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Effect of using guided inquiry teaching method in improving grade eight students' concept of photosynthesis, primary school: Ethiopia

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Abstract

The main objective of this study was to investigate the effect of using guided inquiry teaching method in improving grade eight students' conceptual understanding of photosynthesis. The study employed a quasi-experimental research method. The data collection instruments were multiple-choice tests, observations, as well as informal assessment. The pre-test and post-test were conducted before and after treatment, respectively. The informal assessment was also conducted before and after intervention. Besides, the observation was conducted from the first day up to the last day of the intervention. The pre-test and post-test data were analysed using descriptive statistics and *t*-tests quantitatively, while data collected through informal assessment and observation were presented using narration. The finding of the pre-test revealed that there was no significant difference between the mean score of the two groups. The post-test result revealed that the experimental group students significantly improved their conceptual understanding of the topic photosynthesis compared to the control group students. The study concluded that guided inquiry teaching method was more effective than the lecture method in improving students' conceptual understanding of photosynthesis. Based on the findings of this study, it is recommended that governments should encourage biology teachers to apply guided inquiry teaching method by providing appropriate instructional material.

Keywords: Conceptual understanding guided inquiry, photosynthesis.

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1. Introduction

Education is a process of active participation of students and teachers to achieve the goal of education by using different forms of work, strategy, teaching aids and media involvement. It enables individuals and society to make all-rounded participation in the development process by acquiring knowledge, ability, skills and attitude (Oskouei & Saemian, 2012). Education is the main tool in the creation of human capital. It is the process of different activities. It involves refining, instruction and exercise. The main aim of education is to evaluate all the teaching and learning processes in every field of study (Hannasari & Bangun, 2017). Selection of teaching method is one of the primary principles in education by taking in to account the subject matter, the objective of the lesson and the nature of the learner. Therefore, teaching students how to communicate effectively, cooperate with others and learn independently have become the basics of education (El-sayed et al., 2017).

Science education has become an integral part of a school environment; however, the process of teaching and learning science faces several challenges, including the idea of memorising uncorrelated concepts, the lack of investigative activities and the use of a teaching method that does not give a chance for the student and focuses on the information as the crucial target (Qarareh, 2016). Qarareh (2016) also states that the application of educational principles and science subject should be connected in order to comprehend science teaching and learning in the classroom.

The quality of science teachers and the success of teaching science are the two sides of a coin in the teaching and learning processes of science and the main basic activity in science education is product, process and scientific attitude, not only formula and calculation (Hannasari & Bangun, 2017).

Biology is one part of science that deals with plants and animals. It is one of the science subjects studied at the primary school level in Ethiopia. Biology teaching and learning requires the best teaching method to enhance students' participation and conceptual understanding (Nkechinyere & Mumuni, 2018). Teaching methods are the several ways in which knowledge, skills, etc. are inculcated in a teaching–learning process, through the guidance of the teacher and the application of an appropriate instructional method, giving rise to an enriched learning environment and imperative outcome (Ajaja, 2013).

The main cause for this research to be written is the fact that in our teaching practice successful application of innovative learning and teaching methods are extremely rare, which is especially the case in teaching the area of natural science, or, more precisely, biology. In biology, the teaching method affects the cognitive ability and classroom participation of students in the teaching–learning process; it increases their interest to do further investigation or activities; it also makes students become independent learners who can use different sources of knowledge (Oghosa & Ekholuenetale, 2016). Kola (2017) stated that there are different types of teaching methods that are commonly used in science education. These methods include the inquiry method, lecture method, demonstration method, project method, etc.

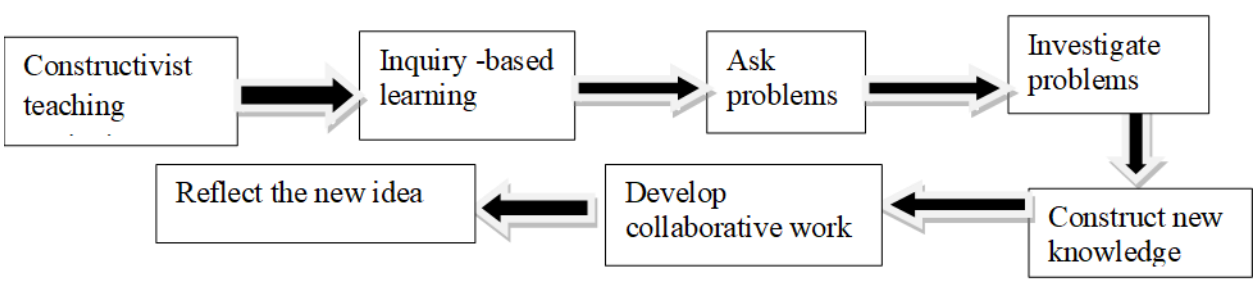

Figure 1. Model of inquiry-based learning

The inquiry teaching method is an active learning method which is learning by doing. In this type of teaching method, it is supposed that the teachers should be viewed as the guide, while students should be viewed as the knowledge maker rather than a passive listener (Dorgu, 2016). An inquiry is a process of understanding concepts by individuals through the process of testing experiments and finding additional information through investigation, and finally that the individual starts to observe associations or patterns (Shamsudin et al., 2013). In inquiry-based learning, students become engaged in many of the activities that scientists apply to construct new knowledge and this inquiry-based learning is important for learners in order to accomplish their objectives.

