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About the Journal

Founded in 2013, the Journal of Teacher Action Research (ISSN: 2332-2233) is a peer-reviewed online journal indexed with EBSCO that seeks practical research that can be implemented in Pre-Kindergarten through Post-Secondary classrooms. The primary function of this journal is to provide classroom teachers and researchers a means for sharing classroom practices.

The journal accepts articles for peer-review that describe classroom practice which positively impacts student learning. We define teacher action research as teachers (at all levels) studying their practice and/or their students' learning in a methodical way in order to inform classroom practice. Articles submitted to the journal should demonstrate an action research focus with intent to improve the author's practice.

Editorial Team

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THE IMPACT OF PEER LEARNING APPROACH OF TEACHING IN A PHOTOSYNTHESIS CLASS

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Abstract Teachers are confronted with many challenges in the science classroom. One of these challenges is finding a reliable learning approach to improve students' performance. This study used peer learning approach of teaching to help students learn and understand concepts in a photosynthesis class. The participants of the study were 40 science students at Shama Senior High School in the Western Region of Ghana. These students were put into mixed ability groups and taught for 10 consecutive weeks. Pre-intervention test, post-intervention test, and questionnaire were the main instruments used to collect data from the students. Descriptive statistics of the data collected shows an immense improvement in students' performance after the implementation of the intervention. The strategy used improved students' learning of photosynthesis in the classroom as well as their performance in the post-intervention test. Based on the findings of this study, it can be said that peer learning approach of teaching has a positive impact on the performance of students in the classroom.

Keywords: teacher action research, peer learning, photosynthesis, intervention, performance

Introduction

The importance of the concept of photosynthesis cannot be overlooked because of its direct link to life. This understanding is fundamental to student's understanding of how energy is transferred from the sun to living organisms in the world. According to Griffith (1997), some

common misconceptions that manifest in the classroom are that photosynthesis is a reverse of respiration, and photosynthesis only occurs in plants. For learning to be meaningful, misconceptions should be corrected by modifying students' previous knowledge in an approach known as the conceptual changes process (Smith, Blakeslee & Anderson, 1993). Panijpan, Ruenwongsa, and Sriwattanarothai (2008) investigated learners' basic understanding of simple light-dependent and light-independent processes in photosynthesis in Thailand. Findings from their study reveal that students understanding of the main concepts was poor and so could not apply basic knowledge to answer simple questions about photosynthesis even after several introductions to the topics. They attributed these weaknesses to rote learning and master-disciple relationship which is predominantly practiced in Thailand. They propose an emphasis to be placed on self-learning, collaborative learning, self-reflection, and integration of knowledge by self.

Literature Review

A classroom environment that elicits thinking must be one in which students feel safe enough to share their formative thoughts (McKeown & Beck, 1999). Peer group learning sometimes called cooperative learning has been found to have a number of beneficial effects on students and should be encouraged (Brown & Palinscar, 1989 cited in Govender, 2007). Erinosho (2008) explain collaborative learning as a practice that allows students to benefit from one another's abilities and knowledge as they interact in a small group within a non –imposing, non-threatening and non – competitive environment. Educators nowadays are more interested about the usage of collaborative problem-solving approach in improving students learning (Dillenbourg & Traum, 2006; Liu & Kao, 2007). Educators habitually do not plan well for peer interactions (Kutnick, Blatchford & Baines, 2002). The proper use of cooperative learning improved academic achievement increased, self – confidence, motivation and increased liking of school and classmates (Balckon, 1992). Peer dialogue enables students to restructure and elaborate their thoughts (Bereiter, 2002) and is very useful tool in the process of knowledge construction in classroom learning (Mercer, 1996). Studies has shown the importance of peer interaction in science classroom (Howe, Rogers &Tolmie, 1990; Howe, Tolmie, Greer & Mackenzie, 1995). The emphasis is on getting students to work together on a problem or task in small heterogeneous groups in order to achieve a common goal and support one another. Johnson, Johnson and Holubee (1993) listed five essential elements of cooperative learning processes. These elements were positive independence, face to face interaction, individual accountability, social skills and group processing. Grouping processing enables group to focus on good working relationship, facilitate the learning of cooperative skills and ensures that members receive feedback (Effandi, 2006). Groupings that consist of above average, average and below average students in groups had been reported to be most effective (Webb, 1989). American Association for the Advancement of Science (1989) re-echoed the importance of group activities. They strongly believe that the collaboration nature of scientific and technological work must be strengthened by regular group activity in the classroom.

