

AN INVESTIGATION INTO THE EFFECTS OF THE USE OF DIAGRAMS IN TEACHING AND LEARNING BIOLOGY AT THE HIGH SCHOOL LEVEL

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Abstract

The purpose of the study is to investigate the effects of the use of diagrams in teaching and learning biology at the high school level. Mix-Method Research: QUAN-qual Model was used in the study. Two Basic Education High Schools were selected from Yesagy Township, Magway Region by using simple random sampling method. The sample size was (176) Grade Ten biology students of 2018-2019 Academic Year. Pretest and posttest, questionnaire items, and interviews were used as instruments to measure the effects of the study. The two intact groups in each school were assigned into experimental and control groups. Before the treatment, both groups were administered by the pretest to determine group equivalence between experimental and control groups. According to the t value, it was found that the students in both schools were essentially the same before the treatment. In each school, the experimental group was given a treatment by using extensive diagrams while the control group was taught only with textbook. Independent samples t -test was used to analyze the quantitative data ($t = 7.515$, $df = 84$, $p < .001$) at BEHS, Yesagy and ($t = 7.950$, $df = 78.995$, $p < .001$) at BEHS, Ma-U-Out-Seik. The result indicated that the students who were taught by using diagrams performed significantly better than those who were not on the overall posttest achievement scores in both schools. Based on the findings of interviews and questionnaires, it can be interpreted that the students had good perception on using diagrams in teaching and learning biology and they enjoyed teaching with diagrams. Therefore, diagrams are essential to support teaching and learning process. Teaching biology can be effective through the use of diagrams, which helps students have a meaningful learning.

Keywords: biology, visual representations, diagram

Introduction

At the beginning of the last century, children were taught in a rigidly formal and stereotyped way. Education was then conceived as a process of transmission of factual knowledge only. The teacher adopted an authoritarian attitude. The facts learnt by rote by children were tested from time to time but such tests were neither concerned with conceptual understanding nor effective performance. The main emphasis was on testing memory. The teacher very often used the verbal method. The teacher had little or no sensory or other visual material to supplement his/her oral teaching.

The science of biology concerns itself with living system from cellular to the biosphere. Biology is developing more rapidly today than in any period of past. The teaching matters of biology are always changed because of the changing nature of biological sciences. The new information is observed from time to time. Teaching strategies and the teaching styles are needed to develop to encourage thinking and enquiry process in teachers. Thus, the teacher should emphasize to develop effective teaching and learning by using proper resources.

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Importance of the Research

Biology is a science of living things. Science is a methodology for learning about the world. It involves the application of knowledge. Scientists create, share, and negotiate the meanings of representations – notes, reports, tables, graphs, drawings, diagrams (Anderson, 1999). In such a case, representations play a central role in explaining scientific concepts to enhance students' learning and understanding and facilitate learners' conceptual learning processes. Ainsworth (2006) argued that the use of representations as an aid to the transmission of scientific ideas is proving to be one of several theoretical accounts relevant to classroom use of representations to support science teaching and learning. Therefore, in order to learn science effectively students must understand different modes of representations demonstrating scientific concepts and processes, and be able to translate the knowledge learnt from one representation to another, as well as realize the co-ordinated relations in representing expertise (Ainsworth, 2006).

Studies on multiple external representations have shown that representations can provide unique benefits when students are learning complex concepts (Ainsworth, 1999, 2006). When learners are interacting with multiple forms of representations to learn complex scientific concepts, representations such as diagrams, graphs and written text can provide learners with visualizations of phenomena that are difficult to achieve without such representations. Scientific ideas cannot be separated from their representation, and the learning process implies the need for students to harness the representational usage and to develop their own skills of interpreting scientific phenomena.

Representational learning environments require careful handling because different representations have different implications. Ainsworth (2006) insisted that multiple external representations can play many cognitive roles in learning complex material and these different roles fall into three distinct categories: to complement, constrain and construct. This design, functions and tasks framework for learning with multiple representations provides some insights into considering how multi-representational systems might be designed to support learning.