In fact, the teaching of biology requires making necessary provisions for students' active participation in the learning process; but in many schools, there is a gap in the teaching and learning processes of biology. The researcher understands this gap based on his experience when he taught biology for 6years at Kon Secondary School where he usually adopted the lecture method. However, the method has not allowed for better conceptual understanding by students and many students have a common misconception about the topic photosynthesis, like plants can take their own food from the environment in the form of air and minerals. The traditional teaching method is also known as the 'chalk and talk' method, which is one of the teaching methods in which the teachers transfer the information verbally to the students. This teaching strategy does not enhance students' academic achievement, does not promote students' higher level of thinking and reduces student participation since students remain passive in the lesson (Achimugu, 2018). But, according to the study by Syarkowi et al. (2018), in the constructivist theory of learning, students must participate in the teaching–learning process in order to construct their own knowledge and to understand the theory. That means in this theory of learning, students are supported as to investigate, discuss and interpret knowledge by themselves.

Literature studies revealed that in biology, photosynthesis is a very challenging concept and it is difficult to understand simply by learners. Eke (2016) noted that the concept of photosynthesis is a very abstract concept for students because of its biophysical and biochemical nature. Therefore, it requires the implementation of innovative teaching and learning methods. The study by Dimec and Strgar (2017) revealed that a tany school level all students learn about photosynthesis by the lecture learning method. Consequently, students face many difficulties in understanding the concept of this fundamental process. Research studies also showed that students have many misconceptions in relation to photosynthesis. For example, as stated by Kele and Kefeli (2010), students cannot understand the concept of photosynthesis because they have some misconceptions, like plants do not do respiration (when, in fact, plants can do respire), carbon dioxide is harmful to plant (but, in fact, carbon dioxide is important to plant as raw material for making glucose) and the main role of sunlight for the plant is to make plants more attractive in colour. In another study, many students have common misconceptions and they believe that plants get their food from the soil (Nas, 2010). In addition to this, students also have other misconceptions, like plants get their mass from the soil (Connell, 2008).

Therefore, to overcome these above-mentioned problems from the researchers' finding and experience, there is a need to strike a balance of effective teaching methods for biology, especially for photosynthesis, such as the guided inquiry method of teaching. Regarding this method, many researchers have carried out studies on photosynthesis by using the guided inquiry teaching method. For example, Eke (2016) states that the guided inquiry teaching method is more effective to improve the conceptual understanding of students about photosynthesis and facilitating students' academic achievement. Guided inquiry learning on photosynthesis is very successful and valid because it can increase the practical ability of students and develop their conceptual understanding of the concept of photosynthesis (Choirunnisak et al., 2018). The guided inquiry teaching method plays an important role in developing a student-centred approach and to improve students' conceptual understanding of photosynthesis. Thus, we hope this study can solve the above-mentioned problem as well as answer the basic research questions for this study.

2. Conceptual framework of the literature

The study was modelled by a conceptual framework which depicted a representation of dependent and independent variables and the relationships between them, as shown by arrows in Figure 1. In this conceptual framework, the teaching method and students' conceptual understanding are the two main variables. It is supposed that the dependent variable (students' conceptual understanding) might be affected by the independent variables (the traditional teaching method and the guided inquiry teaching method) and would improve after treatment by developing an appropriate or effective teaching method. In other words, if the teacher is to follow an effective teaching strategy, then the students have to improve their conceptual understanding. This study claims that the implementation of the guided inquiry teaching method significantly improves the conceptual understanding of students than the traditional teaching method.

