blazar & Kraft, 2017; Fatoke & Olaoluwa, 2014; Kousa, Kavonius, & Aksela, 2018; Vlckova, Kubiatko, & Usak, 2019). Researchers like Blazar and Kraft (2017); Kubiatko, Balatova, Fancovicova, and Prokop (2017); Mbonyiryivuze, Yadav, and Amadalo (2021); Musengimana, Kampire, and Ntawiha (2021); Oyinloye and TemisanIge (2018) and Shishigu, Ali, Belay, and Edessa (2021) identified various factors for students' attitude toward learning science subject including instructional materials, teachers' classroom management, learning environment classroom work and feedback to the students, overloaded syllabuses, teachers' affective support, peer influence, gender, school location, and instructional strategy. Nonetheless, different researchers indicate that the most significant elements influencing students' attitudes toward science learning are the teaching strategies used by teachers (Adejimi, Nzabalirwa, & Shivoga, 2022; Barry, Stofer, Loizzo, & DiGennaro, 2023; Burks, 2022; Manishimwe, Shivoga, & Nsengimana, 2023). This implies that the attitude is not inherited and consequently can be changed through the teaching and learning process. The premise stated above suggests that a large part of students' attitudes about their subject of study is determined by the instructional strategy adopted by teachers. This results from the fact that a range of teaching methods are required due to the numerous topics that need to be covered, students' cognitive promptness, behavior, skills, and competencies that need to be developed (Njoku & Nwagbo, 2020; Omeiza, 2019). To this effect, they propose the use of learner-centered innovative methods of teaching. Additionally, they maintained that these strategies play a significant role in determining how students view academic subjects. Concept Mapping (CM) is one such instructional strategy.

The CM is an active teaching approach based on assimilation theory which places a focus on meaningful learning (Ausubel, 1963). According to Ausubel, meaningful learning enhances learners' cognitive structures by adding new ideas into the established conceptual structure. Accordingly, knowledge is created by students through a continual process of self-construction that involves the three fundamental ideas of accommodation, equilibration, and assimilation (Daley, Canas, & Stark-Schweitzer, 2007; Pulaski, 1980). Equally, assimilation takes place when newly acquired information aligns with the preexisting cognitive structure. Accommodation takes place when students' preexisting framework is insufficient to understand the novel experience while to reach equilibrium, individual people modify or expand their existing ideas to align with the just acquired understanding.

Early in the 1970s, Novak and his colleagues at Cornell University created the CM model of instruction method as a way to organize and represent information (Novak, 2011). According to Hsieh et al. (2016) the CM is designed and arranged graphically and hierarchically, demonstrating a strong conceptual connection with the keyword. This method of teaching that makes use of a concept map arranges concepts so that they show the progression from more inclusive to more particular ones (Cañas, Reiska, & Möllits, 2017). In the end, creating maps of concepts helps learners become more engaged by gradually displaying ideas in a hierarchical order, which helps them to stand out from one another (Novak, 2011). Consequently, when students work with graphical representations of the concepts in hierarchically organized structures that distinguish the concepts, the CM improves meaningful learning.

The large body of empirical research investigating the CM evidenced its effectiveness in critical thinking and conceptual understanding (Jack, 2013; Turan-Oluk & Ekmekci, 2018) and problem-solving skills (Olarewaju & Awofala, 2011). Moreover, the CM provides graphical tools that link previously studied concepts with recently acquired ones, assisting learners in visualizing their knowledge (Singh & Moono, 2015). These studies supported the superiority of CM over Conventional Teaching Methods (CTM) in fostering scientific knowledge and learning-related outcomes. Besides, researchers have assessed how well the CM works to improve secondary school students' attitudes towards various academic subjects when compared to the CTM. The students' attitudes in Physics were significantly affected by CM as discovered by Alebiosu and Micheal (2013). Similar findings were made by Otor and Achor (2013) who discovered that students taught chemistry with the CM scored much higher on attitude ratings than students taught with the CTM. The studies by Bii and Chris (2019); Luchembe, Chinyama, and Jumbe (2014) and Omeiza (2019) found that students' attitudes toward physics and mathematics were significantly different in the CM group than in the CTM group, respectively. While several studies have shown the benefits of utilizing the CM to raise students' academic achievement, only a small number of studies have looked at how the CM affects students' attitudes toward biology. Furthermore, the way CM's effects on the attitudes of learners in biology while teaching and learning the most challenging and abstract concepts like photosynthesis are not fully addressed in the literature, especially in the Rwandan context. As a result, this study examined how the use of the CM in teaching and learning biology enhances students' attitudes to contribute to the body of literature.

Concern has also been raised about the disparities in biology performance among schools based on student attitudes toward the subject. Okorie and Ezeh (2016) found that student's academic success is impacted by the location of their school. Parallel to this, Alordiah, Akpadaka, and Oviogbodu (2015); Ellah (2017) and Nnenna and Adukwu (2018) noted that the location of the school was one of the key factors affecting the academic performance in, and attitude of students towards biology. Besides recent studies that compared school location differences in interest and self-efficacy mostly reported that urban students had higher interest and self-confidence in science than rural ones (Kao & Shimizu, 2020; Pov, Kawai, & Matsumiya, 2021). The school locations are more commonly categorized based on the existence of various infrastructures, such as hospitals, water, power, and educational facilities (Okorie & Ezeh, 2016). Consequently, in order to locate a school both urban and rural environments would work as long as facilities are there. Thus, in comparison to schools in rural areas, schools in urban areas are supposed to have more sufficient and better infrastructures. In Rwanda, the literature revealed among other things, that a school in a rural location typically struggles with a lack of trained teachers, a lack of laboratories with inadequate equipment, internet connectivity issues, and energy (Rubagiza et al., 2016). These flaws may impair student motivation to learn as well as their attitudes toward learning class subjects especially sciences, which in turn may affect negatively their learning outcomes. School location can profoundly influence students' attitudes in concept mapping-based biology classrooms by shaping both the physical and socio-environmental context in which learning occurs. Schools situated in urban areas often benefit from proximity to additional resources, such as specialized science labs, extracurricular programs, and field trip opportunities, which can enhance the concept mapping experience (Okorie & Ezeh, 2016). In contrast, schools in rural or underserved areas might face limitations in these resources, potentially affecting the quality of concept mapping activities and, consequently, students' attitudes. The environment around the school whether it's dynamic and resource-rich or quiet and resource-constrained can impact students' engagement levels, motivation, and overall perception of the learning process (Rubagiza et al., 2016).

Moreover, the socio-economic and cultural context of a school's location can affect students' attitudes toward learning methods like concept mapping (Macmillan, 2012). For instance, students from schools in economically disadvantaged areas may experience greater challenges related to access to materials and technology, which can influence their attitude toward innovative educational methods. Conversely, schools in well-funded districts might have the infrastructure to support diverse and interactive learning strategies, fostering a more positive attitude among students (Pov et al., 2021). Understanding these dynamics can help educators and policymakers tailor interventions and resources to enhance the effectiveness of concept mapping-based biology instruction, ensuring that all students, regardless of their school's location, have the opportunity to engage meaningfully with the subject matter.