Peer learning as a strategy of improving students' achievement in the classroom has been demonstrated in studies (Slavin, 1987; Lou, Abrami, Spence, Poulsen, Chambers & D'Apolonia, 1996; Topping, 2002). Gillies (2004) studied the effects of structured and

unstructured cooperating groups on students' behaviors, discourse and learning in Junior High School. He reported that the students in structured cooperating groups showed more cooperative behavior and demonstrated more complex and problem-solving skills than their peers in the unstructured groups. Lewis (2011) evaluated the effectiveness of Peer-Led Team Learning (PLTL) reform model in first semester general chemistry lectures. The PLTL was used in place of one-third of time allocated for lecture and maintaining the same amount of structured class time. The result shows that classes implementing the PLTL reform at the setting showed a statistically significant improvement of 15% in the pass rate compared to lecture-only classes at the same setting. The objective of this study is to improve on students' understanding of photosynthesis in plants. Therefore, the study employed peer learning as a cooperative learning strategy to help students learn and understand the processes involved in photosynthesis.

Methodology

This study is action research, which seeks to find solution to students' inability to form the right concept in photosynthesis (Griffard, 1999). The total sample size was forty science students at the Shama Senior High School in Ghana. A class of 3rd year science students were chosen as the sample of the study. This class of students was chosen because it is the only final year class pursuing general science program and they have been taught photosynthesis in the previous term. These students were taught for ten consecutive weeks. Pre-intervention test and post-intervention test (see Appendix A) were the methods used for the collection of data. A pre-intervention test on photosynthesis was given to the target group to find out their strength and weaknesses. The pre-intervention test was made up of ten (10) items. The first seven items were based on simple basic facts in photosynthesis. For the last three items on the pre-intervention test, the researcher asked the students to solve practical questions. The duration of the pre-intervention test was thirty (30) minutes. Answers of the students to the pre-intervention test items were marked using a marking scheme. After the intervention, a post-intervention test was conducted to find out how far the intervention activities helped the students to improve their understanding of photosynthesis. The post-intervention test was not exactly the same as the pre-intervention test, with the reason that if the intervention has been effective then the students should be able to answer simple questions on photosynthesis. The post- intervention test consisted of five (5) items and the duration of the test was thirty (30) minutes. A three-item questionnaire was also administered to students in order to gather further information about perceptions of their situations after the implementation of the intervention. Data on the tests were analyzed using descriptive statistics.

Intervention. To help students learn and understand the concept photosynthesis and stages involved in photosynthesis, students were put into ten groups of four. This group was formed based on students' performance in the pre-intervention test. The average score of the test was 2.4. Students who scored below 3, were classified as below average students. Students who scored 3 and those who scored above 3 were classified as average and above average students respectively. Each group consisted of one above average student, one average student and two below average students. Students were made aware that the

groups were formed for them to work together, share ideas and present one solution on assignments and activities giving during lessons. Students working together would maximize their own and each other's learning. Weekly lesson scheme as shown in Table 1 was developed and used for ten consecutive weeks. The lesson scheme consisted of basic topics and activities under photosynthesis in the syllabus developed by Ministry of Education, Ghana.

Table 1: Scheme of Work

Week	Topic/Activity
1	Autotrophs and heterotrophs
2	Photosynthesis in green plants
3	Structural adaptation of leaf for photosynthesis
4	The stages of photosynthesis (light dependent and light dependent stages)
5	Experiment to demonstrate the presence of starch in green leaf
6	Experiment to show that chlorophyll is necessary for photosynthesis
7	Experiment to show that water is necessary for photosynthesis
8	An experiment to show that carbon dioxide is necessary for photosynthesis
9	Experiment to show that oxygen is given off during photosynthesis
10	Evidence to show that there is production of starch during photosynthesis

A work plan was developed to aid the students in their lessons. This work plan as shown in figure 1, consist of five steps:

- *Reading*: students are expected to read extensively about the problem or situation they would be working on. Students are encouraged to read relevant literature on the materials provided, this will help them perform the activity successfully.
- *Discussion*: students are expected to deliberate on how to carry out the activity or solved the problem. They share ideas on the topic and discuss the guidelines for carrying out the activity
- *Activity*: Based on the instructions given, Students collaborate with each other to manipulate, demonstrate and examine the materials in a bid to come out with their findings
- *Findings*. This stage students come out with agreed solutions with inputs from each member of the group.