Some biology concepts are complex and abstract to comprehend and understand for students. Teaching of biology is a challenging work for the biology teacher, while teaching the biology concepts in classroom, teachers faced many difficulties. Thus, biologists use several types of visual representations, including graphs, photographs and drawings as well as diagrams. By using diagrams, students can understand some biology concepts that are abstract and difficult. Therefore, it is necessary to investigate the effects of the use of diagrams in teaching and learning biology at the high school level.

Purpose

The purpose of the study is to investigate the effects of the use of diagrams in teaching and learning biology at the high school level.

Objectives

The objectives of the research are as follows:

1. To examine the improvement of students' achievement in teaching and learning biology with the use of diagrams.
2. To compare the achievement between the students who are taught by using diagrams and those who are not.

Research Hypotheses

The research hypotheses of the study are as follows:

1. There is a difference between the students who are taught by using diagrams and those who are not.
2. Students will have good perception on using diagrams in teaching and learning biology.

Definition of Key Terms

Biology : Biology is the science of life and the study of the structure, function, growth, origin, evolution and distribution of living organisms. Its name is derived from the Greek words 'bios' (life) and 'logos' (study) (Bagley, 2017).

Visual Representation : Visual representations translate data into a visible form that highlights important features, including commonalities and anomalies (Szent-Gyorgyi, 2005).

Diagram : A diagram is a simplified drawing designed to show inter-relationship primarily by means of lines and symbols. Diagrams are used in the teaching of almost all subjects (Kochhar, 1981).

Review of Related Literature

Biology is the science that studies living organisms and how they interact with one another and with their environment. Biology is the science of life. Science employs both deductive reasoning and inductive reasoning (Raven, Johnson, Losos & Singer, 2005). Some biology concepts are complex and abstract to comprehend and understand for students. So, many educationists agree that instructional materials bring about improvement in the teaching/learning process as well as permit teachers and students to interact as human beings in a climate where people control their environment for their own best purposes. Also, most educators generally and equally agree that the creative use of variety of instructional materials will increase the probability that student would learn more, retain better and bring about the skills they are expected to perform. The instructional materials also offer real experiences in giving the teacher basis for thinking and understanding. They supply concrete basis for conceptual thinking and therefore reduce meaningless responses of students (Kamal-deen, 2013).

Visual-aids are items that are designed (most by teachers) to support written or spoken information so that it can be understood more easily. Visual-aids have the ability to arouse and maintain students' interest, simplify teaching, accelerate learning and improve the retention of learned information. Visual-aids bring the real thing closer to the student. They make learning experiences more natural more realistic. Learning is faster and therefore more effective when students are interested to learn when visual-aids make it easier for them to see patterns and relationships. Visual-aids make it easy for students to form mental images of abstract ideas (Foliaki, 2012).

Therefore, teachers should use the visual materials such as diagrams because visual representations play a very important role in the communication of science concepts (Ametller & Pinto, 2002, cited in Cook, 2011). Among visual representations, diagrams are important tools for biologists (Perini, 2013).

Visual Media

Visual-aids are items that are designed (most by teachers) to support written or spoken information so that it can be understood more easily. Visual-aids have the ability to arouse and maintain students' interest, simplify teaching, accelerate learning and improve the retention of learned information. Visual-aids bring the real thing closer to the student. They make learning experiences more natural more realistic. Learning is faster and therefore more effective when students are interested to learn when visual-aids make it easier for them to see patterns and relationships. Visual-aids make it easy for students to form mental images of abstract ideas (Foliaki, 2012).

Visual media may provide the chance to learn visually and are more effective and easy for human beings. During teaching with visual media and models, students try to recognize it, or know its functions and try to have its interpretation, to understand its use. They compare it with their pre-concepts, assimilating the new phenomenon and seeking to know about it. Hence, it is good to activate the students or keep them active for eliciting in teaching and learning process (Baser, 2013).

