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Effects of School Location on Students' Achievement in Photosynthesis Based on Concept Mapping Instructional Strategy

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ABSTRACT

Despite years of research, students' difficulties in understanding and retention of photosynthesis concept have persisted among secondary school students, especially in rural areas. Consequently, this study examined the effect of school location on lower secondary school students' academic achievement in photosynthesis based on the concept mapping (CM) instructional strategy. The design of the study was a non-randomized pre-test, post-test control group quasi-experimental. The population of the study was 6,708 students from which a sample of 192 students was purposively sampled from four schools. Photosynthesis achievement test with the reliability value of 0.82 determined using the Kuder-Richardson 21-Formula was used for data collection. Data were mainly analyzed using mean and standard deviations to answer the research questions while analysis of covariance was used to test the hypotheses at 0.05 level of significance. Among others, the result showed no significant difference between rural and urban students' achievement taught photosynthesis using the CM ($F_{(1, 91)}$=2.340, p=.130>.05). Based on the findings, it was recommended among other things that the CM should be adopted by biology teachers in secondary schools as an instructional strategy and that faculties and colleges of education in various schools of higher learning should ensure that CM is included as a viable alternative strategy of teaching biology.

Keywords: academic achievement, biology, concept mapping, conventional teaching

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INTRODUCTION

Biology's importance to human existence and national progress vis-à-vis other science subjects, cannot be overstated. Apart from physics and chemistry, biology is another compulsory science subject taught at the lower secondary in Rwanda (Rwanda Education Board [REB], 2015). These science subjects are designed to prepare students who are interested in science to continue their studies after school. Besides, biology is still an important subject that is necessary for entrance to higher education institutions for professional courses such as medicine, nursing, pharmacy, agriculture, biotechnology, and other science-related careers (Joda, 2019). These fields of learning contribute greatly to the technological and economic growth of the nation.

Despite the great benefits of biology, reports and study findings show that lower secondary school students in most Sub-Saharan African countries have performed abysmally in the subject over the years, especially in rural areas, with Rwanda being no exception (Bizimana et al., 2022; Joda & Mohamed, 2017; Ntawiha, 2016).The students' poor performance is primarily due to a lack of comprehensive grasp of the topics covered in biology (Cimer, 2012; Etobro & Fabinu, 2017; Hadiprayitno et al., 2019; Kyado et al., 2019).

Students learn important biology concepts that lay the groundwork for their understanding of a variety of earth processes. Photosynthesis, a critical process in plants, is one of them. Photosynthesis refers to the process by which carbohydrates or sugars get combined with water (H_2O) and form carbon dioxide (CO_2) aided by sunlight energy consequently producing oxygen (O_2) as a by-product (mostly let out in the air) (Aboho et al., 2013; Johnson, 2016). As a result, understanding photosynthesis is critical to comprehend many aspects of biological systems. Although a lot of research has been done about the difficulty of students' understanding and retaining of the photosythesis concept, the issue still persists in secondary (Hadiprayitno et al., 2019). Besides, Métioui et al. (2016) and Nasution (2018) have found that learners have had numerous misconceptions about photosynthesis.

Some reasons that one may advanve that make students have problems in learning biology concepts include the material presented in abstract form (Etobro & Fabinu, 2017); lack of textbooks, content overloaded biology curriculum, and a non-conducive biology learning classroom environment (Zeidan, 2010), and insufficient of science laboratories (Ndihokubwayo, 2017; Nizeyimana & Nkiliye, 2015). In addition, Nzabalirwa and Nkiliye (2012) and Rubagiza et al. (2016) in different studies observed a lack of adequate teaching materials, and unskilled and discouraged teachers, especially in most rural secondary schools. Above all, the use of inadequate teaching methods by teachers in conveying biology content has been widely identified as a major contributor to this heinous trend (Cimer, 2012; Kambaila et al., 2019; Nsengimana, 2021; Nsengimana et al., 2017).

At all stages of education, the adoption of an effective teaching strategy can improve students' acquisition of biology content. Consequently, the last few decades have seen the rise of constructivist-based teaching strategies. These innovative teaching and learning strategies aim to improve student performance and encourage students' active participation in the construction of their knowledge. One such teaching and learning strategy that has recently arisen as a means of assisting students' critical thinking and meaningful learning is concept mapping (CM).