- *Resolution*: The findings from each group are discussed by the class. Representative from each group present their findings to the class. The findings presented are compared with the expected answer provided by the teacher.

The steps were discussed with the students and were told to use the plan whenever work or assignment is given to them.

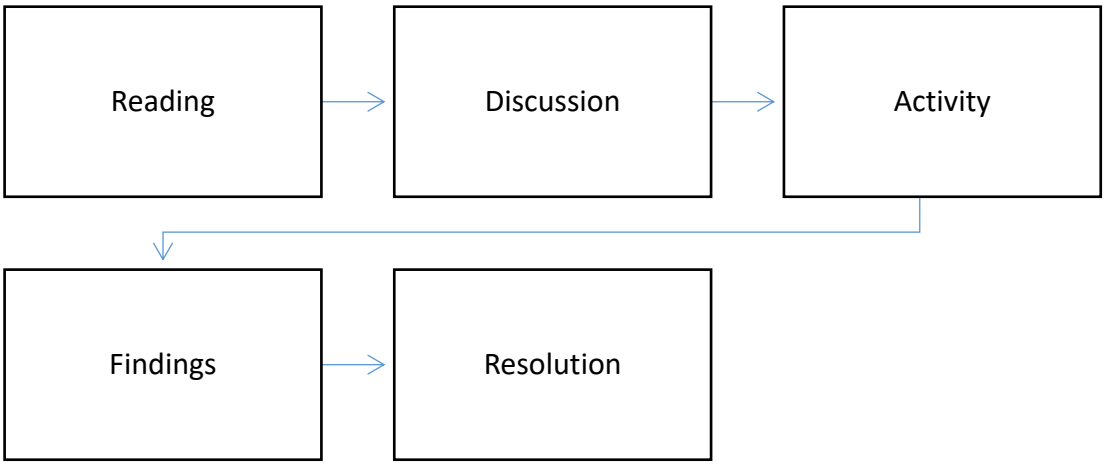

Figure 1. Students' work plan

Students were taken through weekly activities that were developed based on the scheme of work (Table 1). Details of these activities carried out are as follows:

Week One. The first lesson was on autotrophs and heterotrophs. Students were supposed to distinguish between autotrophs and heterotrophs and give at least five examples each. Students following the work plan discussed the two concepts and went out of the classroom to pick samples of autotrophic and heterotrophic organisms. Students presented guinea grass, bougainvillea, rose plant, hibiscus plant, cocoa seedlings, and plantain sucker as examples of autotrophs. They classified them as autotrophs because these organisms manufacture their own food. They presented houseflies, grasshoppers, bees, butterflies, moths, lizards as examples of heterotrophs. They classified these organisms as heterotrophs because they do not produce their own food but depends on autotrophs for their food.

Week Two. The second lesson was on photosynthesis in green plant. Students were expected to explain the concepts of photosynthesis, identify plants that can photosynthesize and those that cannot. Students discussed the concepts in groups and were asked to go out of the classroom to bring samples of plants that can photosynthesize and those that cannot. They brought in green grass, hibiscus and other examples of green plant as plants that photosynthesize. Unfortunately, they could not find plants that do not photosynthesize so they mention examples they have read in books (snow plants and Indian pipe).

Week Three. The third lesson was on the structural adaptation of leaf for photosynthesis. Students were given transverse section and cross section of a leaf to examine under a light

compound microscope and described what they see. Students described and explain what they saw under the microscope. The anatomical features important to the study of photosynthesis: stoma, guard cell, mesophyll cells, vein and chlorophyll were discussed. Most of the explanations that students gave during the discussion showed that students prepared well before coming to class.

Week Four. The concepts of light dependent and light independent processes in photosynthesis were introduced and students were given 20 minutes to discuss the concepts among themselves in each group and present their explanations to the class. Most of the explanation students gave relate with the concepts. They went on to described the Calvin cycle.

Week Five. The fifth lesson was an experiment to show the presence of starch in leaves. Each group was given the needed materials to carry out the activity. Before the commencement of the activity, students were engaged in a short discussion on how to write their reports.

Apparatus and reagents: beaker, tripod, Bunsen burner, test tube, tongs, porcelain plate, bottle containing iodine, a dropper and ethanol

The students:

- Plucked off a green leaf from a plant.
- Placed it in a beaker containing water and boiled it for about 5 minutes
- Removed the leave and placed it in a beaker/test tube containing a boiling solution of ethanol
- Rinsed ethanol from leaf by washing it with hot water
- Placed the leaf in a white porcelain plate and put few drops of iodine solution on it.