When visual aids are used as teaching aid, it is one of the factors which cause involvement of students in the lesson because when students look at visual aid or model, it is considered as a kind of involvement. Also the uses of visual aids encourage the body movement and it may strengthen the control. So, visual aids, then, is mutually beneficial to the students and teacher. Visual aids increase the interest of students and teacher to the subject matter. Visual senses contribute to about 90 percent to all students or human learning. It means other senses have only 10 % contribution to learning. Clear pictures and diagrams increase the student's level of understanding of the material presented, and its use facilitate learning, reinforce the sayings, clarify ideas, and create excitement (Rautrao, 2012, cited in Baser, 2013).

Diagram

A diagram is a simplified drawing designed to show inter-relationship primarily by means of lines and symbols (Kochhar, 1981). Diagrams being of an abstract character require a careful foundation work before they can be used effectively with a class of pupils. Diagrams are used in the teaching of almost all subjects. They are indispensable in geometry and science. Diagrams are very helpful to show arrangements and relations. In biology teaching, the diagrams are used to explain the abstract biology concepts.

Diagram could be used to explain many facts easily using a variety of symbols and labels. Diagrams can explain facts more easily than charts. Teachers use diagrams every day and in many subjects. A diagram must be as simple as possible. Diagrams should be used along with the other aids. A good diagram must approximate two standards:

- (i) It must be technically correct and neatly drawn in paper proportions well-labeled and explained.
- (ii) It should be so prepared that it can be moved and seen from all angles (Kochhar, 1981).

Advantages and Disadvantages of Diagrams

According to Bhaavani, Khimani and Kinger (n.d.), the followings are the advantages of diagrams.

- The information gathering stage on most projects produces a substantial amount of data. This information, sometimes may not give the essence of data and hence misunderstanding create a chaos on the mind of viewer. But, good diagrams turn chaos into clarity. The essence of data becomes clear on the mind of the viewer. The diagram translates all the information and helps us to plan for the next.
- The amount of information can be overwhelming sometimes. The initial diagrams are always a good reference point – a good reminder of the most important aspects on a project. These diagrams act like a roadmap which guides the viewer.
- The data collected may require to be communicated with different persons. These persons may come from different castes and may have different mother tongue. This can lead to misunderstandings between them as these different persons are not mind-readers. To remove this misconception, the data can be communicated with diagrams and hence, a common plan of action could be carried out.
- The huge amount of data collected may not be grasped in mind within a short period of time. Also, the characteristic of the variables of data may not be revealed easily. But, all the difficulties while grasping data can be removed with diagrams. Diagrams provide an effective way to summarize the whole data. This summarized data could be grasped up easily and be remembered for a sufficiently long time. The characteristic of the variables of data are easily revealed. Hence, learning data through diagrams saves time.

Bhaavani, Khimani and Kingler (n.d.) also pointed out the disadvantages of diagrams. The disadvantages are:

- There is a loss of accuracy of data while representing data through diagrams. It is obvious that there will be loss of data as it is the summarization of the whole data.
- Sometimes the illusionary effect creates a wrong impression on the mind of viewer.

Research Method

In the research, “the effects of the use of diagrams in teaching and learning biology at the high school level”, Mix-Method Research: QUAN–qual model, also known as the explanatory mixed methods design was used.

Table 1 Population and Sample Size

Name of School	Population Size (Student)	Sample Size (Student)
BEHS, Yesagy	235	86
BEHS, Ma-U-Out-Seik	124	90
Total	359	176

Instruments

Pretest and posttest, questionnaire and interviews were used as instruments to measure the effects of the study.

Data Analysis

The pretest was used to see if the groups were essentially the same before the treatment. To be able to determine whether there are significant differences between the experimental group and control group, the posttest scores of the groups were used. Because of this procedure, it is

most appropriate to use the *t*-test for independent samples. The Statistical Package for Social Scientists (SPSS) version 23 was used to analyze the quantitative data. Descriptive statistics showing mean, standard deviation and independent samples *t*-test are commonly presented. For qualitative study, after data are collected, qualitative data analysis is conducted by a multistage process of organizing, categorizing, synthesizing, analyzing, and writing about the data (Gay, Mills & Airasian, 2012). The following table shows that there is no significant difference between the means of the experimental and control groups in both schools before they are treated.