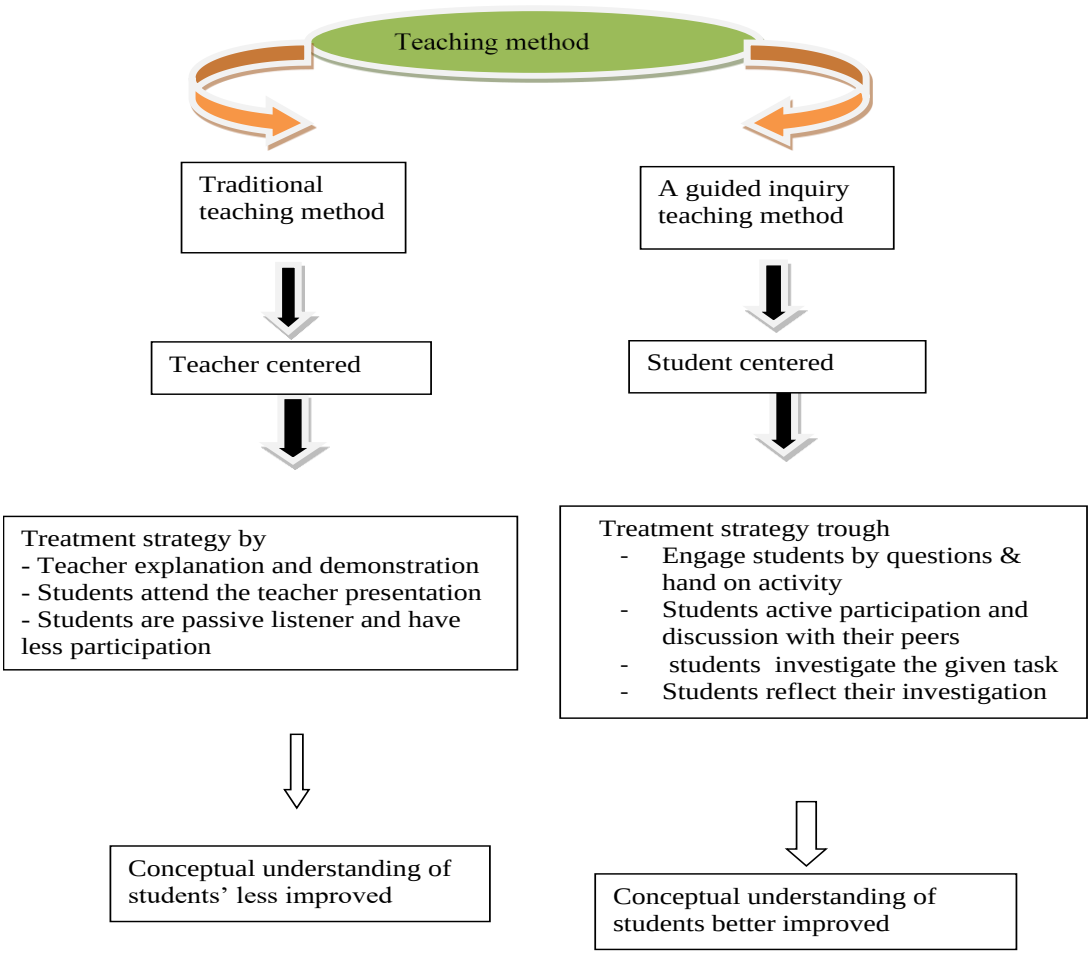

Figure 2. The conceptual framework model

The main objective of this study was to investigate the effect of using the guided inquiry teaching method in improving grade eight students' conceptual understanding of photosynthesis.

2.1. Specific objectives

- To examine the effect of using the guided inquiry teaching method in improving students' conceptual understanding of photosynthesis.
- To compare the significant difference in the test scores of students taught with guided inquiry and lecture methods about photosynthesis.
- To observe the engagement of students when they are taught by the guided inquiry teaching method.

2.2. Research questions

The following research questions are formulated to guide the study:

1. What is the effect of the guided inquiry teaching method in improving students' conceptual understanding of photosynthesis?
2. Is there a significant difference in the test scores of students taught with guided inquiry and lecture methods about photosynthesis?
3. What is the engagement of students when they are taught by the guided inquiry teaching method?

3. Materials and methods

In this study, the design-based research process was conducted. Design-based research is a systematic study of designing, developing and evaluating educational interventions. The research design adopted for this study was the quasi-experimental research methodology. This design was adopted because it used pre-tests and post-tests within experimental and control groups. The experimental group was the group receiving the treatment of a guided inquiry method, while the control group was the group receiving the treatment of the lecture method by the researchers.

In this study, there are two main variables. They are dependent and independent variables. The independent variables are the guided inquiry teaching method and the traditional teaching method, whereas the dependent variable is the students' conceptual understanding of photosynthesis.

3.1. Source of data

In order to investigate this research, the researchers used grade eight students as a source of data from Dill Chibo Primary School.

The population of the study consisted of grade eight students in Dill Chibo Primary School. The total population was217 students out of which 101 were male students and 116 were female students.

3.2. Sample and sampling technique

From the population of the study, out of four sections with a total number of 217 students, two sections with a total number of 101 students were selected as a sample by random sampling technique or lottery system. Fifty-one students were assigned to the experimental group (male 24 and female 27) and 50 students were assigned to the control group (male 23 and female 27). Therefore, the total sample population of this study was 101.

3.3. Intervention procedure

In order to investigate the effect of using the guided inquiry teaching method in improving students' conceptual understanding of photosynthesis, the researchers conducted the intervention

process for 3 weeks by preparing an intervention plan on the subtopic introduction to food manufacturing in green plants, how glucose is formed during photosynthesis, do all parts of variegated leaves carry out enough photosynthesis, the internal parts of the leaf, is oxygen a by-product of photosynthesis and does the intensity of the light affect the rate of photosynthesis. Before the implementation of the intervention, the researchers conducted the same pre-test for both experimental and control groups at the same time in order to check the background of students about the concept of photosynthesis. After this, the researchers implemented the intervention process by preparing a lesson plan through the 5E instructional design model to encourage students in each step for the experimental group. In this case, the experimental group was treated with the guided inquiry teaching method about photosynthesis, whereas the control group was treated with the lecture method about photosynthesis by preparing the lesson plan.