CM is a constructivist strategy that stresses student ownership of their learning, with the instructor serving as a facilitator (Abamba & Esiekpe, 2021). The CM is derived from Ausubel's (1968) assimilation theory of cognitive learning and it is suited to teach science concepts (Schmid & Telaro, 2018). In CM, concepts are organized by showing their relationship from more inclusive to more specific concepts using concept maps (Novak & Gowin, 1994; Huang et al., 2017). According to Novak and Gowin (1984), a concept map is a schematic device for representing a set of concept meanings embedded in a framework of propositions. This is a graphically organised design and moreover in an hierachical manner showing significant conceptual relationship with keywords (Hsieh et al., 2016).

The construction of a concept map involves hierarchically presenting concepts with general concepts at the top of the concept map, and the more specific, less general concepts are arranged hierarchically at the bottom of the map (Cañas & Novak, 2008). Eventually, meaningful learning is enhanced by mapping concepts into maps as the learner gets involved by representing concepts progressively in a hierarchical order, hence differentiating them (Novak et al., 1983). Thus, concept maps help in organizing and structuring knowledge.

Several advantages of the use of concept maps in learning have been documented in the literature. CM aids in the development of critical thinking that is infused with creativity, resulting in more effective learning and higher academic achievement (Auta, 2015). Besides, by making inter-relationships between two or more concepts, a concept map enhances the understanding of science concepts (Jack, 2013). It aids students in the development of problem-solving skills and the ability to find answers to questions that require the application and synthesis of concepts (Olarewaju & Awofala, 2011). It also promotes higher-order thinking and knowledge retention (Chang et al., 2016). Moreover, this strategyaids learners' efforts to visualize their knowledge in the form of graphical tools that connect previously learned concepts with newly acquired concepts (Sing & Moono, 2015). As a result, rather than being passive, the learning process becomes more active.

Both in learning and teaching, concept maps have been in use and research has shown positive gains in achievement in the concepts being learned. For instance, in the teaching of biology, researchers (Agaba, 2013; Ajaja, 2013; Dashne & Sinaa, 2019; Sakiyo & Waziri, 2015; Woldeamanuel et al., 2020) observed that groups taught using concept maps achieved more. In the same vein, the CM, according to Iwanger and Eriba (2018), Ogonnaya and Abonyi (2016), and Qarareh (2017), enabled students to achieve better in basic science than the conventional lecture teaching method. Similarly, Ariaga and Nwanekezi (2018), Bot and Eze (2016), Onuoha et al. (2016), and Wasonga (2015) in chemistry, mathematics, and economics; and Okorie and Ezeh (2016) in physics observed that students taught in a group with a CM approach showed a more significant performance than the one of those taught using conventional teaching methods (CTMs).

In addition to the teaching strategy, the school's location plays a role in students' achievement in science, without forgetting biology. This is in agreement with Nworgu et al. (2013) and Okorie and Ezeh (2016) who stated that the area in which a school is located can affect the academic achievement of a student. Similarly, Bizimana et al. (2022) and Ellah and Ita (2017) found the location of the school as among the most significant factors impacting students' academic success in biology.

According to Okorie and Ezeh (2016), they are two types of school locations: urban and rural. The presence of different infrastructures such as hospitals, water, electricity, and educational institutions are more frequently utilized to classify these locations. Schools in cities are expected to have better infrastructure than schools in rural areas. As a result, the school location implies an urban-rural setting, depending on the availability of facilities. In Rwanda, a school located in a rural area is usually faced with a shortage of qualified teachers, lack of laboratory, poorly equipped laboratories, lack of internet facilities, and electricity among others (Harerimana & Toyin, 2017; Rubagiza et al., 2016). These shortcomings harm both student motivation and learning outcomes.

Moreover, there is ample evidence that rural students' educational expectations are lower than those of their urban counterparts (Arnold et al., 2005). Other research findings also revealed that students in rural schools place less value on education (Macmillan, 2012). It follows then that, lower educational expectations coupled with less emphasis on academics by students in rural schools could result in poor academic achievement in biology than their urban counterparts.

Another effect of the location of rural and urban schools is that teachers tend to dislike rural schools in favour of urban ones due to the imbalance in social amenities; this is detrimental to the former (Ronfeld et al., 2014). Furthermore, in addition to government remuneration, urban school teachers receive a wage supplement through parental contributions. In addition, in comparison to rural locations, the options to make supplementary income in cities are generally greater (Bennell & Ntagaramba, 2008; Rubagiza et al., 2016). This resulted in qualified teachers being unwilling to eagerly post to rural places, which increases their likelihood to leave and finally affects students' academic achievement (Ronfeldt et al., 2014; Tumwebaze, 2016). Therefore, there is a gap in the quality of teachers in the two mentioned areas and hence the imbalance in academic output or performance.