Table 2 Analysis of Means on Pretest

School	N		M		SD		t	df	Sig.(2-tailed)
	E	C	E	C	E	C			
BEHS, Yesagy	43	43	32.84	32.47	3.988	3.954	.434	84	.665(ns)
BEHS, Ma-U- Out-Seik	45	45	39.51	39.07	4.879	5.227	.417	88	.678(ns)

Note: E = Experimental, C = Control, ns = not significant

Procedure

For studying the effects of the use of diagrams in teaching and learning biology at the high school level, two Basic Education High Schools were selected from Yesagy Township.

First of all, the researcher requested and discussed the headmasters and two teachers who teach Grade Ten biology to cooperate in the study and to assign the content area. Two classes from each school were assigned as experimental and control groups to receive the treatment. The pretest was administered to both groups. The mean scores of the two groups were compared by using the independent samples *t*-test to determine group equivalence between experimental and control groups at the beginning of the study.

In each school, the experimental group was given a treatment by using diagrams. The researcher prepared the lesson plans for the content assigned for this study with the help of supervisor before teaching for the class of experimental groups. During instruction, the researcher used many diagrams. On the other hand, the control group was taught only with textbook. The researcher wrote the lesson plans for the content assigned for the study with the help of supervisor before teaching for the class of control group.

The researcher taught both the experimental and the control groups. The treatment period was four weeks. One period per day was taken for each group in each school. One period was lasted 45 minutes. At the end of the treatment period, the posttest was conducted for both groups. The allocated time for the posttest was 1:30 hours and the given marks were 50 marks. And then, questionnaire on perception of students towards using the diagrams was administered to experimental groups, followed by the interview given to all students who had been exposed to the treatment with the diagrams at the conclusion of the study. Then, the findings were presented based on experimental and control groups' scores, the students' perception to the questionnaire and the interview data.

Findings

This section describes quantitative and qualitative findings.

Quantitative Findings

This section deals with the findings of the experimental study and perception of students towards using diagrams. Data obtained from the posttest were analyzed by using independent samples *t*-test to compare the differences between the experimental and control groups of each school.

Analysis on Overall Posttest Achievement Scores

Table 3 Analysis on Overall Posttest Achievement Scores

School	N		M		SD		t	df	Sig.(2-tailed)
	E	C	E	C	E	C			
BEHS, Yesagy	43	43	43.16	35.86	4.359	4.647	7.515	84	.000***
BEHS, Ma-U-Out-Seik	45	45	42.67	36.07	3.205	4.555	7.950	78.995	.000***
Total	88	88	42.91	35.97	3.798	4.575	10.954	168.310	.000***

Note: E = Experimental, C = Control, ****p* < .001

The means of experimental group were significantly higher than those of control group in both schools. It indicated that there was a significant difference between experimental and control groups on overall posttest biology achievement scores. It can be seen in following Figure.