Finally, after the implementation of intervention, the researchers conducted the same post-test for both experimental and control groups at the same time to assess the effect of the treatment. During the intervention process, the researchers collected data through observation and informal assessment from the first day up to the last day of the lesson.

3.4. Teaching approach for the experimental group

In the experimental group, the teacher-directed strategy was the guided inquiry teaching method. At the beginning of the lesson, the teacher arranged students in the experimental classes in to heterogeneous groups according to their grades in the first-semester biology final exam and asked engaging questions about the daily lesson to identify the misconception of students and to capture their prediction. Then, the teacher invited them to do activities or experiments through their own procedures within their group by asking inquiry questions in order to eliminate their misconception and to develop their conceptual understanding. At that time, the teacher helped students by giving suggestions or comments about their activity or their procedures as a facilitator. After this, the teacher also invited them to explain or reflect their findings from their experiment and gave feedback about their answer to the guiding questions. Finally, the teacher evaluated the students by asking several questions to check whether they attained the intended objective or not and to recap the main concept of the daily lesson.

3.5. Teaching approach for the control group

In the control group, the teacher-directed strategy used was traditional instruction, and the teacher used the lecture teaching method to teach the concepts of photosynthesis. At the beginning of the lesson, the teacher invited students to read the topic of the daily lesson from their textbook within a group in their classroom. Then, the teacher gave a short note and explained the concept of the daily lesson about photosynthesis. After the explanation of the concepts, the teacher demonstrated different activities and experiments related to photosynthesis that were listed in the textbook. The demonstration was followed by the procedure listed in the students' textbook. During this time, the students observed the teacher's demonstration and could ask questions if they had any or if the demonstration was not clear. At the end of each lesson, the teacher asked several questions related to the demonstrations and the daily lesson, received students' responses and explained the results.

3.6. Data gathering instruments

The data gathering instruments for this study were a conceptual understanding test (pre-test and post-test), observation and informal assessment. These data gathering instruments were used to collect adequate information from the participant of the study.

3.7. Conceptual understanding test (pre-test and post-test)

This instrument was in the form of multiple-choice tests which were drawn from the concepts of photosynthesis. The tests were prepared by the researchers to investigate the effect of using the guided inquiry teaching method in improving students' conceptual understanding of photosynthesis. The main purpose of conducting the pre-test was to check the prior knowledge or the background of students about the topic photosynthesis. In other words, it was important to identify what student's knew about the topic photosynthesis before the intervention process. However, the main objective of conducting the post-test was to check the effect of the treatment or to compare the conceptual understanding of experimental and control group students about the topic photosynthesis. Both pre-test and post-test were similar, except the colour of the question paper, the order of the questions and the time of administration.

3.7.1. Observation

Observation is the systematic screening of people's actions, and analysis and interpretation of their activities. The researchers collected data during the treatment stage through observation from the beginning up to the last day of the lesson about students' participation, their interest towards the lesson and his teaching method, their interaction during the discussion, etc., by preparing the observation checklist.