Furthermore, research from the literature demonstrates that urban students have greater expectations for their education than their rural counterparts (Li & Hou, 2022). Also, learners in rural schools appreciate education less (Macmillan, 2012). Therefore, it stands to reason that students in rural schools may perform worse academically in biology than their urban counterparts due to a combination of lower educational expectations and less emphasis on academics. This may imply that urban students' attitudes toward learning school subjects is more positive compared to those of rural ones. This is because positive attitudes among students enhance learning outcomes (Ahmad, Sultana, & Jamil, 2022; Kurniawan, Effendi, & Dwita, 2018). Moreover, students who approach the subject with positivity are more likely to be interested in it and to pursue it as a future study Kurniawan et al. (2018) as well as their career choices (Reilly, Neumann, & Andrews, 2019). Although few studies investigated the effect of school location on the attitudes of secondary school students towards school subjects based on instructional strategy, those available yielded conflicting findings especially when innovative instructional strategy was used (Morenike & Oloyede, 2012; Musengimana, Kampire, & Ntawiha, 2022). For example, research suggests that urban students are more likely than rural ones to develop positive attitudes (Rawatee, 2007). Others claimed that rural students develop positive attitudes than urban students (Anwer, Iqbal, & Harrison, 2012; Kurniawan & Anggraini, 2020). Other researchers found that urban and rural students have similar attitudes towards science subjects (Mbonu-Adigwe, Bianca, Rose, & Ifebuche, 2024; Mbonyiryivuze et al., 2021). Given these contradicting results, more research is required to determine how students' attitudes toward biology are affected by the location of their school.

Students' engagement in class might suffer from unfamiliar teaching techniques because they would become confused and discouraged. Therefore, Kober (2015) suggested that teachers should look into how students feel about a novel teaching strategy. Regarding this, research on students' opinions about using CM revealed that they all agreed that concept maps are an effective learning tool (Agarwal, Bhandari, Gupta, Panwar, & Datta, 2023; Markow & Lonning, 1998; Talbert et al., 2020; Turan-Oluk & Ekmekci, 2018). However, in other studies, students revealed challenges as well as hesitation in using it. They advanced that using CM is time-consuming extra and busy work (Brondfield, Seol, Hyland, Teherani, & Hsu, 2021; Fang, 2018) or makes students frustrated in CM (Chiou, 2008). These inconsistent findings about CM imply that students experienced differently the use of CM. These contradictory findings offer a solid justification for further research in the field.

Furthermore, in Rwanda, this study may fulfil the gap that lies in understanding how geographical and socio-economic factors impact educational methods and student engagement in the context of developing educational infrastructure. Also, while there is growing interest in innovative teaching strategies like concept mapping, there is limited empirical evidence on how the location of schools whether urban or rural affects students' attitudes and outcomes when using such methods. Rwanda, with its diverse educational settings and varying levels of resources across different districts, presents a unique context where location-specific challenges and opportunities can significantly influence the effectiveness of concept mapping in biology classrooms. By addressing this gap, the study can provide valuable insights into how location-related factors such as access to educational resources, infrastructural support, and socio-economic conditions affect the implementation and reception of concept mapping techniques. This understanding can inform targeted strategies to enhance teaching practices and resource allocation, thereby improving educational outcomes and student engagement across Rwanda's varied school environments.

In light of the above premises, there is a need for a study to explore more, the effect of school location on students' attitudes towards biology and students' experiences in using the CM. Therefore, this study investigated the effect of school location on students' attitudes towards biology and how they experienced the CM instructional strategy in selected schools in Nyamagabe district, Rwanda.

3. MATERIAL AND METHODS

3.1. Study Research Design

The study employed a quasi-experimental methodology with a pre-test-post-test non-equivalent comparison group design, and school location was used as a moderating variable (Creswell, 2014).

Table 1. Research design.

Groups	Moderating variable	Pre-attitude	Methods	Time	Post-attitude
Experimental	School location	BAQ	CM	4 weeks	BAQ, ACMQ
Comparison	School location	BAQ	CTM	4 weeks	BAQ

Table 1 presents the design of the study, showing that the Biology Attitude Questionnaire (BAQ) was administered at the pre-test to both the experimental and comparison groups; the group using Concept Mapping (CM) and the group using Conventional Teaching Methods (CTM), respectively. Additionally, to examine post-test attitudes, both the BAQ and the Attitude Towards Concept Mapping Questionnaire (ACMQ) were used.

3.2. Population of the Study and Sampling Techniques

The population was 6,708 senior secondary two (SS2) students in the Nyamagabe district of Rwanda. To choose the participating schools for the study, purposive sampling was used. The selection process considered the following factors: equivalency (schools with comparable facilities, resources, and the availability of qualified and experienced biology teachers); ownership; gender composition (co-educational schools); school type (boarding school); enrollment of students in the second year of secondary school; school location; and having students take national exams.

According to Ndihokubwayo, Uwamahoro, and Ndayambaje (2020) throughout the district all boarding co-educational schools were used as samples in order to maintain similar features of the schools, mainly structure, students' aptitude, and infrastructure. Thus, four boarding schools having 305 students distributed in six intact classes were sampled. Subsequently, the selected schools were randomly assigned to the experimental and comparison groups. As a result, 151 students were placed in the CM group and 154 in the CTM group.

3.3. Research Instrument and Validation

The Biology Attitude Questionnaire (BAQ) was used to determine the attitude of the students towards biology before intervention and to see whether the difference exists in their attitude as a result of the intervention. The BAQ was based on the relevant literature (Prokop, Prokop, & Tunnicliffe, 2007; Zeidan, 2010). The 30-item., Likert-type BAQ consisted of four dimensions: interest, career, importance, and enjoyment. Each dimension included statements about the particular variable, and students used a five-point response scale to indicate whether they agreed or disagreed (5= Strongly agree to 1= Strong disagree).

Students' attitude towards CM was assessed using the Attitude Towards Concept Mapping Questionnaire (ACMQ). The ACMQ was adopted from the Turan-Oluk and Ekmekci (2018) questionnaire as revised by Huynh and Yang (2024). The ACMQ consisted of 23 statements categorized into 3 subscales: cognition, affection and behavioral intention to use CM in learning (Huynh & Yang, 2024). Students indicated their level of agreement or disagreement using a five-point response scale (5= Strongly agree to 1= Strong disagree). The internal consistencies of the BAQ and ACMQ were calculated using Cronbach alpha (α). The results showed that they were 0.95 and 0.90 respectively.

The reliabilities of BAQ dimensions (interest, career, importance, and enjoyment) were also found to have good internal consistency (0.80, 0.76, 0.92, and 0.97 respectively) while that of ACMQ dimensions (cognition, affection, and behavior) yielded appropriate values for internal consistency (0.90, 0.76, 0.76, and 0.85, respectively). These instruments' reliabilities make them appropriate for this study (Creswell, 2014; Fraenkle & Willen, 2012).

3.4. Intervention

Before the intervention started, the regular biology teachers who volunteered to be research assistants took a five-day orientation training. Teacher assistants for the experimental schools had independent instruction on the procedures required to apply and practice the CM. The comparison school teachers were told to carry on with their regular methods of instruction, which included lectures and group discussions. Nonetheless, they were informed about the purpose of the research, how the lesson plans would be used, the topics that would be covered, how both pre-and post-BAQ would be administered, and how the study would be conducted as a whole. Before starting treatment, all groups of students completed the BAQ to ascertain whether the students' pre-intervention attitudes regarding biology were similar. After that, biology teachers of those study groups taught the concept of photosynthesis throughout the four weeks. A one-week course on Concept Mapping (CM) and concept map creation techniques was provided to a group of students. Once the students completed these exercises, teachers began the photosynthesis unit lessons to ensure they understood concept map construction. The CM group's teaching-learning process included an introduction, presentation, and summarization, with daily assessments conducted through concept map construction. For example, Figure 1 illustrates the process of photosynthesis.