The school location and students' performance relationship, have been documented and reported (Ellah & Ita, 2017; Umar & Samuel, 2018). In this regard, different researchers (Alordiah et al., 2015; Bizimana et al., 2022; Nnenna & Adukwu, 2018; Olusola & Omotade, 2014; Olutola, 2016; Umar, 2017), concluded that urban students outscored students from rural areas in science and mathematics. However, Awodun and Oyeniyi (2018) discovered that wherever the school was located, played insignificant role on students' achievement in basic science. Similarly, Macmillan (2012) observed that when students from urban and rural schools were taught physics using computer-assisted instruction, their mean performance scores did not

Table 1. Research design layout

Groups	Pre-test	Treatment	Post-test
EG	O_1	X_1	O_2
CG	O_1	X_O	O_2

Note. EG: Experimental group; CG: Comparison group; X_1: Concept mapping; X_O: Conventional teaching method (teachers' regular teaching methods); O_1: Pre-test (pre-PAT); O_2: Post-test (post-PAT)

statistically significantly differ. Likewise, Yusuf and Adigun (2010) found that a student's attendance in a rural or urban secondary school has no significant influence on his or her academic achievement.

According to the literature review above, more researchers feel that urban students outperform rural ones. Others, however, maintain that the location of the school does not affect students' academic achievement. Therefore, the purpose behind this study meant to determine whether the use of CM in photosynthesis education will significantly improve the achievement of students irrespective of the school location. It will also add to the discussion because studies examining the effect ofthe location of the school on the academic achievement of students are still inconclusive.

After establishing that students' academic achievement in the sciences, notably in biology, is declining, it has become critical to identify an innovative teaching strategy to reverse this downward trend in students' achievement in that subject. Besides, having reviewed and found out the effectiveness of the CM strategy in improving students' achievement in science subjects, and having observed poor achievement in rural areas compared to urban areas, this study, therefore, sought to investigate the effects of the location of the school on students' achievement in photosynthesis using the CM instructional strategy. The general purpose of this study was to examine the effect of school location on students' achievement in photosynthesis based on a CM strategy. Specifically, the study was guided by the following research questions:

1. What is the difference in the mean achievement scores in photosynthesis between students taught using CM and those taught using CTMs?
2. What is the difference in the mean achievement scores between students from urban and rural schools taught photosynthesis using CM strategy?
3. What is the difference between the mean achievement scores of urban and rural secondary school students taught photosynthesis with the CTMs?
4. What is the interaction effect of instructional strategies (CM and CTM) and school location (urban and rural) on students' achievement in photosynthesis?

METHODOLOGY

Research Design

The study was quasi-experimental using a pre-test-post-test non-equivalent comparison group design (Creswell, 2014). This design was chosen since the students were taught in their previously established intact courses, as it would be unethical to disrupt classes for four-week experimental purposes. As a result, the usage of entire classes allowed some of the classes to be in the experimentalgroup while the other classes served as a comparison group.

Two instructional groups served as the independent variables in the design. One group was assigned to the experimental group (EG), while the other was assigned to the comparison group (CG). The dependent variable was the students' achievement in biology. Hence, there were two groups altogether in this study as illustrated in **Table 1**.

The target study population was 6,708 students in 46 lower secondary schools from which the study sample was purposively sampled. When making the selection, the following factors were considered: equivalence (schools with comparable teaching materials, infrastructure, and the availability of experienced and qualified biology teachers), school type (boarding school), school ownership, gender composition (co-educational schools); and student enrolment in year two of secondary school, geographical location of the school and having presented students in national examination. Boarding schools were chosen over day schools to maintain the same school qualities such as structure, infrastructure, and student aptitude, as boarding schools admit the highest performers (Ndihokubwayo et al., 2020). Using the above-mentioned sampling criteria, 192 SS2 students from six intact classes were sampled for this study from four secondary schools. After that, the experimental and comparison groups were assigned at random to the chosen schools. As a result, 94 students were placed in the CM group, whereas 98 were placed in the CTM group.

Research Instrument and Validation

Data was collected using the photosynthesis achievement test (PAT) before and after the intervention. Before intervention, the PAT was used to measure the students' baseline knowledge and academic homogeneity. The PAT was again used after the intervention to find out the level of students' academic achievement in photosynthesis. There were 40 multiple-choice items on each PAT (pre- and post-test). These questions were mainly past biology ordinary level national examinations. The table of specifications was used to examine the PAT elements, ensuring that they were content valid (Fives & DiDonato-Barnes, 2013). According to the table, 35% of the questions assessed their understanding of the concepts, 22.5% checked comprehension, 17.5% tested application, 15% tested analysis, and 10% examined synthesis. The achievement test was prepared by researchers and verified by two biology teachers from secondary schools with over ten years of biology teaching experience and two specialists in science education, test, and measurement. The Kuder-Richardson (KR-21) internal reliability was 0.82 after pilot testing.

