THE USE OF ALTERNATIVE ANIMATION AND 3-D MODEL IN TEACHING PHOTOSYNTHESIS

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Abstract

The study aimed to make an alternative animation and three dimensional models as instructional materials and use them in teaching photosynthesis topic to determine their effectiveness in different levels of assessment specifically in Knowledge, Process, Understanding and Performance. Sixty Grade 8 students who were officially enrolled in the academic year 2014-1015 comprised the participants of the study. The students were randomly assigned into two groups. The experimental group was composed of the students who were exposed to the alternative animation and 3-D model of chloroplast, light reaction and dark reaction of photosynthesis. The control group, on the other hand, was composed of the students who were exposed to pictures which illustrate the light and dark reaction of photosynthesis. The study employed a quasi-experimental design. The instruments used were the teacher-made test and the lesson plan in teaching photosynthesis. The lesson plan used was in accordance with the constructivist approach specifically the 5E model for the experimental and control group. The test followed the K to 12 guidelines in the assessment and rating of students' learning outcome. The study came up with the following findings: More students exposed to the alternative animation and 3-D model of light and dark reaction of photosynthesis demonstrate excellent competence in the knowledge level than the students who were exposed to 2-D models. The students in experimental and control group have excellent competence in the process assessment. There is a significant difference between the mean score of both groups in the understanding level of assessment. Majority of the students in both groups are in the "Beginning" and "Developing" level of proficiency in transferring their knowledge gained in solving real-world problems through the performance of real-world tasks. Moreover, there is a significant difference between the mean score of both groups in the over-all learning outcomes of the students.

Key words: Alternative Animation, 3-D Model, Photosynthesis

Introduction

Living things vary from the basic singled-cell bacterium to the complex form of organism; the human being. Despite of its differences, living things share a common characteristic to survive and proliferate. Living things need a source of energy to maintain its metabolism. The major source of energy on earth is the sun. Organisms containing chlorophyll in their cells are the only living things that can convert sun's energy into food molecules. One of these organisms is the plants. Plants are able to produce their own food through photosynthesis.

Photosynthesis is the process in which light energy is transformed into chemical energy of organic food molecules (Rabago, Joaquin, Lagunzad, & Carvajal, 2003). This process occurs in autotrophic organisms which contain chloroplast in their cell. To convey the concept of photosynthesis to the students is a great challenge for teachers because educators stressed that one of the most difficult topics in biology is photosynthesis (Eisen & Stavy, 1992).

Due to its abstract nature, photosynthesis is challenging both to teach and to learn at all year levels of schooling even in tertiary level (Bahar, Johnstone, & Hansell, 1999). Nevertheless, this process is an ultimate and essential prerequisite for ecology studies. Indeed, photosynthesis has a central role for living systems by converting the inorganic substances into organic compounds making it available for heterotrophic organism (Anderson, Sheldon, & DuBay, 1990). Since the process is quite complex and each event is intangible, students develop vague ideas and misconceptions before, during and after receiving Science lesson (Amir & Tamir, 1994). Studies revealed that students established significant misconception about the concept. One of the incomplete understandings about it is that plants are nourished by water and mineral substances from the soil through their roots (Canal, 1999). Moreover, Andersson (2008) as cited by Canal (1999) impliedly stated that foods of the plants are the water and minerals as well. Barak, Sheva, Gorodetsky and Gurion (1999) said that photosynthesis is learned properly if teaching goes beyond words and concept.

Teachers employ different teaching strategies to overcome the barriers of understanding and to achieve effective teaching-learning process. One way of achieving this goal is the need to use of instructional materials (Nwike and Onyejegbu, 2013). Agun (1992) defined instructional materials as those resources which are helpful both to educators and students, hence, maximizes learning. There are many examples of instructional materials that can be used in photosynthesis. Vikstrom (2008) suggested that the use of an actual plant species can increase the students understanding. Bringing a hydrilla leaf for example help awaken the interest and curiosity of the students and can somehow increase their performance.