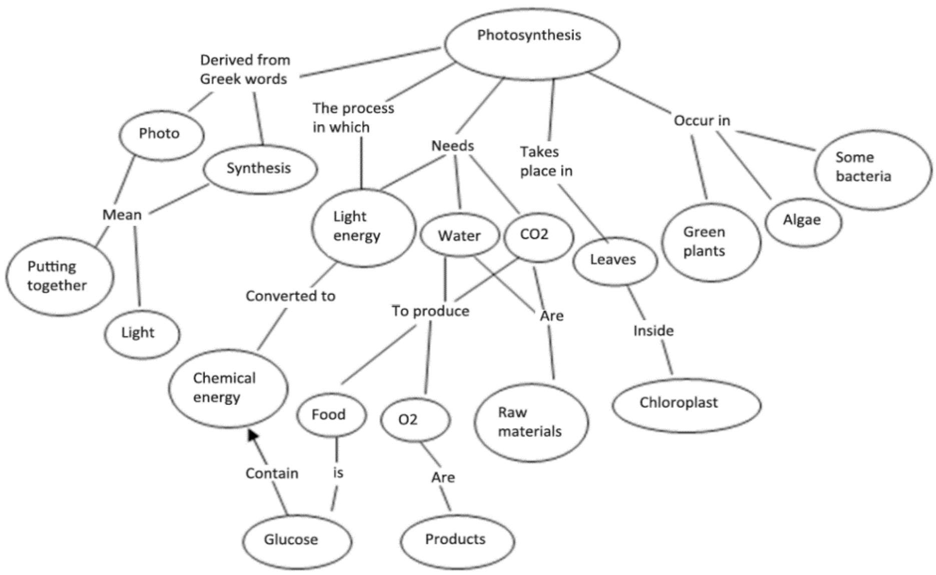

Figure 1. Concept map constructed to show the links to the concept of photosynthesis.

Students created concept maps for each subject they studied. After completing the photosynthesis unit, all individual maps from each class topic were combined to form a comprehensive overview. Additionally, they were provided with a general reference concept map (Figure 2) for photosynthesis, allowing them to verify and refine their own maps.

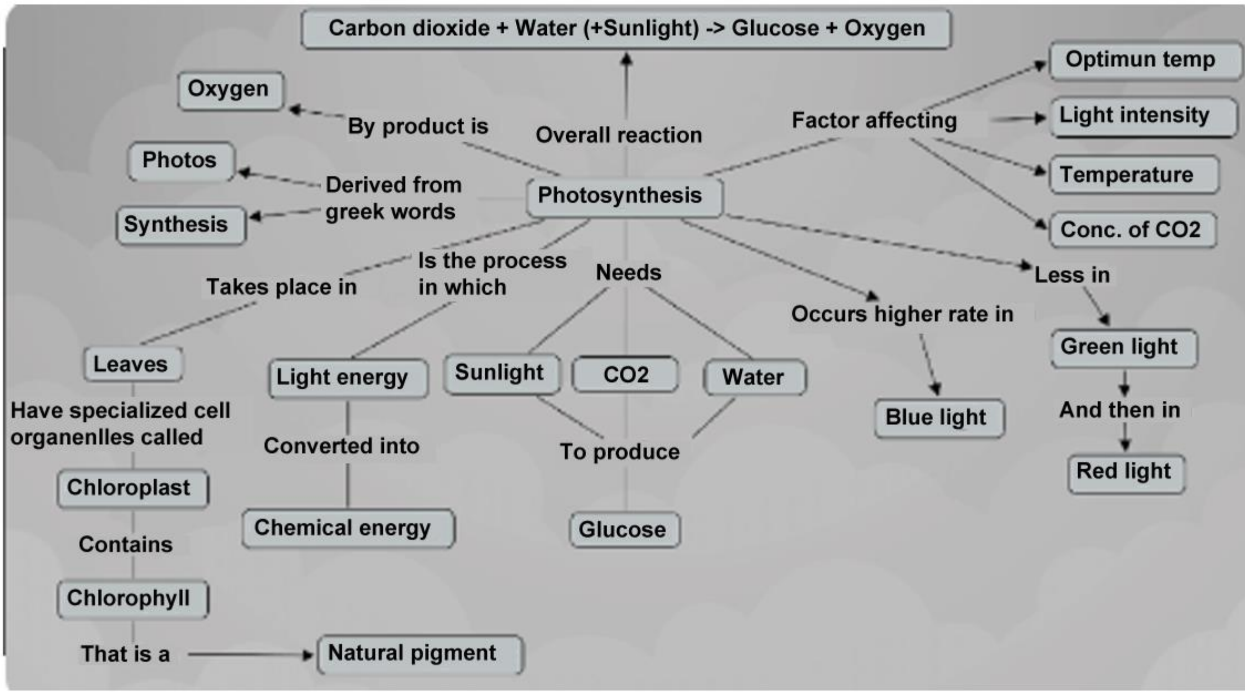

Figure 2. General concept map for photosynthesis.

On the other hand, students in the comparison group were taught using conventional teaching methods such as lectures, group work, and demonstration. To make sure CM and CTM were being applied as directed, visits were made to the classes in the chosen schools during the treatment period. After the four-week of teaching activities, students in each group completed the post-BAQ while only students in the CM group completed the ACMQ.

3.5. Data Analysis

The SPSS package program version 21.0 was used to analyze the questionnaire results. Using the ANOVA test, the homogeneity of the research groups was examined, and a statistical difference in the post-test scores was examined using analysis of covariance (ANCOVA). This was preferred considering its great potential in partially explaining the original differences in the underlying pre-attitude scores because the study contained intact classes (Ary, Jacobs, Irvine, & Walker, 2013). To clarify the effect of interaction of teaching methods together with the school location on the attitudes of students regarding biology, graph plot was as well used while the Multivariance Analysis of Variance (MANOVA) was for analyzing the interaction between instruction and school location for the BAQ dimensions. Finally, a t-test was used to compare students' attitudes toward CM between urban and rural school students in the experimental group.

4. RESULTS

4.1. Preliminary Data Analysis

Preliminary data analysis and interpretation were conducted to grasp the nature of the data set from the pre-tests and post-tests to check assumptions and prepare for the proper inferential statistical methods of analysis. The assumptions checked were the normal distribution of the dependent variables in each group as well as the equal variance of the dependent variable across the study groups. The normal distribution was checked using Skewness and Kurtosis. The descriptive statistics related to the scores on pre-BAQ and post-BAQ for the treatment and comparison groups are presented in Table 2.

Table 2. Descriptive statistics of the scores on pre-BAQ and post-BAQ for the treatment and comparison groups.