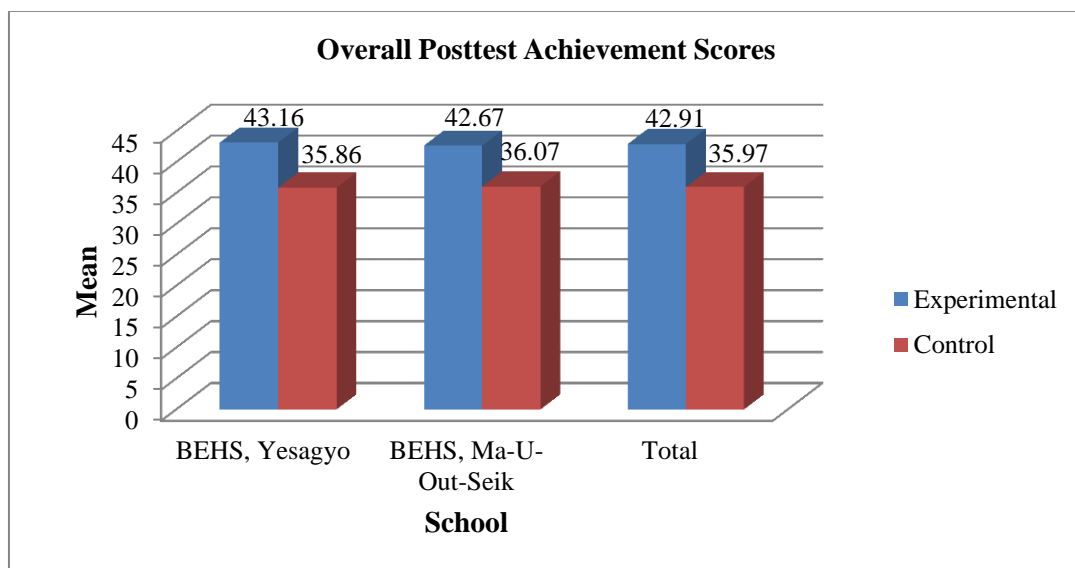


Figure Comparison of means for overall posttest achievement scores.

Based on the above findings, it can be interpreted that the use of diagrams has significant effect on biology achievement scores. Hence, the use of diagrams has a positive effect on biology teaching at the Basic Education High School level. Using the diagrams can make effective learning in the students’ cognition.

Perception of Students towards Using Diagrams

Responses from questionnaire on perception of students towards using diagrams were used to see if there was consensus of opinion about the use of diagrams.

From the questionnaire data, it was observed that all of the students (100%) from the experimental groups agreed with the following facts that the diagrams help them in:

- understanding the meaning of the lesson better,
- promoting learning and retention of new lessons,
- making biology class interesting and
- knowing the links between new knowledge and previously obtained knowledge.

Motivation of learners is one of the most important factors in teaching. It was observed that teaching by using the diagrams improved the students' motivation to learn the lesson and made the class more interesting. So, they understood the meaning of the lesson better and could know the links between new knowledge and previously obtained knowledge. Therefore, they improved their learning and retention of new lessons.

Over 90% of the students agreed with the following items:

- Diagrams stimulate the students to learn biology.
- The use of diagrams has improved the students' learning in biology.
- Using the diagrams makes the students feel comfortable in learning biology.
- The student would like to learn biology with extensive diagrams in addition to those in textbook.
- When the students can explain a biology concept with different types of diagrams, the students feel more confident about their learning.

It was observed that teaching by using the diagrams could stimulate the students to learn the lesson and helped them to learn the lesson easily. So, they felt comfortable in learning and improved their learning in biology. Therefore, they are likely to learn biology with the diagrams.

Eighty six percent (86%) of the students agreed that the diagrams help me to contribute in class discussion.

It was observed that because the diagrams helped the students to contribute in class discussion, the students could share the ideas with each other, they participated actively in learning activities, they are interested the lesson and improved their interpersonal skills. It can also be interpreted that students enjoyed teaching with the diagrams and they had good perception on using the diagrams in teaching biology.

Qualitative Findings

For this section, semi-structured interview was conducted in order to make quantitative findings more reliable.

Analysis on Students' Interview

Interview was given to six experimental students, three from each school, to find out students' perceptions about the use of diagrams in the classroom. Interviews were semi-structured type and in face to face format. Responses were recorded by audio-taping and they

were transcribed. Interview questions can be found in below. The interview was given at the conclusion of the study; after all students had been exposed to the treatment with the diagrams. The answers to each question varied. Answers to each interview question are summarized as follow.

1. Do you think that diagrams play an important role in teaching and learning biology?

Student 1: Yes, I do. This is because teaching and learning biology with the help of diagrams make it easier to understand the content more quickly and more exactly than the words alone.

Student 2: Yes, I do. This is because I can learn the lessons more easily with the help of diagrams than the words alone. That is why I think diagrams play an important role.

Student 3: Yes, I do. This is because I can remember the lessons more easily with the help of diagrams than the words alone.

Student 4: Yes, I do. This is because we have to learn biology in English. If we learn it through the diagrams, we can understand it more easily. That is why diagrams are important.

Student 5: Yes, I do. This is because in learning biology, we can learn it more easily with the help of diagrams than the words alone. That is why diagrams are important.

Student 6: Yes, I do. This is because it is difficult to learn the words alone, and it is easy to learn the lessons with the help of diagrams.