3.7.2. Data gathering procedures

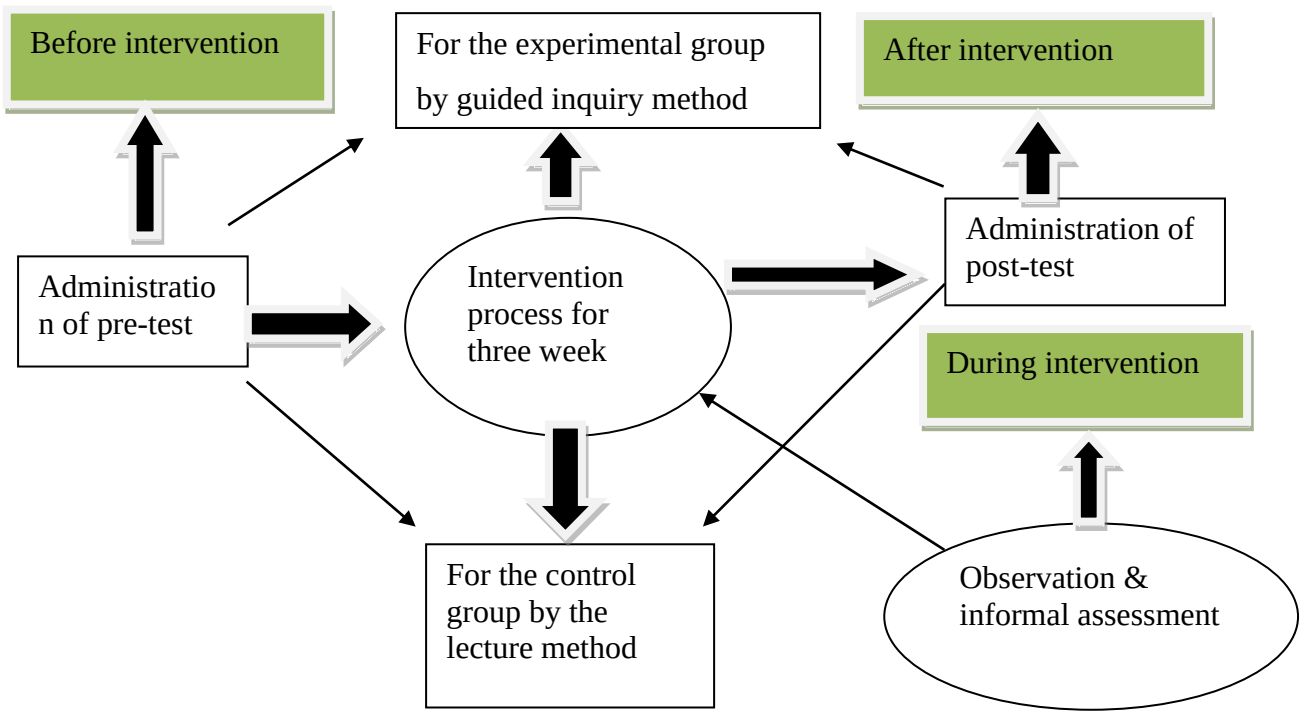

Figure 3. Data gathering procedures

As shown in Figure 3, different procedures were followed by the researchers in order to collect the necessary information for this study. First, the pre-test was conducted for the experimental and control group students at the same time. The main objective of conducting the pre-test was to check the background of students on the topic of photosynthesis. After conducting the pre-test, the treatment was conducted for 3weeks. The experimental group students were taught the

photosynthesis concept using the guided inquiry teaching method, while the control group students were taught the same concept using the lecture method. At this time, the researchers collected data through observation and informal assessment. At the end of 3weeks of instruction, the post-test was conducted for both experimental and control groups in order to compare the conceptual understanding of students in the experimental and control groups and to assess the effect of the treatment. All the tests (i.e., pre-test and post-test) were submitted to the researchers by the students immediately after the tests.

3.8. Method of data analysis

The data collected through pre-test and post-test were analysed using descriptive statistics and *t*-tests (independent sample *t*-test and paired sample *t*-test) through Statistical Package for Social Sciences (SPSS) software version 20 quantitatively, while data collected through informal assessment and observation were analysed and narrated using a narrative description of words qualitatively.

The data collected through pre-test and post-test were analysed by using SPSS programme version 20 in order to answer the first and the second research questions. Firstly, the results of the pre-test and post-test were analysed through descriptive statistics to find the mean and the standard deviation of the scores of each group. Secondly, the pre-test and the post-test were also analysed through independent *t*-test to prove if there were significant differences between the experimental group and the control group. Thirdly, both tests were also analysed through a paired *t*-test to compare the mean scores of the pre-test and post-test in the same group. In addition to pre-test and post-test, the first research question was also answered by assessing students through informal assessment (to check the conceptual understanding of students about the concept of photosynthesis). The data collected through observation were analysed to answer the third research question. These qualitative data were analysed through narration.

4. Data analysis and results

This chapter reports the analysis of the data collected through pre-test, post-test, informal assessment and classroom observation in order to answer the three basic research questions mentioned earlier and to achieve the objective of this study.

4.1. Results obtained from pre-test and post-test

4.1.1. Descriptive statistical analysis of pre-test and post-test for both groups

Table 1. Comparison of pre-test and post-test scores of students in both groups by descriptive statistics

Test	Group	*n*	Minimum	Maximum	Sum	Mean	Std. deviation
Pre-test	Experimental	51	0	6	159	3.12	1.532
	Control	50	0	7	162	3.24	1.585
Post-test	Experimental	51	5	15	522	10.24	2.605
	Control	50	3	12	363	7.26	2.311

The results in Table 1show that in the pre-test the experimental group recorded a maximum score = 6 and a minimum score = 0, and the mean score of this group was 3.12, with a standard deviation of 1.532, while the control group students recorded a maximum score = 7 and a minimum score = 0, and this group also had a mean score of 3.24, with a standard deviation of 1.585. However, in the post-test (after the treatment), the experimental group students recorded a maximum score = 15 and a minimum score = 5, and this group also had a mean score of 10.24, with a standard deviation of 2.605, while the control group students recorded a maximum score = 12 and a minimum score = 3, and the

mean score was 7.26 with a standard deviation of 2.311. This result showed that in the pre-test both experimental and control groups had approximately equal mean scores and they have the same background on the concept of photosynthesis, but after the treatment, the experimental group students had a higher mean score than the control group. This implies that the guided inquiry teaching method was an effective method to improve the conceptual understanding of students on the concept of photosynthesis.