Group	Variable	N	Mean	SD	Min.	Max.	Skewness	Kurtosis
Treatment	Pre-BAQ	151	11.76	1.73	7.00	17.00	-0.03	0.13
	Post-BAQ	151	15.41	1.75	11.00	20.00	0.07	-0.52
Comparison	Pre-BAQ	154	11.57	1.89	7.00	17.00	-0.13	-0.07
	Post-BAQ	154	13.29	2.55	8.00	19.00	0.48	-0.70

As can be observed from Table 2, the mean scores of the treatment group on pre-BAQ (M = 11.76, SD= 1.73) were almost equal to the mean score of the comparison group (M = 11.57, SD = 1.89). These findings showed that before the intervention, the two groups' attitudes regarding biology were nearly similar. As a result, the impact of the intervention would be responsible for any variation in the post-test outcomes between the treatment and comparison groups. It can be seen in Table 2 that attitude scores had skewness and Kurtosis values between -1.96 and +1.96. This data distribution demonstrates that each group's variables were at least normally distributed in each group (Landau & Everitt, 2017). To determine if a difference existed in the attitude towards biology between the treatment and comparison groups before the intervention, the Analysis of Variance (ANOVA) was computed and the results are presented in Table 3.

Table 3. ANOVA for the pre-attitude scores.

Group	N	Mean	SD	F	Sig.
CM	151	11.76	1.73	0.83	0.362
CTM	154	11.57	1.89		

Table 3 shows that the two groups pre-attitude mean scores showed no differences that were significant statistically ($F_{(1,303)}$ =. 83, $p = 0.362 > 0.05$). This indicates that students in the sampled schools had an equal attitude before the introduction of the interventions.

4.2. Effect of Using CM on Students' Attitude towards Biology

After the teaching practices in both experimental and comparison groups, the post-BAQ scores on the four dimensions related to attitude (interest, career, importance, and enjoyment) and overall attitude scores were analyzed by mean and standard deviation, and the findings were presented in Table 4.

Table 4. Descriptive statistics of the components of biology attitude post-test scores for the treatment and comparison groups.

Group	Variable	N	Mean	SD
Experimental	Post-interest	151	3.66	0.45
	Post-career	151	4.43	0.78
	Post-importance	151	4.08	0.68
	Post-enjoyment	151	4.03	0.73
	Overall attitude	151	15.41	1.75
Comparison	Post-interest	154	3.45	0.53
	Post-career	154	3.77	0.72
	Post-importance	154	3.90	0.69
	Post-enjoyment	154	3.64	0.78
	Overall attitude	154	13.29	2.55

According to the results in Table 4, students' attitude scores increased after the CM and CTM had been used in teaching and learning biology. However, the mean attitude scores of the students in the CM group were higher than those in the CTM group. Figure 3 illustrates the situation.

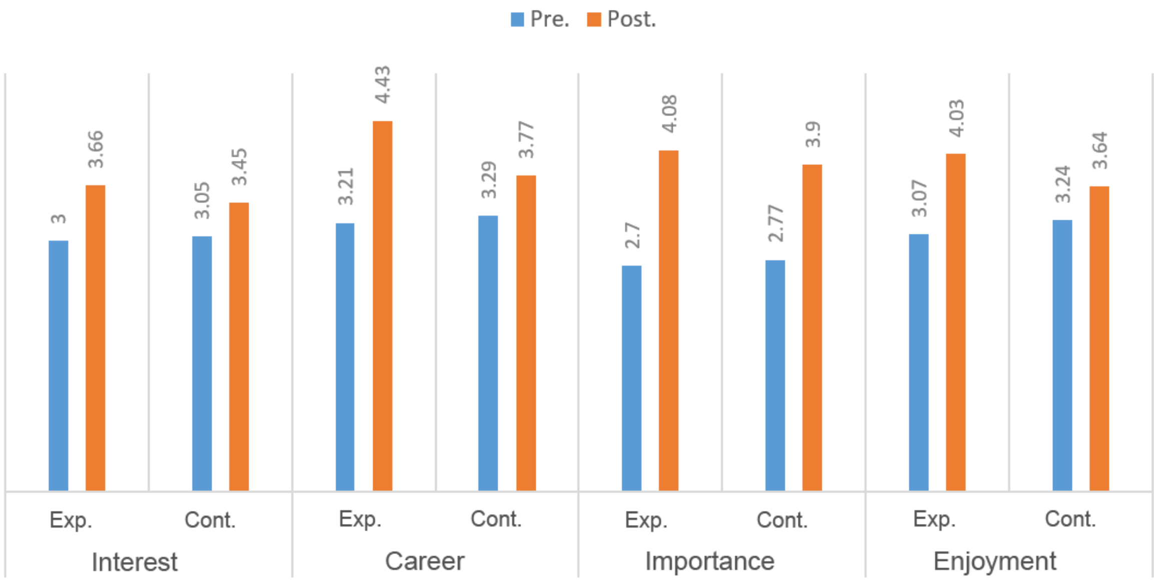

Figure 3. A comparison between pre and post attitude scores in CM and CTM groups.

To determine whether there was a statistically significant difference between experimental and comparison groups in the attitudes of students toward biology the mean attitude scores of both groups were subjected to inferential statistics using ANCOVA (Table 5).

Table 5. Summary of ANCOVA for the difference in attitude scores between students exposed to CM and those exposed to CTM.

Source	Type III sum of squares	df	Mean square	F	Sig.	Partial Eta²
Corrected model	342.306ᵃ	2	171.153	35.334	0.000	0.190
Intercept	1507.401	1	1507.401	311.196	0.000	0.507
Pre-attitude	0.120	1	0.120	0.025	0.875	0.000
Treatment	341.918	1	341.918	70.587	0.000	0.189
Error	1462.855	302	4.844			
Total	64590.000	305				
Corrected total	1805.161	304				

Note: a. R squared = 0.190 (Adjusted R squared = 0.184).

The ANCOVA gave an $F_{(1, 302)} = 70.587$, $p < 0.05$ with an effect size of 0.189. This effect size means that 18.9% of the difference between the treatment and comparison group is due to the implementation of CM. It can therefore be deduced from this result that the CM is superior to CTM in terms of improving students' attitudes towards biology. To compare the treatment and comparison groups on the attitude components (interest, career, importance, and enjoyment), an Analysis of Covariance (ANCOVA) was used by considering the pre-interest, pre-career, pre-importance and pre-enjoyment scores as covariates. Table 6 shows the findings.

Results displayed in Table 6 indicate that there was significant difference between the treatment (CM) and comparison group (CTM) on interest ($F_{(1, 302)} = 7.655$, p< 0.05), career ($F_{(1,302)} = 85.660$, $p < 0.05$), importance ($F_{(1,302)} = 4.558$, $p < 0.05$) and enjoyment (F (1,302) = 19.703, $p < 0.05$). As evident from Table 6, 2.5 % variance in the post-interest, 22.1 % of the variance in the post-career, 1.5% of the variance in the importance, and 6.1% of the variance in the post-enjoyment between the treatment and comparison groups were explained by the independent variables of this study. Therefore, using CM in teaching and learning biology was more effective than the CTM in influencing these attitudinal components in favor of the CM group. This demonstrates how the incorporation of CM into biology classrooms significantly enhanced students' attitudes towards biology.

Table 6. Summary of ANCOVA test for significant effect of teaching methods on students' attitudes towards biology.