From this question, all students indicated that they think that diagrams play an important role in teaching and learning biology.

2. Do you like being taught by using diagrams in biology?

Student 1: Yes, I do. This is because learning the lessons with the help of diagrams make me remember it more easily.

Student 2: Yes, I do. I can learn the lessons more quickly and easily with the help of diagram.

Student 3: Yes, I do. This is because I like drawing and it also makes me feel relaxed. That's why I like it.

Student 4: Yes, I do. I can learn the lessons more quickly in a short period of time with the help of diagrams.

Student 5: Yes, I do. Studying the lessons with the help of diagrams not only makes me easy to learn, but also makes me feel relaxed. So, I can learn a lot.

Student 6: Yes, I do. This is because studying diagrams is easier than studying the lessons alone.

All six students like being taught by using diagrams in biology.

2. What are the difficulties during learning with diagrams?

Student 1: I have some difficulties in drawing.

Student 2: The difficulty is that drawing takes a long time.

Student 3: We have to draw the portraits of living things. It takes some time to do so. That's the difficulty.

Student 4: I like drawing but it is time-consuming. It is also difficult when we don't know how to draw.

Student 5: Yes, I have difficulties in drawing the portraits of plants and animals and incorrect labeling and spelling.

Student 6: The difficulty is that I have to draw diagrams that I have not seen before.

Four of the six students indicated that they have some difficulties in drawing because drawing takes a long time. Two of the six said that they have difficulties in drawing the portraits of plants and animals and in correct labeling and spelling.

3. When you were taught biology concepts by using diagrams, do you think it would help you learn better?

Student 1: Yes, I do. When the teacher explains to us the lessons by using diagrams, I can remember almost all the lessons. Even when I can't recall the lessons, I can recall the lessons with the help of diagrams.

Student 2: Yes, I do. This is because even if we can't remember the lessons we have learned by heart, we can write it our own words since we remember the diagrams.

Student 3: Yes, I do. Learning the lessons with the help of diagrams can save times and make us learn it more quickly than the rote learning with only text.

Student 4: Yes, I do. Since I learn the lessons with the help of diagrams, it is easy to remember the lessons. In the exam, we can get clue to answer the questions from the diagrams even if we forget the lessons.

Student 5: Yes, I do. I can not only draw the diagram but also retain the lessons longer. I can also label the diagrams with correct spellings. That's why I think it is an improvement.

Student 6: Yes, I do. Learning with diagrams is helpful to remember the lessons.

All students indicate that they feel the diagrams have been most helpful.

4. Tell me your feelings about learning biology with the help of diagram.

Student 1: I like it very much. This is because those are the diagrams of plants and animals, which can be seen in our environment.

Student 2: I like it. This is because we can learn animals and plants with the help of diagrams.

Student 3: I am happy because I like drawing.

Student 4: I feel satisfied because I have become better at drawing.

Student 5: I like it. This is because I can learn the lessons more easily with the help of diagrams.

Student 6: I am happy. I love drawing.

Three of the six students indicated that they like diagrams, and three of the six said that they love drawing.

5. Do you have a long retention of biological concepts taught with the help of diagrams?

Student 1: Yes, I do. I listen carefully to the teacher's teaching as I like diagrams. That's why I can retain them longer.

Student 2: Yes, I do. This is because I can focus on the lessons as I love learning through diagrams.

Student 3: Yes, I do. This is because I can study eagerly.

Student 4: Yes, I do. As learning the lessons through diagrams look like watching a movie, I can retain it longer.

Student 5: Yes, I do. In biology, learning with text alone is easy to forget but through diagrams, I have a long retention of it.

Student 6: Yes, I do. Learning the lessons with the help of diagrams helps me remember the lessons and it is also helpful in the exam in a way that by just thinking about the diagrams, I can answer the questions.

Three of the students indicated that they have a long retention of biological concepts taught with the help of diagrams because learning the lesson alone is easy to forget but through diagrams they have a long retention of it and the lessons through the diagrams helps them remember the lessons and is also helpful in the exam even they can't recall the lessons. Three of the six students said that they also have a long retention because they can focus on the lessons as they love learning through the diagrams.