Intervention

Before the treatment period began, the biology teachers who served as research assistants to facilitate the use of CM and CTM were trained separately. The study purpose guided this training, the topics to be delt with, the methods as well as handling of PAT. Teachers for the CM group were trained on CM strategy using a prepared concept map. They were also shown examples of concept maps created by computers. **Figure 1** depicts an example of the offered computer-generated concept map.

The PAT was given to students in all groups before treatment. This was done to determine whether the students' knowledge of photosynthesis was comparable before the intervention. Following that, for the four weeks of the instructions, the three groups were taught by their respective biology teachers. Before intervention, students in the CM classeswere trained on CM strategy, and this lasted for one week. Students were trained on the use of CM as well as how to

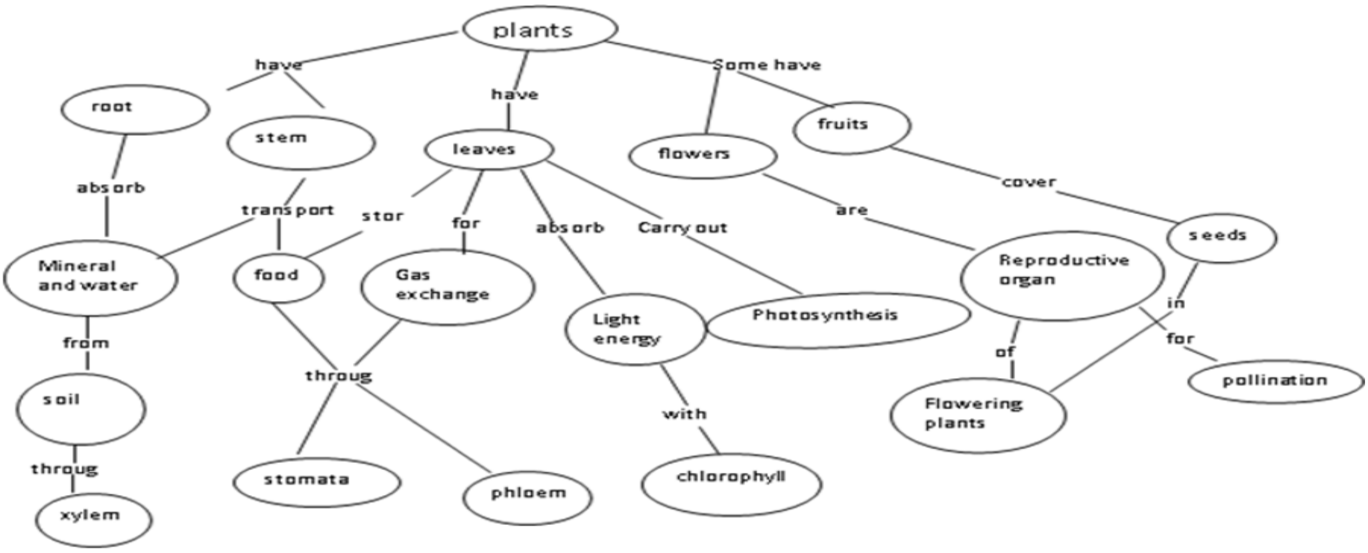

Figure 1. Computer-generated concept map about plant parts and functions

Table 2. Summary of analysis of variance of the students' pre-test scores

Group	N	Mean	Standard deviation	F	Sig.
Concept mapping	94	29.79	6.09	.223	.637
Conventional teaching methods	98	30.25	7.44		
Urban	90	29.36	7.07	1.624	.204
Rural	102	30.61	6.47		

develop concept maps. The plant topic, which was not part of the core study's topics, was also used to teach learners about the stages of CM. Students were given a teacher-made concept map of the plant. Students were provided more guided practice exercises as well as comments from the teachers. To become familiar with CM, students developed concept maps on their own using the terms provided by the teacher. Teachers inspected student-created maps, identifying and correcting flaws, and displaying the finest maps on the glass walls.