Variables	Source of variation	SS	df	MS	F	Sig.	Partial Eta²
Interest	Covariate	0.038	1	0.038	0.090	0.76	0.000
	Treatment	3.242	1	3.242	7.655	0.006	0.025
	Error	127.918	302	0.424			
Career	Covariate	0.019	1	0.019	0.050	0.822	0.000
	Treatment	32.796	1	32.796	85.660	0.000	0.221
	Error	115.627	302	0.383			
Importance	Covariate	0.218	1	0.218	0.405	0.525	0.001
	Treatment	2.451	1	2.451	4.558	0.034	0.015
	Error	162.390	302	0.538			
Enjoyment	Covariate	4.135	1	4.135	6.223	0.013	0.020
	Treatment	13.093	1	13.093	19.703	0.000	0.061
	Error	200.691	302	0.665			

Note: SS stands for sum of square while MS stands for mean of square.

4.3. Effect of CM on Students' Attitudes towards Biology by School Location

To find out the mean attitude score differences by school location, the mean attitude scores for urban and rural students were computed and the findings are presented in Table 7.

Table 7. Descriptive statistic of the components of biology attitude post-scores for experimental group.

Group	Variable	School location	Mean	SD
Treatment	Post-interest	Urban	3.50	0.58
		Rural	3.65	0.55
	Post-career	Urban	4.38	0.60
		Rural	4.46	0.55
	Post-importance	Urban	4.20	0.80
		Rural	4.02	0.79
	Post-enjoyment	Urban	4.22	0.93
		Rural	3.95	0.76
	Overall attitude	Urban	15.12	1.76
		Rural	15.56	1.73
Comparison	Post-interest	Urban	3.78	0.78
		Rural	3.52	0.82
	Post-career	Urban	4.10	0.43
		Rural	3.44	0.77
	Post-importance	Urban	4.13	0.42
		Rural	3.04	0.74
	Post-enjoyment	Urban	4.01	0.56
		Rural	3.12	0.83
	Overall attitude	Urban	14.24	2.88
		Rural	13.14	1.11

To explore whether a statistically significant difference in the post-attitude scores exists between urban and rural school students taught using CM, data presented in Table 7 the ANCOVA was used (Table 8). The analysis in Table 8 shows an $F_{(1, 148)} = .826$, $p > 0.05$ for the overall mean attitude scores. Likewise, when the components of attitude are examined, the results in Table 8 showed that there were no significant differences ($p > 0.05$) for all attitude components. This showed that attitudes of students studying biology in urban and rural schools using CM did not differ statistically significantly. This is to say that the attitudes of rural and urban students were improved by the use of CM alike.

Table 8. Result of ANCOVA of attitude scores between urban and rural students in groups taught using CM.

Variables	School location	N	Mean	SD	F	Sig.	Partial Eta²
Interest	Urban	50	3.50	0.58	2.800	0.096	0.019
	Rural	101	3.65	0.55			
Career	Urban	50	4.38	0.60	0.905	0.343	0.006
	Rural	101	4.46	0.55			
Importance	Urban	50	4.20	0.80	1.502	0.222	0.010
	Rural	101	4.02	0.79			
Enjoyment	Urban	50	4.22	0.93	2.269	0.134	0.015
	Rural	101	3.95	0.76			
Total attitude	Urban	50	15.12	1.76	0.826	0.365	0.006
	Rural	101	15.56	1.73			

The study also checked whether a statistically significant difference existed between students in urban and rural students in the CTM group. To achieve this, the ANCOVA was used (Table 9).

Table 9. ANCOVA results of urban and rural students in CTM group.

Variables	School location	N	Mean	SD	F	Sig.	Partial Eta²
Interest	Urban	91	3.78	0.78	3.946	0.049	0.025
	Rural	63	3.52	0.82			
Career	Urban	91	4.10	0.43	30.946	0.000	0.170
	Rural	63	3.44	0.77			
Importance	Urban	91	4.13	0.42	131.132	0.000	0.465
	Rural	63	3.04	0.74			
Enjoyment	Urban	91	4.01	0.56	61.107	0.000	0.288
	Rural	63	3.12	0.83			
Total Attitude	Urban	91	14.24	2.88	8.542	0.004	0.013
	Rural	63	13.14	1.11			

Table 9 shows that the primary effect of CTM on attitudes among students resulted in an ($F_{(1,151)} = 8.542$, $p < 0.05$). This suggests that CTM improved the attitudes of urban students than rural students towards biology. Similarly, when the attitude components were examined, there was a significant difference ($p < 0.05$) between urban and rural students' mean attitude scores in favour of urban students in each attitude component.

4.4. Interaction Effect of Treatment and School Location on Attitude toward Biology

The ANCOVA test was employed to determine the effect of interaction of treatment and school location on students' attitudes towards biology. The result is shown in Table 10.

Table 10. Summary of ANCOVA for a significant interaction effect between the instructional strategies and school location on attitudes towards biology.

Source	Type III sum of squares	Df	Mean square	F	Sig.	Partial Eta²
Corrected model	400.810[a]	4	100.203	21.405	0.000	0.222
Intercept	1432.041	1	1432.041	305.915	0.000	0.505
Pre-attitude	0.015	1	0.015	0.003	0.955	0.000
School location	16.882	1	16.882	3.606	0.059	0.012
Treatment	339.731	1	339.731	72.574	0.000	0.195
School location * treatment	38.736	1	38.736	8.275	0.004	0.027
Error	1404.350	300	4.681			
Total	64590.000	305				
Corrected total	1805.161	304				

Note: a. R squared = 0.222 (Adjusted R squared = 0.212)

Table 10 shows $F_{(1, 187)} = 8.275$; $p < 0.05$ which reveals that there is a significant interaction effect between teaching methods and location on students' attitudes towards biology. This implies that teaching methods and school location interacted significantly to affect the attitudes of students towards biology.

A line graph was put in place as shown in (Figure 4) to explain the effect of interaction of treatment and school location on the attitudes of students toward biology. Due to the fact that the lines intersect, it implies that there is an interaction. Thus, the school location influences students' attitudes towards biology in the CTM group but not in the CM group with a significant effect of CTM in favor of students in urban schools. However, the CM is effective in enhancing students' attitudes towards biology in both urban and rural schools.

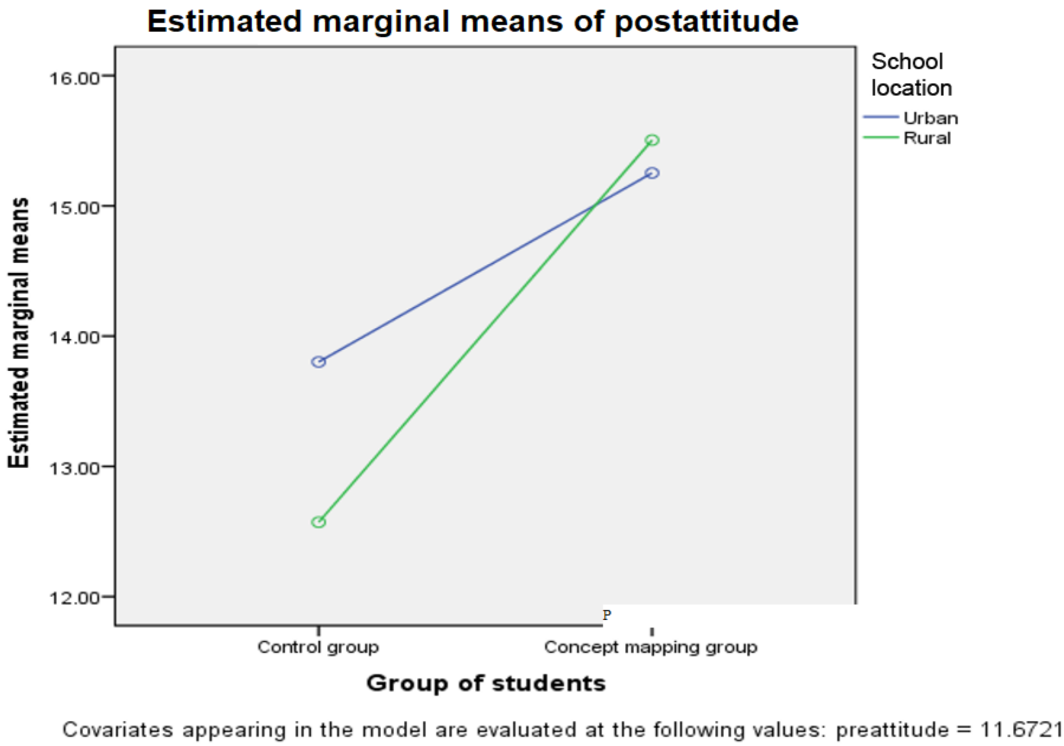

Figure 4. Line graph illustrating significance interaction effect of treatment and school location on students' attitudes towards biology.