6. Teaching with the use of diagrams makes the classroom an interesting place.

Do you agree with this statement?

Student 1: Yes, I do. Most students including me like diagrams and listen carefully to the teacher's explanations of how to draw diagrams and how to explain by using diagrams.

Student 2: Yes, I do. Most students like the teacher's teaching in which he uses diagrams. So, they can pay attention to the teacher.

Student 3: Yes, I do. This is because studying the lessons with diagrams is very interesting and knowledgeable.

Student 4: Students are interested in diagrams. If they are taught through them, the classroom will be a happy and interesting place.

Student 5: Yes, I do. This is because diagrams can be both the plants and animals that we have seen and the ones we haven't seen, students are interested in that.

Student 6: Yes, I do. This is because teaching students by using diagrams can make them happy and they like drawing.

Three of the six felt that the diagrams were specifically shown during the study helped them learn concepts. All six felt the diagrams made class more interesting.

7. Can teacher's teaching with the use of diagrams from many sources (Google, Facebook, Internet and Website etc.) besides textbook make conducive learning? Why or why not?

Student 1: There are not only the lessons with diagrams but also the lessons with no diagrams. If we can make a text with diagrams, it can be understood easily.

Student 2: If we can teach the lessons with the help of diagrams, it will be more effective.

Student 3: The lessons with the help of diagrams can be memorized more easily than the lessons without diagrams.

Student 4: Yes, I do. This is because we can learn the plants and animals extensively. Diagrams should be used because they can raise the speed of studying.

Student 5: Yes, I do. In biology textbook, there are not only the lessons with diagrams but also the lessons with no diagrams. If we can learn the lessons through the diagrams, we can understand them.

Student 6: Yes, I do. It is beneficial.

Four of the students indicated that diagrams are beneficial to them because there are not only the lessons with diagrams but also the lessons with no diagrams in biology textbook. So, learning the lessons through the diagrams makes students easier to understand the concepts. Two of the six students said that the lessons with the diagrams can be memorized more easily than the lessons without diagrams and it will be less time consuming.

To sum up, students indicated in the interview that diagrams were useful and made class more interesting. Thus, students had good perception on using diagrams in teaching and learning biology.

Conclusion

Discussion

The following points are discussed as the results of the study.

Discussion for Hypothesis 1

The posttest means of experimental group was significantly higher than the means of control group for overall posttest achievement scores in each school. The finding revealed that there was a significant difference between the students who are taught by using diagrams and those who are not. As a result, experimental groups performed more effectively than the control groups for overall posttest achievement scores. Baser (2013) believed that the use of visual media is good to activate the students or keep them active for eliciting in teaching and learning process. Visual media is mutually beneficial to the students and teachers. Visual media increase the interest of students and teacher to the subject matter (Rautrao, 2012, cited in Baser, 2013). According to Foliaki (2012), visual-aids have the ability to arouse and maintain students' interest, simplify teaching, accelerate learning and improve the retention of learned information. It was found that diagrams facilitate and promote in teaching and learning biology. Furthermore, when properly combined and appropriately used, the diagrams could help the teacher to teach more efficiently and effectively and learners to learn faster, better retain longer and transfer learned material more effectively. There is a link between attitude and achievement. If students are more engaged and more motivated to learn, then achievement is likely to increase. When students have a more positive attitude towards class and the content learned, then achievement could follow. This implies that the use of diagram was successful and boosted students' achievement.

Discussion for Hypothesis 2

When analyzing data for the student surveys, it was observed that all of the students (100%) from the experimental groups agreed with the statement that teaching by using the diagrams improved the students' motivation to learn the lesson and made the class more interesting. So, they understood the meaning of the lesson better and could know the links between new knowledge and previously obtained knowledge. Therefore, they improved their learning and retention of new lessons. Over 90% of the students agreed that teaching by using the diagrams could stimulate the students to learn the lesson and helped them to learn the lesson

easily. So, they felt comfortable in learning and improved their learning in biology. Therefore, they are likely to learn biology with the diagrams. Eighty six percent (86%) of the students agreed that the diagrams helped the students to contribute in class discussion, the students could share the ideas with each other, they participated actively in learning activities, they are interested the lesson and improved their interpersonal skills. It can be interpreted that students enjoyed teaching with the diagrams and they had good perception on using the diagrams in teaching biology.