The photosynthesis unit topics taught included the introduction to photosynthesis, necessities of photosynthesis, adaptation of the leaf to photosynthesis, limiting factors of photosynthesis, the importance of photosynthesis, and mineral requirements for plant growth. An introduction, presentation, and summation were all part of the teaching-learning process. Teachers used a concept map to analyze each day's lesson at the end of each class. This process was repeated, and students created concept maps for all of the topics presented. Students created a more general concept map after finishing the photosynthesis course by combining all of the maps they had created after each topic class. To double-check their concept maps, they were provided a reference concept map.

During the study intervention period, the comparison group (CTM classes) was taught the same unit as the experimental group. Teachers used their normal teaching procedures, which included presentations, discussions, and practical work. The teaching and learning process in all study groups took four weeks. All classes of SS2 in all selected schools were exposed to the same lessons by regular class teachers, using the instructional strategies/ methods assigned to each school to avoid the Hawthorne effect. Nevertheless, teaching activities were closely monitored during the whole treatment period. At the end of the treatment, the PAT was then administered to students in all three groups as a post-PAT.

Analyzing of Data

The inferencial and descriptive statistics were applied to analyze data. The analysis of variance (ANCOVA) was used to test the hypotheses while the research questions were answered with the help of mean and standard deviation. In ANCOVA, the groups' pre-test scores were the covariates and their post-test ones which were the dependent variables; these were used to compare the post-test means among the groups. Besides, Scheffe's test was employed to establish the direction of the significant difference between the group means (Kim, 2018).

FINDINGS

Results for the Pre-Test Scores

Table 2 reveals that the mean achievement scores of the two groups in the pre-test are not statistically significantly different ($F=223$, $p=.637>0.05$). Furthermore, the differences in the mean achievement scores of students were not statistically significant by school location ($F=1.624$, $p=.204>0.05$). As a result, it was discovered that before the interventions, the two groups, as well as students from both urban and rural locations, were homogeneous.

What is the difference in the mean achievement scores in photosynthesis between students taught using CM and those taught using conventional teaching methods?

PAT was used as a pre-test and post-test for students in EG and CG to answer the above research question. For EG and CG, PAT pre-and post-test scores were calculated, and the results are displayed in **Table 3**.

Table 3. Pre- and post-test mean and standard deviation based on treatment

Group	N	Pre-achievement test		Post-achievement test		Mean gain
		Mean	Standard deviation	Mean	Standard deviation	
CM	94	29.79	7.44	73.32	5.15	43.53
CTM	98	30.25	6.09	49.49	6.93	19.24

Table 4. ANCOVA for mean achievement scores of students taught using CM and CTM

Source	Type III sum of squares	df	Mean square	F	Sig.	Partial Eta squared
Corrected model	27,246.693[a]	2	13,623.347	360.380	.000	.792
Intercept	34,731.724	1	34,731.724	918.761	.000	.829
Pre-test	.161	1	.161	.004	.948	.000
Groups	27,219.139	1	27,219.139	720.030	.000	.792
Error	7,144.724	189	37.803			
Total	752,426.950	192				
Corrected total	34,391.417	191				

Note.[a]R-squared=.792 (Adjusted R-squared=.790)

Table 5. Mean and standard deviation achievement scores of urban and rural students taught using CM

Location	N	Pre-achievement test		Post-achievement test		Mean difference
		Mean	Standard deviation	Mean	Standard deviation	
Urban	49	28.68	7.79	74.13	5.70	45.45
Rural	45	30.99	6.94	72.43	4.38	41.44

Table 3 shows that the mean achievement score of students inthe CM group improved by 43.53, while that of the CTM group improved by 19.24. These mean gain show that students in CM classes outperformed students in CTM classes.

However, the findings in **Table 3** do not show whether the observed differences were significant. Hence, the results were subjected to inferential hypothesis one (HO_1) testing which stated that thereis no significant difference in the mean achievement scores of students between groups taught by using the CM and those taught by CTM. To test HO_1, ANCOVA testanalysis was carried out and **Table 4** shows the finding.

The result of the ANCOVA gives an $F_{(1, 189)}=720.030$, $p=.000<0.05$, which is significant at a 0.05 level of significance. This indicates a group statistical differential achievement. Consequently, this gives rise to the rejection of the hypothesis 1. Therefore, there is a significant difference in the mean achievement scores of students taught photosynthesis using the CM and those taught by using the CTM. Furthermore, the adjusted R-squared has a value of 0.790. This implies that the CM accounted for 79.0% of achievement mean scores in photosynthesis.

The results in **Table 4** do not, however, reveal the source of the significant difference in the ANCOVA test. It, therefore, becomes important to compare the two groups to find out the direction of the significant difference. This was achieved using Bonferroni multiple comparisons. The result shows that the differences between the post mean achievement scores of the CM (exerimental group) and the CTM (control group) were statistically significant differences between the post mean achievement scores of the CM (experimental group) and CTM (control group) after Bonferroni post-hoc pairwise multiple comparisons.