To find out which of the attitude scales on which the interaction effect of treatment and school location occurred, the multivariate analysis of MANOVA/ANOVA was used (Table 11).

Table 11. The two-way MANOVA/ANOVA results for CM and CTM groups and school location for each attitude scale.

Attitude scale	Instruction		School location		Instruction x school location	
	F	Eta²	F	Eta²	F	Eta²
Interest towards biology	7.65*	0.025	0.377	0.001	7.69*	0.025
Future career in biology	85.66*	0.221	1.459	0.005	19.69*	0.061
Importance of biology	4.55*	0.015	14.035*	0.045	3.74	0.012
Enjoyment of biology lessons	19.70*	0.061	18.98*	0.060	13.06*	0.042

Note: *p< 0.05.

The results in Table 11 show that the interaction between instruction and school location for three of the four BAQ scales, namely, the interest scale ($F_{(1,301)} = 7.69$, $p< 0.05$), career ($F_{(1,301)} = 19.69$, $p< 0.05$) and enjoyment ($F_{(1,301)} = 13.06$, $p< 0.05$) showed statistics that was significant. The variance accounted for was 0.025, 0.061, and 0.042

for interest, career, and enjoyment, respectively. Figure 5 and Figure 6 illustrate the interpretation of the significant interaction effect of treatment and school location for interest and career scales of the BAQ.

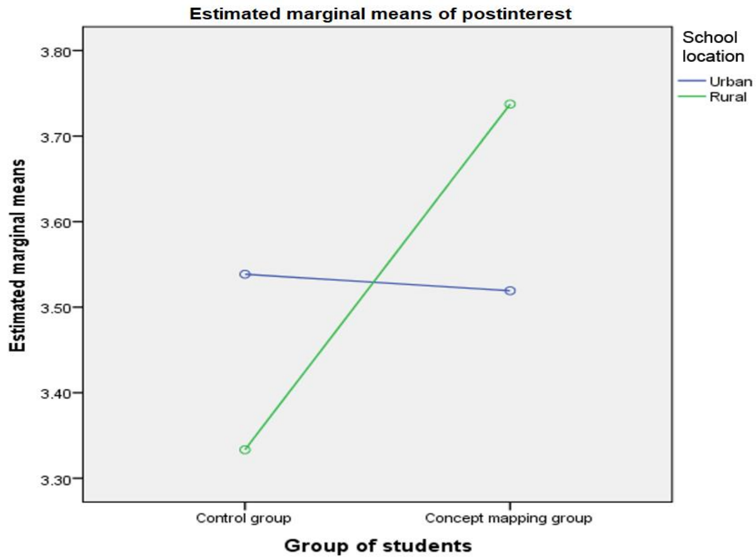

Figure 5. Instruction-by-school location interaction for interest scale.

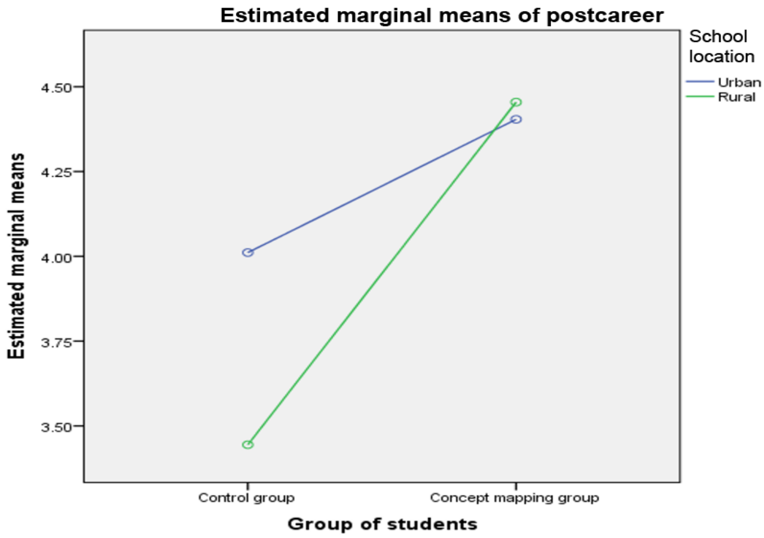

Figure 6. Instruction-by-school location interaction for career scale.

The analysis of the significant interaction effect of treatment and school location for interest in Figure 3 and career in Figure 4 is that urban students perceived more positive interest and future career in CM class than in CTM classes. However, rural students perceived less positive interest and future careers in the CM class than in the CTM class. This implies that the CM was more effective for urban students than rural ones for interest and career scales, while CTM was nearly equally effective for both urban and rural students.

4.5. Students' Attitude toward the Use of Concept Mapping

Additionally, the study explored how students in the experimental group perceived the use of Concept Mapping (CM) in their biology classes. Regarding their responses to cognitive items, Figure 6 demonstrates that the students in the CM group agreed that CM was useful.