Week Six. The sixth lesson was a practical work and the objective was to find out whether chlorophyll is necessary for photosynthesis. Before the experiment was carried out, the students were given a tutorial and the needed materials were given to them.
Apparatus and reagents: iodine solution and dropper

The students:

- Took a variegated leaf (croton) with green and white patches
- Placed it in a beaker containing water and boiled it for about 5minutes
- Removed the leaf and placed it in a beaker/test tube containing a boiling solution of ethanol
- Rinsed of ethanol from leaf by washing it with hot water

- Placed the leaf in a white porcelain plate and put a few drops of iodine solution on it.

Week Seven. The seventh lesson was a discussion on whether water is necessary for photosynthesis. During the discussion it was disclosed that, there is no simple experiment that can be carried out to show that water is necessary for photosynthesis. This is because we cannot deny the plant of water. This plant will not survive without water. However, the role of water in starch production has been investigated using water containing oxygen -18.

Week Eight. The eighth lesson was an experiment to show that carbon dioxide is necessary for photosynthesis.
Apparatus and reagents: two potted plants, polythene bags, elastic bands, damp soda lime and sodium hydrogen carbonate

Students:

- Took two potted plants (balsam)
- Kept them in the dark for 3 days.
- Covered each plant with a plain polythene bag.
- Within the enclosed environment of plant A, placed damp soda lime.
- Within the enclosed environment of plant B, placed sodium hydrogen carbonate
- Placed both plants side by side in a well-lit place for 3 days.
- After the 3 days tested the leaf of each plant for starch

Week Nine. The ninth lesson was an experiment to show that oxygen is given off during photosynthesis.
Apparatus and reagents: water, beaker, funnel and testing tube

Students:

- Took a beaker of water and placed in it some pond weed.
- Covered the weed with an inverted funnel making sure the mouth of the funnel is about 2-3cm below the level or surface of the water in the beaker.
- Filled a test tube with water and place their thumb over the open end.

With the thumb covering the end of the test tube, they inverted it and placed it inside the water over the neck or stem of the inverted funnel and left it to rest
Placed some small amount of sodium hydrogen carbonate in the water contained in the beaker to ensure that carbon dioxide is released to enable the pond weed photosynthesis.
Placed the set up in an area/place where there is enough light and left it for 3 days.
Lifted the test tube from the funnel and placed their thumb over the open end.
Allowed the water to run out but did not allow the gas to escape.

Tested the gas for oxygen by using a splint of wood

Week Ten. The tenth lesson was a practical lesson and the objective was to find whether starch is produced during photosynthesis.
Apparatus and reagents: beaker, testing tube, dropper, petri dish, ethanol and iodine solution

Students:

- Used two similar potted plants of balsam to show the process.
- Kept both plant in the dark for 4 days
- Took one of the potted plants and placed in the light whilst the other was left in the dark.
- Took a leaf from each plant 3 days later and tested for starch.
- A dark blue color was formed with iodine for the leaf that was kept in the light while the leaf in the dark turned pale brown with iodine.

Results

The pre-intervention test aimed at finding the knowledge level of the students on the concept photosynthesis. Data collected from the pre-intervention test served as guide in developing suitable activities to help reduce the students' difficulties in understanding the concept photosynthesis. The post-intervention test was conducted to see how the intervention activities helped to improve the students' understanding in the concept photosynthesis. Students' performance in the pre-intervention test and post intervention test are presented in Figure 2.