The t-test result ($t=23.832$; $p=.0000<.05$) reveals that there is a significant difference in the achievement in favour of the CM group. This means that the CM group outperformed the CTM group significantly. As a result of this finding, the CM technique is far more advanced than the CTM strategy as far as improving students' achievement in photosynthesis is concerned.

What is the mean achievement scores difference in photosynthesis between the urban and the rural students taught with the concept mapping strategy?

To answer the above research question, the pre- and post-test mean achievement scores for EG were computed as shown in **Table 5**.

Table 5 reveals that in pre-achievement tests, the students' urban and rural mean achievement scores were 28.68 and 30.99, respectively. The post-achievement test scores are 74.13 and 72.43, respectively. Furthermore, the urban students' mean increased by 45.45 points from pretest to posttest, whereas the rural students' mean increased by 41.44 points. According to the findings, there is a difference in the mean achievement scores between rural and urban students taught using the CM.

Table 5, on the other hand, does not indicate whether the observed differences were statistically significant. As a result, the data were subjected to inferential hypothesis one (HO_2) testing. This stated that between urban and rural students, there was no significant difference in the mean achievement scores when taught by using the CM. To test HO_2, the ANCOVA test was carried out and the results are shown in **Table 6**.

The result of the ANCOVA in **Table 6** gives an $F_{(1, 91)}=2.340$, $p=.130>0.05$. As a result, the achievement mean scores of urban and rural students taught photosynthesis using the CM do not differ significantly. As a result, hypothesis two is accepted implying that there is no significant difference in mean achievement scores between urban and rural students taught photosynthesis using the CM.

What is the difference between the mean achievement scores of urban and rural secondary school students taught photosynthesis with the conventional teaching methods?

To answer the above research question, both achievement scores for CG from the pre- and post-test for CG were calculated, and the results are displayed in **Table 7**.

Table 7 shows that in pre-achievement tests, the students' mean scores from both locations were 30.17 and 30.04, respectively. In the post-achievement test scores, the mean scores were 52.46 and 47.35,

Table 6. ANCOVA for mean achievement scores between urban and rural students taught photosynthesis using CM

Source	Type III sum of squares	df	Mean square	F	Sig.	Partial Eta squared
Corrected model	70.734[a]	2	35.367	1.339	.267	.029
Intercept	29,211.976	1	29,211.976	1,105.603	.000	.924
Pre-test	2.981	1	2.981	.113	.738	.001
Groups	61.822	1	61.822	2.340	.130	.025
Error	2,404.379	91	26.422			
Total	50,7761.360	94				
Corrected total	2,475.113	93				

Note.[a]R-squared=.029 (Adjusted R-squared=.007)

Table 7. Mean and standard deviation achievement scores between urban and rural students taught using CTM

School location	N	Pre-achievement test		Post-achievement test		Mean difference
		Mean	Standard deviation	Mean	Standard deviation	
Urban	41	30.17	6.12	52.46	8.33	22.29
Rural	57	30.04	6.11	47.35	4.76	17.31

Table 8. ANCOVA for mean achievement scores between urban and rural students taught photosynthesis using CTM

Source	Type III sum of squares	df	Mean square	F	Sig.	Partial Eta squared
Corrected model	641.569[a]	2	320.785	7.565	.001	.137
Intercept	8,581.916	1	8,581.916	202.393	.000	.681
Pre-test	20.040	1	20.040	.473	.493	.005
Groups	623.931	1	623.931	14.715	.000	.134
Error	4,028.203	95	42.402			
Total	244,665.590	98				
Corrected total	4,669.773	97				

Note.[a]R-squared=.137 (Adjusted R-squared=.119)

Table 9. ANCOVA for interaction effects of instructional strategies and school locations on students' achievement in photosynthesis

Source	Type III sum of squares	df	Mean square	F	Sig.	Partial Eta squared
Corrected model	27,938.284[a]	4	6,984.571	202.400	.000	.812
Intercept	33,984.011	1	33,984.011	984.795	.000	.840
Pre-test	2.471	1	2.471	.072	.789	.000
Groups	25,842.288	1	25,842.288	748.862	.000	.800
Location	549.740	1	549.740	15.930	.000	.079
Groups*location	133.362	1	133.362	3.865	.051	.020
Error	6,453.133	187	34.509			
Total	752,426.950	192				
Corrected total	34,391.417	191				

Note.[a]R-squared=.812 (Adjusted R-squared=.808)

respectively. Furthermore, the urban students' mean scores increased by 22.29 points from pretest to posttest, whereas the rural students' mean scores increased by 17.31 points. Therefore, there is a difference in mean achievement scores between rural and urban students who were taught photosynthesis using CTM in favour of students from urban schools.