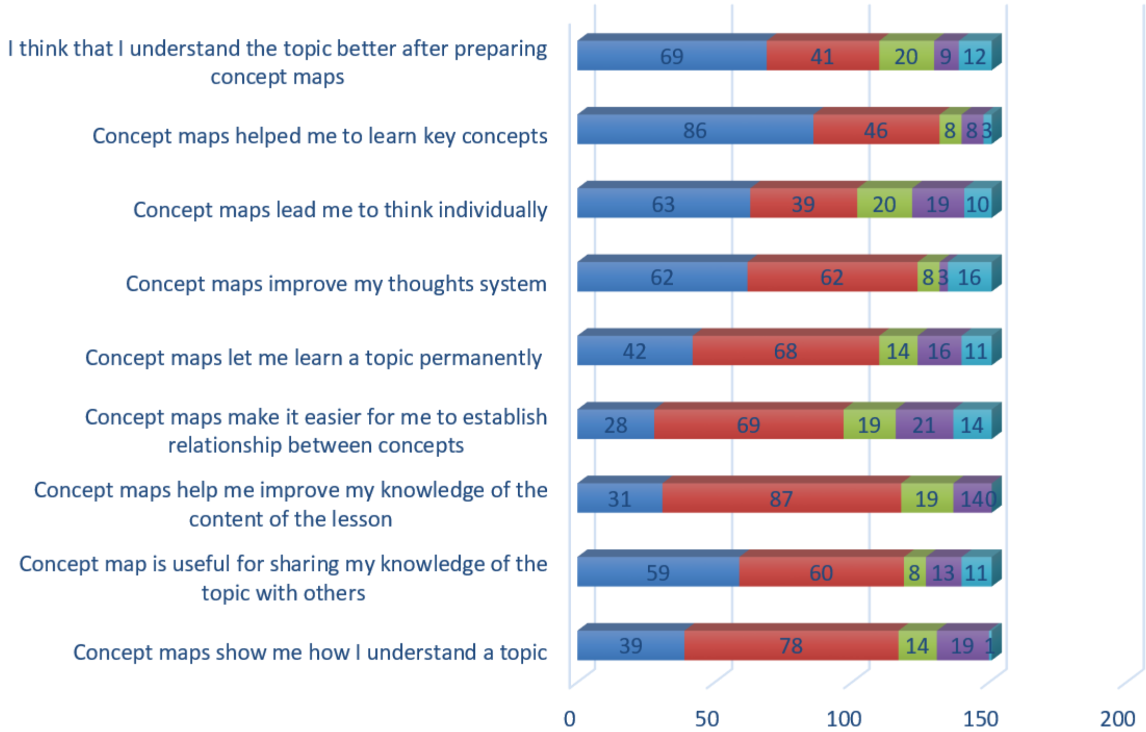

Figure 6. Usefulness of concept maps.

Concerning the items on students' feelings about using CM, Figure 7 shows that most students showed affection feeling about using concept maps.

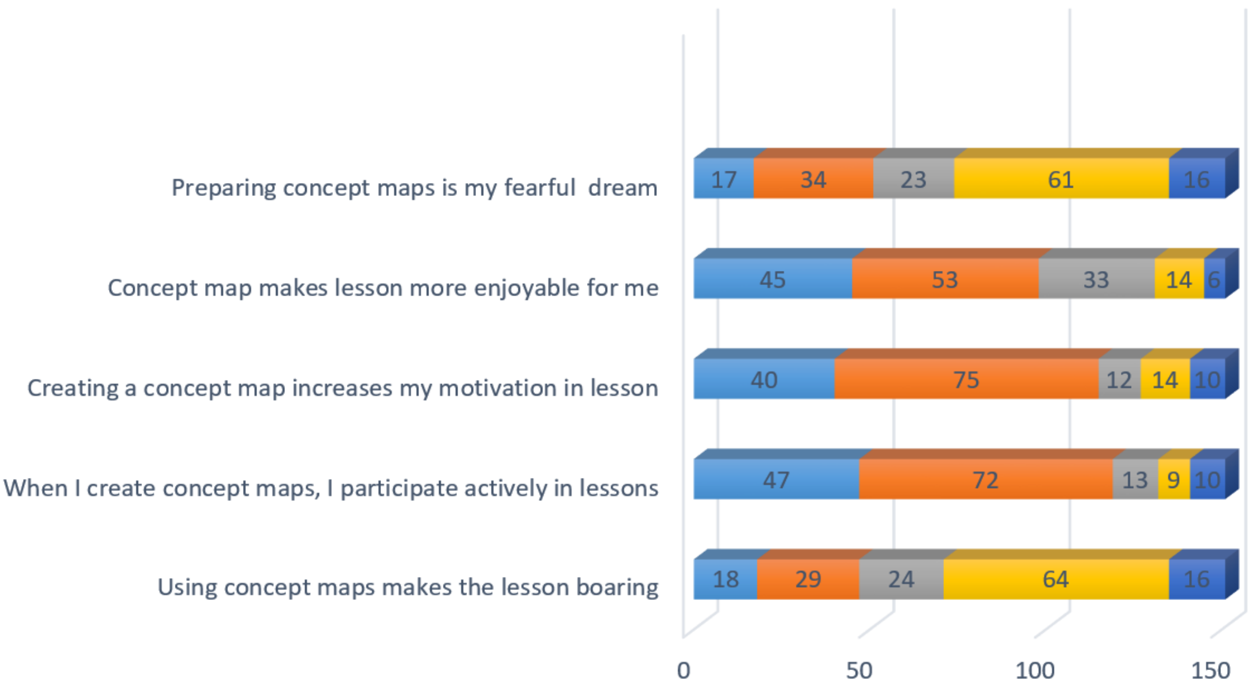

Figure 7. Affection-feeling about using concept maps.

Regarding the items related to students' intention to use the CM, Figure 8 indicates that most students disagreed with negative items, suggesting that they intend to use the CM in learning while some students had a certain degree of hesitation to use CM.

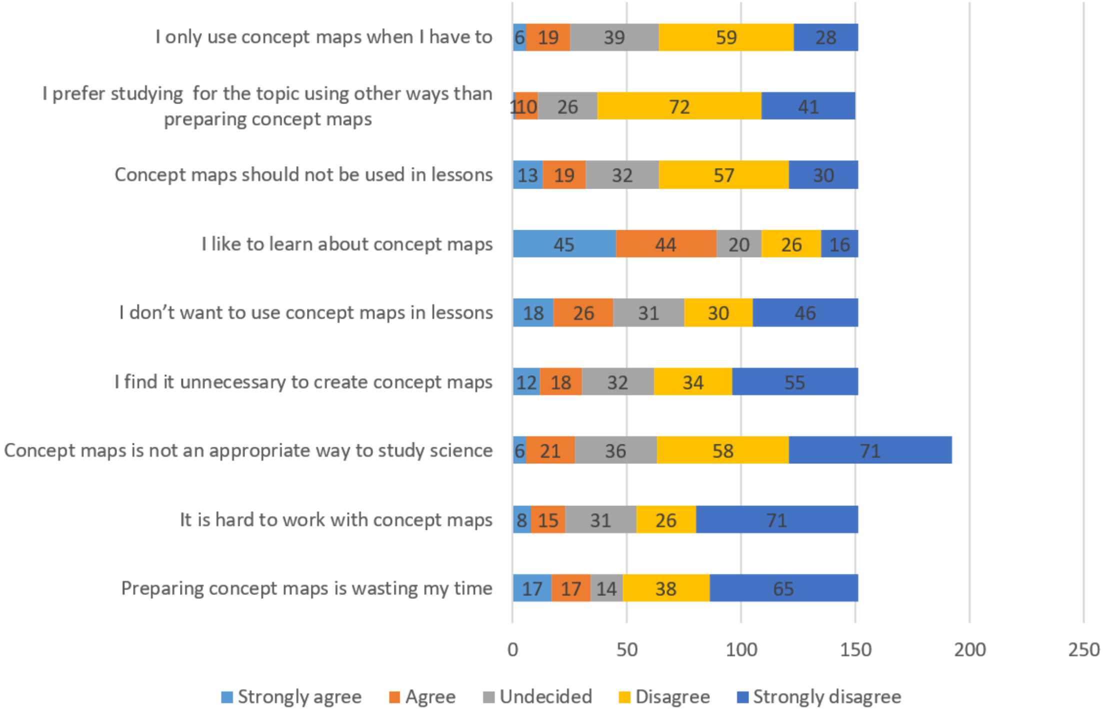

Figure 8. Intention to use concept maps.

The mean scores of the components of the ATCM questionnaire were 35.14 ($SD = 3.56$) for cognitive, 17.11 ($SD = 2.68$) for affective, and 22.19 ($SD = 4.35$) for behavior. These results indicate that students had a positive attitude towards the use of CM. This implies that they found it useful in learning biology concepts.