4.2. Inferential statistics analysis of pre-test and post-test

4.2.1. Independent t-test analysis of pre-test and post-test results for both groups

Table 2. Comparison of pre-test results in both groups through independent sample t-test

Group	*t*-test for Equality of Means					
Experimental and control	*t*	df	Sig.(2-tailed	Mean difference	95% confidence interval of the difference	
					Lower	Upper
	0.395	99	0.694	0.122	−0.49303	0.73773

Not significant at $p > 0.05$.

Table 2shows the independent *t*-test analysis of the pre-test score for both experimental and control groups. The results of the *t*-test are presented as follows: the mean difference between two groups was 0.122; level of significance α value =0.05; Sig. two-tailed (*p*-value = 0.694) and $t(99) = 0.395$; $p > 0.05$. Since *p* value is greater than α value, we have enough evidence to not reject the homogeneity of the two groups in the pre-test, i.e., the mean is approximately equal with a minimum mean difference. Therefore, this result shows that there was no significant difference between the mean scores of the experimental and control groups in the pre-test or before the treatment.

Table 3. Comparison of post-test results in both groups through independent sample t-test

Group	*t*-test for Equality of Means					
Experimental and control	*t*	df	Sig.(2-tailed	Mean difference	95% confidence interval of the difference	
					Lower	Upper
	6.069	99	0.000	2.975	2.00249	3.94810

Significant at $p < 0.05$.

Table 3 shows the independent *t*-test analysis of the post-test scores for both experimental and control groups. The results of the *t*-test are presented as follows: the mean difference between the two groups was 2.975; level of significance α value = 0.05; Sig. two-tailed (*p*-value = 0.000) and $t(99) = 6.069$; $p < 0.05$. Since *p* value less than α value, we have enough evidence to reject the homogeneity of the two groups in the post-test, i.e., the mean is not equal with a wide mean difference. Therefore, this result shows that there is a significant difference between the mean score of the experimental and control groups in the post-test or after the implementation of the treatment. As this result, the experimental group students taught with the guided inquiry method had a better mean score than the control group students taught with the lecture method. This means that there is significant difference in favour of the guided inquiry teaching method.

4.2.2. Paired sample t-test for both groups between pre-post test scores

Table 4. Comparison of pre-post results for the experimental and control groups through paired sample t-test

Group	Test	Mean	Std. deviation	Paired differences			*t*	Df	Sig. (2-tailed)
				Mean difference	Std. Deviation	95% Confidence Interval of the Difference			

						Lower	Upper			
Experimental group	Pre-test	3.12	1.532	7.118	3.051	6.260	7.976	16.663	50	0.000
	Post-test	10.24	2.605							
Control group	Pre-test	3.24	1.585	4.020	2.774	3.232	4.808	10.248	49	0.000
	Post-test	7.26	2.311							

As shown in Table 4, the paired sample *t*-test was conducted to evaluate the effect of guided inquiry and lecture method on students' conceptual understanding of photosynthesis. The results of the paired sample *t*-test indicate that there was a significant difference in the mean score of both experimental and control groups in their pre-test and post-test in favour of the post-test. This means in the experimental group the mean increases from pre-test (mean =3.24, standard deviation = 1.585) to post-test (mean = 10.24, standard deviation = 2.605). The mean difference between pre-test and post-test is 7.118 with a 95% confidence interval ranging from 6.260 to 7.976. In this group, at $t(50) = 16.663$; $p < 0.05$. The same result in the control group shows that the mean is increased from pre-test (mean = 3.24, standard deviation = 1.585) to post-test (mean = 7.26, standard deviation = 2.311). The mean difference between pre-test and post-test is 4.020 with a 95% confidence interval ranging from 3.232 to 4.808. In this group, at t (49) = 10.248; $p < 0.05$.Therefore, this shows that there is a significant difference in pre-test and post-test results in favour of the post-test. However, the experimental group students recorded a higher mean score with 7.118 mean differences between pre-test and post-test, but the control group students recorded a relatively low mean score, with 4.020 mean differences between pre-test and post-test.

5. Discussion of results

The main objective of this study was to investigate the effect of using the guided inquiry teaching method in improving grade eight students' conceptual understanding of photo synthesis. To achieve this objective and to answer the following research questions, the experimental group students were treated with the guided inquiry teaching method, whereas the control group was treated with the lecture method on the concept of photosynthesis by the researchers.

5.1. What is the effect of the guided inquiry teaching method in improving students' conceptual understanding of photosynthesis?

According to the pre-test data results in Table 1, the experimental and control group students had approximately equal mean scores and standard deviations, with minimum mean differences and they had the same background on the concept of photosynthesis, but after treatment, the experimental group students had a higher mean score than the control group. This implies that the guided inquiry teaching method was an effective method in improving the conceptual understanding of students on the concept of photosynthesis.

5.2. Is there a significant difference in the test scores of students taught with guided inquiry and lecture methods about photosynthesis?

According to this table, the *p* value is 0.694, which is greater than the value of alpha (0.05). Therefore, we can conclude that there is no significant difference between the mean scores of the experimental and control groups before the implementation of treatment. After the implementation of treatment, the experimental group was taught by guided inquiry method of teaching and the control group was taught by lecture method, the researchers conducted the post-test for both groups to see the effect of the treatment.