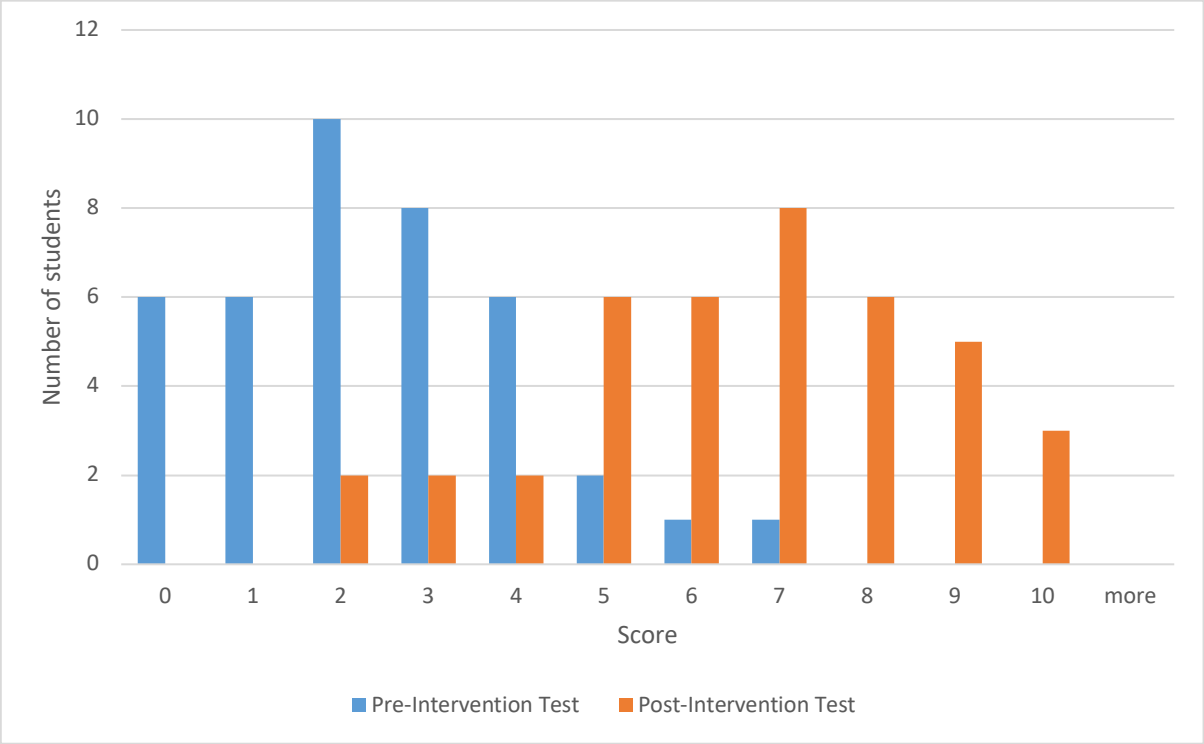

Figure 2. Performance of Students' in Pre-Intervention and Post-Intervention Tests

From Figure 2, more than half of the students (36) scored below 5 in the pre-intervention test. Six students scored 0 with the highest number (10) of students scoring 2. This result indicates that most of the students were not familiar with the questions. For example, students were asked to write a balanced chemical equation for the overall reaction of photosynthesis. Most of them could not write the equation, others could not write the chemical formula of the compounds in the reaction. Only few students wrote the balanced equation for the reaction. Students' performance improved immensely in the post-intervention test as shown in Figure 2. Most of the students scored 5 and above in the test. It can also be seen from the graph that no student scored 0 or 1, only few students (6) scored below 5. The result shows remarkable improvement in the performance of the students.

Table 2 shows the descriptive statistics of pre and post-intervention test results. From the table it can be seen that the mode, median and mean values in the pre intervention test statistics were significantly lower than in the post intervention test analysis. The mode, median and mean values of 2, 2 and 2.425 respectively in the pre intervention test shows that the general performance of the students in the test was not satisfactory. Most of the students scored below half of the total marks allocated for the test. A mean value of 6.575 in the post intervention test statistics compared to 2.425 in the pre intervention test clearly indicate significant improvement in the performance of the students. The mode and the median values of the post intervention test statistics are 7, and 7 respectively.

Table 2. Descriptive Statistics of Students' Performance before and after the Intervention

Pre-Intervention Test		**Post-Intervention Test**	
Mean	2.425	**Mean**	6.575
Median	2	**Median**	7
Mode	2	**Mode**	7
Standard Deviation	1.708013	**Standard Deviation**	2.122982
Range	7	**Range**	8
Minimum	0	**Minimum**	2
Maximum	7	**Maximum**	10
Sum	97	**Sum**	263
Count	40	**Count**	40

These statistics show that more than half of the students scored above half of the total marks allocated for the test. This change in performance can be credited to the strategy and the numerous activities that the students were exposed to. Few students who scored below 5 found it difficult to understand, interpret and apply the knowledge gained. These students were slow learners and needed lot of time in other to comprehend the concept.

A short questionnaire was administered to students after the post intervention test in an attempt to determine the effects of the intervention on their learning. Each question is listed below with sample responses:

1. Did you feel more or less comfortable in this class setting and why?
All of the students reported that they were very comfortable. They were relaxed and cooperated with each other. The activities aroused their interest and made the lessons very interesting to them.