In order to discover if the observed differences in mean achievement scores of both locations taught photosynthesis using CTM were statistically significant, the inferential testing three hypothesis (HO_3) post-test achievement scores was put in place. Hypothesis three looked at whether there was a significant difference in mean achievement scores between urban and rural students who were taught using the CTM. The ANCOVA test was used to test this hypothesis, and the results are shown in **Table 8**.

The result of the ANCOVA gives an $F_{(1, 95)}=14.715$, $p=.000<.05$. This implies that the difference in the mean achievement of urban and rural students taught using the CTM is statistically significant. Thus, hypothesis two was rejected. Furthermore, the value of adjusted R-squared is 0.119. This implies that the CTM contributed 11.9 % to the achievement of learners in photosynthesis.

What is the interaction effect of instructional strategies (CM and CTM) and school location (Urban and Rural) on students' achievement in photosynthesis?

In determining the interaction effects of instructional strategies and location of school on the achievement in photosynthesis, a two-way ANCOVA for achievement mean scores by study groups and locations was employed (**Table 9**).

Table 9 shows an $F_{(1, 187)}=3.865$; $p=.51>0.05$. This implies that the interaction effect of teaching strategies (CM and CTM) and location of school (rural and urban) on students' achievements in photosynthesis was not significant. The implication is that these teaching strategies and location did not interact to influence achievement in photosynthesis. Thus, the null hypothesis of non-significant interaction effect of teaching methods and school location on students' achievement in photosynthesis was accepted.

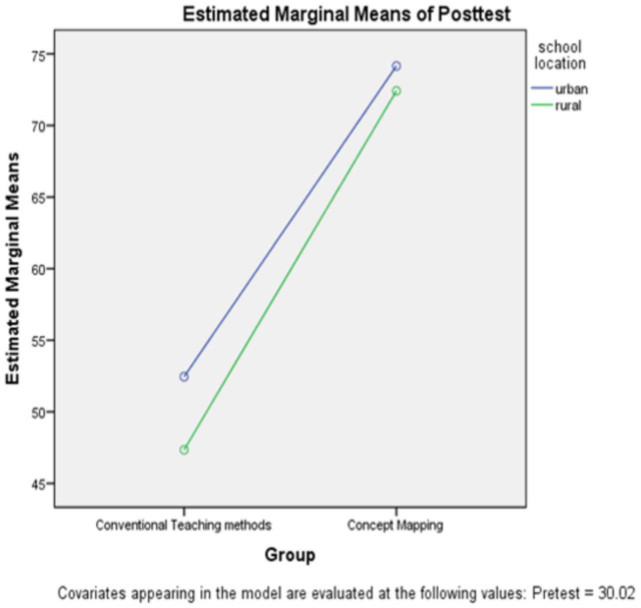

Figure 2. Interaction effect between methods and location on students' achievement in photosynthesis

The graph of interaction in **Figure 2** shows no interaction because the lines do not cross each order. This suggests that the teaching strategies and location had no interaction effect on students' achievement in photosynthesis.

DISCUSSION

This study examined the effects of school location on students' academic achievements based on the concept mapping instructional strategy. The study also examined the interaction between the methods employed and school location. According to pre-test results, EG and CG students' achievement levels were similar prior to the intervention. The effect of the CM on the students' achievement in photosynthesis was investigated in accordance with the first study question.

The finding revealed that the CM group's mean achievement score was higher than that of students in CTM group. This means that the CM group outperformed the CTM group. Besides, the inferential statistics using ANCOVA ($F_{(1,\ 189)}$=720.030, p=.000<0.05) and the Bonferroni post-hoc pairwise multiple comparisons also confirmed that the difference was significant in favor of the CM group. This result aligns with Ajaja (2013), Kyado et al. (2019), and Sakiyo and Waziri (2016); Woldeamanuel et al. (2020) who reported a significant difference in students' achievement in favor of the students in CM. However, Martins-Omole et al. (2016) found insignificant difference between students taught biology using CM and those taught using CTM.

The likely explanation of this finding may be attributed to the fact that students who were taught using CM were more efficient in activity orientations than those taught using CTM. More specifically, students in CM classes were allowed to actively participate in the teaching and learning process (Mokiwa & Agbenyeku, 2019). The CTM, on the other hand, frequently compels learnersmemorize concepts taught, which do not help learners understand the meaning and relationship between concepts and hence cause them to easily forget them, resulting in poor performance (Schmid & Telaro, 2018).