As shown in Table 3, the results of the post-test revealed that the experimental and control group students recorded different mean scores and standard deviations; that means, the experimental group students recorded a higher mean score than the control group students. This indicates that the two groups were not equivalent in the mean scores of the post-test. This was also checked by using an independent *t*-test. In this result, the *p*-value is 0.000, which is less than the value of alpha (0.05). Therefore, we have enough evidence to say that there is a significant difference between the mean scores of the two groups in favour of the experimental group. This clearly indicates that the guided inquiry teaching method had a significant effect in improving students' conceptual understanding of photosynthesis than the lecture method.

According to Table 4, the paired sample *t*-test was implemented in the same group in order to compare the mean score of the pre-test and post-test. The results of Table 4 showed that in both experimental and control groups there is a significant difference between pre-test and post-test results in favour of the post-test. However, when we compare the mean scores of the experimental and the control groups, the experimental group students recorded a higher mean score with 7.118 mean differences between pre-test and post-test, but the control group students recorded a relatively low mean score with 4.020 mean differences between pre-test and post-test. Because of this reason, the experimental group students were beneficial than the control group students; in other words, the guided inquiry teaching method was effective than the lecture method in improving the conceptual understanding of students in the concept of photosynthesis.

In general, the results of the effect of using the guided inquiry teaching method in improving students conceptual understanding of photosynthesis in grade eight biology class at Dill Chibo Primary School showed that there is a significant difference in the mean scores of students taught the concepts of photosynthesis using the guided inquiry and lecture methods. Students taught through the guided inquiry teaching method recorded better mean scores than those students taught through the lecture method. Since the pre-test results in experimental and control groups produce relatively equal values with a very small difference in the recorded mean scores, the post-test result produces a wide mean difference between the two groups. This difference was due to the effect of the treatment. This indicates that the implementation of the guided inquiry teaching method was more effective in improving the conceptual understanding of students in the concept of photosynthesis than the lecture method. This result is in accordance with the findings of Eke (2016), who investigated the effects of guided inquiry instructional and cooperative instructional strategies on students' academic achievement in conceptual understanding of photosynthesis, and this study showed that the guided inquiry teaching method is a more successful method than the conventional lecture method. Furthermore, these results are also in accordance with the findings of Almuntasheri et al. (2016). The finding of these research studies revealed that students who were treated with the guided inquiry teaching method had a better conceptual understanding of the lesson than other students who had been taught through the traditional teaching method. In addition, the studies by Nbina (2013), Nworgu & Otum (2013), Ugwuadu (2010) found that guided inquiry teaching method is more effective in improving the performance of students than the lecture method, as this study also showed.

The result of this research study showed that students have a misconception on where do plants get their own food? They believe that plants get their food from the soil. The other misconception of students obtained from the informal assessment was that plants get their own mass from the soil and sunlight is important to plants in order to germinate the seed. This finding is supported by Connell (2008). According to this research finding, students often believe that plants and trees get their mass from the soil. In addition to this, the result of this informal assessment also revealed that some students had a misconception about carbon dioxide; they said that carbon dioxide is produced from industries, cars and burning forests; so, it is not important to plants, rather it is harmful to plants. This result agrees with Kele and Kefeli's (2010) study, which revealed that students cannot understand the concept of photosynthesis because they have some misconception, like carbon dioxide is harmful to plants.

After the misconceptions of students were elicited and identified, the next procedure was the reconstruction of students' misconception through different teaching strategies in the intervention process. That means the experimental group students were treated with the guided inquiry teaching method, while the control group students were treated with the lecture method. After the intervention process, the researchers also asked the four open-ended questions to both groups. As shown, the results obtained from post-informal assessment, most students in the experimental group eliminate their misconception that appeared in the pre-test. According to Kestler (2014), inquiry-based teaching is a successful teaching strategy to develop conceptual understanding and to eliminate students' misconception in science, especially in photosynthesis. However, in the control group, most students could not eliminate their misconception and they also could not improve their conceptual understanding. This finding is in accordance with the finding of Balci et al.(2006).The results of these research studies revealed that the teacher-centred teaching method and textbook-based instructions fail to improve students' conceptual understanding of the concept of photosynthesis and cannot change the misconceptions of students.