To find out whether a significant difference in the attitude of students towards CM in urban and rural schools, a t-test was used, and the results are presented in Table 12.

Table 12. School location and students' attitude towards the use of CM.

ATCM components	School location	N	Mean rank	t-value	Sig.
Cognitive	Urban	50	34.98	0.400	0.690
	Rural	101	35.22		
Affective	Urban	50	16.86	0.812	0.418
	Rural	101	1.23		
Behavior	Urban	50	22.28	0.381	0.704
	Rural	101	23.06		
Entire Attitude	Urban	50	74.72	0.832	0.407
	Rural	101	75.59		

Results in Table 12 indicate that when the attitude towards CM is examined, the results show no significant differences ($p > 0.05$) in the whole ATCM. Table 12 also indicated no significant difference between urban and rural students ($p > 0.05$) when the components of ATCM are considered. This suggests that students in urban and rural schools alike valued the application of CM in biology instruction.

5. DISCUSSION

Examining students in the treatment and comparison groups for their general attitudes revealed that there was an improvement in attitude towards biology after the intervention. However, the treatment group's students, in contrast to those in the comparison group, displayed a more favorable attitude toward biology when the two groups' post-test mean scores were compared. This is indicated by the increase in their level of interest, career importance, and enjoyment of biology.

The finding suggests that integration of the CM in the biology classroom was more effective at fostering a favorable attitude towards biology than the CTM. The finding is consistent with that of Ongowo, Keraro, and Okere (2011) which showed that the attitudes of students are significantly improved by CM compared to CTM towards biology. As regards other learning subjects like mathematics, physics chemistry, and basic science, scholars Bii and Chris (2019); Lin, Chang, Hou, and Wu (2016); Luchembe et al. (2014) and Muni and Mishra (2021) were of the view that the attitudes of students were significantly enhanced by CM compared to CTM. Nevertheless, this position contradicts other scholars' finding namely Çömek, Akınoğlu, Elmacı, and Gündoğdu (2016) and Karakuyu (2010) who found no significant difference in attitudes towards biology between CM and CTM groups.

A potential explanation for this shift in attitude in favor of the experimental group may have been brought about by well-planned instructions that created a learning environment where students actively participated in the lessons. According to Hacieminoglu (2016); Mokiwa and Agbenyeku (2019) and Sushma (2020) such an active learning environment boosts students' level of interest which in turn enhances their attitude. To support these perspectives, Wang, Chiou, Lee, and Tien (2017) came up with evidence arguing that CM provided both knowledge to students and full engagement in learning. This might have facilitated understanding, enjoyment of learning, and the development of higher-order thinking abilities in students, which improved their positive attitudes. This is also supported by Oladejo, Akinola, and Nwaboku (2021) that students learn more efficiently when they are taught in methods that they find enjoyable. However, the CTM frequently forces students to memorize the material, which hinders their ability to comprehend and makes it easier for them to forget, which leads to a subpar attitude (Schmid & Telaro, 2018). Besides, Orunaboka (2011) states that active learning strategies encourage the development of positive attitudes towards science. This is a result of the constructivist instructional strategy's inclusiveness, which allows learners to independently create their knowledge by connecting new concepts to prior concepts (Fernando & Marikar, 2017). Besides, teaching methods that establish links between concepts foster positive attitudes in secondary school students (Anwer et al., 2012). The CM strategy makes this possible (Wang et al., 2017).

Additionally, the results of this study showed that when biology was taught using CM, urban students' mean attitude scores were somewhat higher than those of their rural counterparts. However, the ANCOVA test findings, showed no significant difference in the attitudes of students by school location ($F\ (1,\ 148) = .826,\ p > 0.05$). This implies that CM improved urban and rural students' attitudes towards biology comparably. This finding agrees with that of Adigwe and Okonkwo (2014) which revealed lack of difference that is significant in terms of attitude towards biology in rural and urban school students when CM is used. The result is also consistent with that of Mbonyiryivuze et al. (2021) and Musengimana et al. (2022) but at variance with that of Anwer et al. (2012) who reported a difference that is significant in the attitude due to the school location when active learner-centered teaching strategy was used.

The study also looked into mean attitude scores and checked whether there was a difference between CTM-taught urban and rural students. It was discovered that urban students had higher mean attitude scores than rural students did. This suggests that when CTM is applied in biology classes, urban students' attitudes toward biology improve more. Similarly, in the CTM group, the ANCOVA test showed an attitudinal difference between urban and rural students ($F_{(1,151)} = 8.542,\ p < 0.05$) in support of students attending urban schools.

The above result is consistent with that of Saleh (2014) that students in urban areas showed a positive attitude towards science than rural students. However, Shah, Mahmood, and Harrison (2013) findings are contradicted in the sense that for them they argue that the difference in attitudes towards science learning is not linked to school locality. This outcome also contradicts the findings of Anwer et al. (2012) who discovered a statistically significant difference in the attitudes of rural and urban students towards science. In the context of this study, students' decreased motivation to study in rural schools and the absence of facilities that are appropriate for teaching and learning biology may be the cause of their negative attitudes regarding biology education (Nzabalirwa & Nkiliye, 2012). This is supported by Adegbola (2019) and Chepkorir, Cheptonui, and Chemutai (2014) who found that students' attitudes towards learning science are positively impacted by the availability of infrastructure and the existence of teaching aids. Moreover, the ANCOVA result shows that the interaction effect between teaching strategy and school location was statistically significant. This implies that teaching strategy and school location combined affect the students' attitudes. On one hand, this finding gives credence to Fasasi and Olagunju (2016) who reported a significant interaction effect between instructional strategy and school location on the attitudes of students towards basic science. But on the other hand, it is at variance with Adigwe and Okonkwo (2014).

Finally, the results of this study showed that the students in the CM group acknowledged the usefulness of the CM and showed their intention to use it. This finding is similar to that of Huynh and Yang (2024); Markow and Lonning (1998); Turan-Oluk and Ekmekci (2018) and Wagner et al. (2023) who found that students taught using CM recognized the usefulness of CM as a learning tool. The finding here is also consistent with the research results of Karakuyu (2010); Luchembe et al. (2014) and Martins-Omole, Yusuf, and Guga (2016). The study also revealed that some students were unwilling to use CM. Comparable findings were also identified by Brondfield et al. (2021) and Huynh and Yang (2024).

6. CONCLUSIONS

This study investigated the effect of Concept Mapping (CM) on the attitude towards biology of students of lower secondary schools, and school location differences and how students experienced concept maps. The outcomes of this work revealed that both CM and CTM improved attitudes of students towards biology with students in the CM groups improved higher than those in the CTM groups. The study findings also showed that the average attitude scores of urban and rural students exposed to CM and CTM indicated a substantial difference in favor of CM. As a result, the implementation of the CM in biology classes appear to give another solution to the negative attitudes of students towards biology that have long gradually affected their academic achievement in the subject. Also, it was revealed by this study that school location does not affect the attitudes of students toward biology when they are taught biology using the CM. This suggests that incorporating CM into the teaching and learning process would improve students' attitudes toward biology learning regardless of school location. The study also showed that students had positive attitudes towards the use of CM in learning biology. As a result, biology teachers should be trained on how to use CM and adopt the strategy to minimize the urban and rural schools' differences in attitudes towards biology as well as academic achievement.

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