Also, the study examined the effect of CM on students' achievement in photosynthesis between urban and rural students. Descriptive statistics showed that students in urban schools achieved slightly better than those in rural school. However, when their mean achievement scores were subjected to ANCOVA ($F_{(1,\ 91)}$=2.340, p>0.005), the result indicated that difference was not statistically significant. This implies that the achievement of rural and urban students did not differ significantly when they were taught photosynthesis by using CM. The finding agreed with the study findings of Awodun and Oyeniyi (2018), Macmillan (2012), Umar (2017), and Yusuf and Adigun (2010), which revealed no significant difference between the academic achievement of urban and rural school students.

Furthermore, the study examined whether the difference existed in the mean achievement scores in photosynthesis between urban and rural students taught using CTM. It was established that the mean achievement score of the urban students was higher than that of the rural students. This implies that urban students achieved better when the CTM is employed. Also, on exposure to ANCOVA ($F_{(1,\ 95)}$=14.715, p=0.000<.05), the difference was statistically significant. This implies that when students are taught using the CTM, the achievement scores between rural and urban students differed significantly in favor of urban students. This finding agrees with the results of Bizimana et al. (2022) who reported a statistically significant difference in the achievement of students in urban and rural areas. The absence of suitable facilities for teaching and learning biology, as well as students' low motivation to study in rural schools, may account for students' poor achievement in rural locations (Nizeyimana & Nkiliye, 2015).

Finally, the study examined the interaction effect of teaching methods and school location on students' achievements in photosynthesis. The results showed that there was no interaction effect between method and school location on students' achievements in photosynthesis ($F_{(1,\ 187)}$=3.865; p=.51>0.05). This means that the achievement gap between urban and rural students in biology (photosynthesis) is influenced by teaching methods and school location. This finding is consistent with the findings of Iserameiya and Ibeneme (2018), who found no significant interaction effect between instructional strategy and school location on student achievement in basic science in Nigeria. However, the finding is at variance with Agboghoroma (2014), Udoh and Udo (2020) who found in their study that instructional strategy and school location significantly interacted to affect student achievement in integrated science and chemistry respectively. Thus, CM is superior to CTM in enhancing achievement in biology in rural and urban locations. Hence, CM has outstanding qualities for providing an equal learning environment for improving student achievement in photosynthesis regardless of school location.

CONCLUSIONS

Based on the findings of this study, it is concluded that both methods (CTM and CTM) improved students' achievement in photosynthesis. However, the group exposed to the CM performed significantly better than the group taught using the CTM. According to the findings of this study, the learning outcomes (achievement) of students exposed to the CM did not differ significantly by school location (urban and rural), while those taught using the CTM differed significantly in favor of students in urban schools. Furthermore, when the CM is used, it does not interact with school location in determining student achievement in photosynthesis. Our findings statistically demonstrated the effectiveness of the CM instructional strategy in enhancing students' learning outcomes in photosynthesis regardless of school location. As a result, biology teachers are encouraged to use strategy in their teaching process to improve students' achievement in photosynthesis as well as in other difficult concepts in biology.

Recommendations

The following recommendations are made based on the findings and conclusions of this study:

1. The study's findings have statistically proven the efficiency of the CM instruction in improving student achievement in photosynthesis regardless of the school location. As a result, biology teachers are urged to use the strategy in their classrooms in order to improve students' performance in biology.
2. The Ministry of Education shall provide serving biology teachers with the necessary knowledge, and competences in the application of concept mapping as an instructional strategy for teaching and learning through seminars, and workshops. When this is done, it will enhance effective teaching and learning, which will lead to improved academic achievement.
3. The CM should be included as a way of teaching biology and other science subjects by faculties of education at various institutions of higher learning. This will provide prospective teachers with an understanding of this instructional strategy and its benefits.

Limitations

This study was conducted in one of Rwanda's 30 districts and involved lower secondary school level students, and focused on the concept of photosynthesis. Besides, it did involve students from day secondary schools to compare boarding and day schools. As a result, more empirical researches on the effect of CM on students' achievement in other conceptsat different levels and in different types of schools should be done in order to lay a firm foundation for the adoption of CM in secondary schools in Rwanda. Furthermore, the findings of this study were based on quantitative data. As a result, gathering qualitative data on how both biology teachers and students experienced the use of CM in teaching-learning biology (photosynthesis) would have been preferable.

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