The responses to interview questions were also useful in this study. The six students indicated that the use of diagrams make biology class interesting and comfortable in learning, stimulate to learn and improve learning in biology. And then, diagrams helped them to see links, summarize concepts, contribute in class discussion, and understand the lesson better. So, if students feel positively about using extensive diagrams in teaching, then diagrams could still be used in teaching of biology. In teaching, many strategies can be used. The use of diagrams can help students to pay attention more. Students also showed that they had opportunity to interact with their classmates, enjoyed the use of diagrams and wished it to be used in other lessons. Therefore, the students had good perception on using the diagrams in teaching biology.

Recommendations for Further Research

The major findings in the study have prompted the researcher to make the following recommendations so as to facilitate further improvement in the effective utilization of diagrams in teaching and learning biology.

1. Further studies should be conducted to investigate the teachers' attitudes towards the effectiveness of using diagrams in teaching biology.
2. Further research should be extended with a larger sample and a longer term of study in order to obtain more reliable and valid results.
3. This study deals with biology students at the high school level. Therefore, similar studies should be investigated on the teaching of other various subject areas at different grade levels to determine whether similar or different result could be obtained.
4. The study should be replicated in other districts and regions in Myanmar.
5. Teachers should always try their best to make use of available diagrams which make their lessons more interesting.
6. Government and school principals should provide biology teachers with enabling environment for the use of available diagrams in order to make learning more meaningful. Government and school principals should also supply finance for biology teachers to make teaching and learning easier, practical, appealing and enjoyable and promote academic standard.
7. Workshops, conferences and seminars should be organized for teachers where they would be taught how to use the diagrams effectively for the achievement of educational goals and how to incorporate into main stream of pedagogy in teaching various subject areas at different grade levels.

Conclusion

The major purpose of the study was to investigate the effects of the use of diagrams in teaching and learning biology at the high school level. Mix-Method Research: QUAN-qual Model was used to compare students' biology achievement between Grade Ten biology students from two selected schools. It was conducted in Yesagyo Township, Magway Region. The instruments for this study were pretest and posttest, questionnaire and interview. In order to get the validation and expert opinions, the sets of pretest and posttest questions, making schemes and questionnaire items were distributed to the five educators from Sagaing University of Education.

Before the treatment, pretest was used to check the equivalence of the two groups. These two intact groups were assigned as experimental and control groups. According to the *t* value, it was found that the students in both schools were essentially the same before the treatment. In each school, the experimental group was taught by using extensive diagrams and textbook while the control group was taught by using textbook only. After treatment period, the posttest was administered to both groups. Independent samples *t*-test was used to examine whether there were significant differences according to Revised Bloom's taxonomy levels of cognitive domain. And then, the questionnaire was administered to the experimental groups in order to investigate students' perception on using the diagrams. And then, the six students were interviewed to delve into their ideas about the use of diagrams in the classroom.

On these overall achievement scores, there were significant differences between the two groups for all selected schools. According to the questionnaire and interviews, students had good perception on using the diagrams in learning biology and the students felt the diagrams that were specifically shown during the study helped them learn concepts and made class more interesting.

Based on the findings of the study, it can be concluded that the diagrams are essential to support teaching-learning process. The students taught with diagrams have excellent achievement scores compared with those who were not. It is clear that to achieve effectiveness and efficiency in teaching-learning process, the diagrams should be incorporated. The diagrams could facilitate teaching-learning process between teachers, learners and subject matter. Students could pay attention and focus better in class if the teachers used the diagrams in teaching biology. Teaching at any level requires that the students be exposed some form of simulation. Using a variety of diagrams can enliven a class, encourage student participation, and help students grasp difficult concepts. Therefore, teaching biology can be effective through the use of diagrams, which helps students have a meaningful learning.

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