- *Yes. The discussions and activities were very interesting*
- *Yes. The lessons are enjoyable*
- *Yes. Because I get opportunity to handle some of the apparatus*
- *Yes. I felt free and relaxed*
- *Yes. I am able to interact*

2. What effect has this new class setting on your learning?
From their responses the strategy affected their learning positively. All the students said they were motivated by their colleagues in the group. The quality of discussions that ensued between them helped them gained vital information from each other

- *I remember most of the things we discussed*
- *I learnt new things from my classmates because I get opportunity to discuss and compare my ideas with others*
- *My group members helped me when am wrong, they gave me different explanation of the problem*
- *I always read my note book before coming to class*
- *Learning has become easier for me because we do a lot of activities*

3. How do you rate your understanding of photosynthesis?
Students were supposed to respond to the above question by choosing either very good, good, satisfactory, or unsatisfactory. Thirteen students (32.5%) reported very good understanding of the concept, twenty-one students (52.5%) reported good understanding of the concept. Six students (15%) said their understanding of the concept is satisfactory but no student reported unsatisfactory understanding.

Discussion

Before the introduction of the intervention, the general performance of the students on photosynthesis concept was very poor. Students could not distinguish between autotroph and heterotroph, and could not write the balanced chemical equation for photosynthesis. Most of the students could not state the conditions necessary for photosynthesis. The performance of students in the pre-intervention test as shown in Figure 2 was very poor. The students could not analyze simple scientific concepts and facts. This poor performance can be attributed to how the students were taught. In a typical classroom lesson in the school, teachers frequently employ lecture method of teaching which leaves the students with little or no interactions with peers and materials. When the intervention was introduced, students' performance started improving and this was seen in the quality of responses during discussions. The relative success of the strategy reflected much of what is suggested by the literature (Slavin, 1987; Lou, Abrami, Spence, Poulsen, Chambers & D'Apolonia, 1996; Topping, 2002). Students could explain the adaptation of the leaf to carry out photosynthesis and distinguish between light dependent and light independent processes. They were able to describe the experiment that demonstrate the presence of starch during photosynthesis. From Figure 2, it can be seen that students' performance in the post-intervention test was good. Most of the students scored above the pass mark (5). Students performed much better in the post-intervention test than in the pre-intervention test (Table 2). This also sought to suggest that, the students have improved upon their level of understanding of photosynthesis. This improvement in performance by the students was not due to chance, but rather, it was because of the well-planned intervention strategy that was employed in class.

The results of this study support the findings of Lewis (2011) and Gillies (2004). Peer learning approach of teaching enables the students to participate actively in the lessons and also promoted cooperative learning among the students. Each student of a group was responsible not only for learning what was taught but also helped group mates learn, this created an atmosphere of achievement. It was confirmed by the students that, they were inspired and motivated by the way they were taught, which in turn helped improved their level of understanding of photosynthesis concept. The result of this study shows a positive effect of peer learning approach of teaching on students' performance.

Conclusion

The peer learning approach of teaching was the major intervention for this study. Students were put into mixed ability groups and taught for ten consecutive weeks. Based on the findings of the study, it appears obvious that the use of this approach of teaching promotes active participation of students in class. The peer learning approach of teaching promoted and sustained students' interest in the concept throughout the study period. This resulted in the improvement in the performance of students. For students to develop good attitude towards science, teachers must create a conducive and enabling cooperative learning atmosphere for them.

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Appendix A: Pre-Intervention and Post Intervention Test

Pre-Intervention Test

1. The major source of energy in the ecosystem is the……..
2. In an ecosystem, which group of organisms are classified as the most important?
3. The photosynthetic process removes ……..gas from the environment
4. What gas is released during photosynthesis?
5. Write a balanced equation for the overall reaction of photosynthesis
6. Which organelle contains the green pigment which is required for photosynthesis?
7. What is the purpose of each of the following steps or processes (7-10) when testing for starch in a leaf?
8. Boiling of the leaf
9. Placing the leaf in an ethanol solution
10. Washing the leaf with water after placing it in ethanol
11. Adding few drops of iodine to the leaf

Post-Intervention Test

1. State the products of light dependent reaction of photosynthesis
2. Distinguish between light dependent stage and light independent stage
3. Briefly explain the major limiting factors of photosynthesis
4. Describe an experiment that shows the need of carbon dioxide in photosynthesis
5. How is the leaf adapted for photosynthesis?