5.3. What is the engagement of students when they are taught by guided inquiry teaching method?

According to the result of observation data from the beginning of the intervention, the researchers observed that many students in the guided inquiry class were passive in their participation, they were not confident when they revealed their ideas and when they did different activities on their own with minimum guidance, they had less reaction with each other, their interest was less for discussion and their discussion habit also was not good. But, when the intervention process was going on, they showed a change gradually about their reaction in the classroom to do different activities. Then, the classroom observation results revealed that many students were interested, actively participate and they interacted well with their peers to conduct experiments and to discuss the given problem when they taught about photosynthesis through the guided inquiry teaching method. This finding agrees with the finding obtained by Choirunnisak et al. (2018), who found that many students were very interested towards the guided inquiry teaching method, they were very eager or actively participated in different activities or experiments within a group through a discussion on the photosynthesis concept. The other results obtained from observation data showed that students who were taught by the guided inquiry teaching method became confident with time when they performed different activities or experiments and when they reflected their ideas about the given problem by using their results from their investigation as evidence. This finding is supported by Audu et al. (2017), who described that through guided inquiry students increase their confidence and develop a deep understanding of concepts. However, the data obtained from classroom observation in the control group students who were taught by lecture method revealed that most students in this class had less participation and interest, rather they were passive listeners and their interactions during the discussion was not good. Muhammad (2016) stated that the lecture method is important to students by increasing their listening skills to be attentive to what the teacher says; however, the method also affects students' participation as it makes them also passive listeners.

6. Implications of the study

- After completing this study, it is expected that the findings will be useful for the following:
- The finding of the study may boost students' interaction in biology class because it is an activity-based learning method that may lead to positive and meaningful learning of the subject.
- The study will help biology teachers in ensuring the proper implementation of the guided inquiry teaching method during biology lesson and in organising their instructional activities in order to ensure a stable retention of the concepts.

- The finding of the study is also important for curriculum designers, particularly biology textbook writers, as a reference to write and even redesign biology textbooks.
- In addition to this, it will also be significant too ther researchers who are interested in using the guided inquiry method and conducting similar studies with different participants.

7. Major findings

What is the effect of the guided inquiry teaching method in improving students' conceptual understanding of photosynthesis?

Is there a significant difference in the test scores of students taught with guided inquiry and lecture methods about photosynthesis?

What is the engagement of students when they are taught by the guided inquiry teaching method?

As the findings of the pre-test data revealed that both experimental and control group students had approximately equal mean scores, this implies that they have the same level of understanding about the concept of photosynthesis before the treatment. However, the post-test results show that the experimental group students taught with the guided inquiry teaching method could have a higher mean score than those students who were taught by the lecture method. In addition to this, the data obtained from pre-informal assessment result also showed that both experimental and control group students had a misconception in the concept of photosynthesis, but after treatment, most students in the experimental group could eliminate their misconception and could explain the open-ended questions in a good way than control group students. The result of the observation data also showed that the experimental group students were interested in the guided inquiry teaching method, they became confident and they were very eager to participate than the control group students. Therefore, the findings of this study showed that the guided inquiry teaching method is an effective teaching method in improving students' conceptual understanding of photosynthesis than the lecture method.

8. Conclusion

Based on the findings of this study, it is concluded that the application of the guided inquiry teaching method has a significantly different effect in improving students' conceptual understanding of photosynthesis compared to the application of the lecture method. Thus, the application of the guided inquiry teaching is more effective in improving students' conceptual understanding of photosynthesis than the lecture method. The results of the study also showed that the guided inquiry teaching method is important to students, not only in improving their conceptual understanding but also to increase their investigative skill, to be an independent learner, to motivate the participation or confidence of students and to increase the reaction of students in the class with their peer to conduct different activities than the lecture method. The guided inquiry teaching method is an activity-based, learner-centred and teacher-guided teaching method. Because of the result and activity-oriented nature of the guided inquiry teaching method, it can increase the interest of students to give more attention to the lesson.

9. Recommendations

From the results of this study, the following recommendations were made:

- Biology teachers should apply more innovative teaching methods, like the guided inquiry teaching method, since the method can improve the conceptual understanding of students in photosynthesis as proved by this investigation.

- Moreover, biology teachers should engage their students through questions before starting the new lesson and they should also give students the opportunity to explain their prediction or hypothesis. This will be used in order to identify their misconception about the topic and to understand what students know about the concept before this time. The hypothesis of students should also to be discussed and tested through guided inquiry by students. If the teacher can construct a conducive learning environment for students to discuss and to test

- their hypothesis, then students can express their own idea from their discussion and the result of their investigation.

- Educational stakeholders should encourage biology teachers to apply the guided inquiry teaching method by providing appropriate instructional materials and facilities, like laboratory equipment and chemicals, because this teaching method is activity-oriented and it needs different instructional material to perform activities and they should also work together with teachers in order to have discussions on the importance of different teaching method, like the guided inquiry teaching method.

- Colleges of teacher education should encourage the use of the guided inquiry teaching method by giving training, so as to be acquainted with this activity-oriented teaching strategy in the teaching and learning of basic science in our primary schools.

- The current investigation tried to identify the students' conceptual understanding by using multiple-choice test, informal assessment and classroom observation. Thus, the authors of this study would like to encourage other researchers who are interested to conduct a study on the same area (effect of guided inquiry) by adding more instruments, like questionnaires and interviews about the method for students. Such instruments might yield sufficient data to replicate the study in other settings and see the similarities and differences of the results between the studies.

- Finally, this study was limited to Dill Chibo Primary School. It would have been more comprehensive if more schools had been included in the study. Therefore, further research, which may support or reject the findings of the present study, is needed.

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