Photosynthesis can also be explained through the use of models. A model is a visual aid or picture which can highlight the main ideas of a phenomenon (Mcllrath & Huitt,1995). According to Gage and Berliner (1992) models, as a visual representation of the subject matter provide exact and useful symbol of knowledge and make the understanding of the abstract topic easier. They found that students who study models before the discussion may recall as much as 57% more questions than students who received instruction without the benefit of seeing the models.

With the advent of technology, teachers used animation-based learning in their teaching wherein teachers use animation during class discussion. Animation is a technique composed of a variety of pictures or drawings to make an illusion of movement. Animation needs computer, Liquid Crystal Display (LCD) projector, speakers and the like. To be able to own these technologies, the school requires additional budget in their Maintenance and Other Operating Expenses (MOOE). However, the government helps teachers in achieving meaningful learning. Through the initiative of Department of Trade and Industry (DTI), in partnership with the Department of Education (DepEd) and assistance from the Japanese government through its Japanese Non-Project Grant Assistance Counter Value Fund (NPGA-CVF), a project was conceived and implemented to address this problem. The project, dubbed as Personal Computers for Public Schools (PCPS) as its name suggests provides free modern computer sets, printers, software bundles and internet access to public high schools nationwide (Bagaforo and Nieto, 2001).

One of the recipients of PCPS project is the Ozamiz City National High School (OCNHS) which is located in Barangay Lam-an, Ozamiz City. It is the biggest secondary school in the city in terms of its population. It offers facilities such us audio-visual rooms, computer rooms, Dance and Vocal rooms, and laboratory rooms for sciences and for culinary arts that accommodate the Regular, Special Science Curriculum, Strengthened Technical Vocational Education Program and School Programs of the Arts. As one of the science educators in Ozamiz City National High School, the researcher shows its support to the government through answering the call of designing an alternative animation and three-dimensional models and yet does not require expensive technologies in teaching photosynthesis topic with the hope to enhance the performance of the students in Science.

Theoretical Framework

This study is anchored on the constructivism theory which states that learning is an active process (Driver & Bell, 1986). The students renovate the concept, make predictions, and decision based on a cognitive structure. A mental model is an example of cognitive structure which delivers meaningful learning and allows learners to apply this concept to any real life problem situation. These models further help students to make connections between fragments of ideas and thus, can help them draw conclusion and enhance their problem solving skills (Falvo, 2008).

The constructivist approach is a learner-focused instruction. It changes the teaching paradigm from traditional to student-centred teaching. The four principles of learning that Twomey (1989) used as his bases in defining constructivism are the following: learning depends on what we already know; new ideas occur as we adapt and change our old ideas; learning involves inventing ideas rather than mechanically accumulating facts; meaningful learning occurs through rethinking old ideas and coming to new conclusions about new ideas that are in conflict with our old ideas. Constructivism requires that the definition of a concept is not given to the student; instead, it is constructed by them in their own organized way according to their understanding (Duckworth, 1987).

Constructivism draws on the developmental work of Piaget (1977), Vygotsky (1978), Dewey (1938) and Bruner (1960). Piaget (1977) believed that individuals learn through the construction of one logical structure after another. He rejected the idea that learning was the passive assimilation of given knowledge. He further proposed that learning is a dynamic process composed of successive stages of adaptation to reality. Likewise, Vygotsky (1978) believed that learning is developmental. The development of language and articulation of ideas was central to learning and development (Daniels, 1996). Dewey's learning by doing approach emphasizes that students learn through minds-on, hands-on discussion disregarding the logical arrangement of the concept. He added that pupils were active learners that could achieve their learning using the teacher as a guide. Classroom environment is a place that allowed social interaction of real life problems in which the subject content was not taught in a logical order of facts (Archambault, 1964). He further identified human learning as a scientific process which requires team working between teachers and students. Bruner (1960) emphasized the role of the teacher, language and instruction. He thought that learners must be exposed to different processes in problem solving and these processes should vary from person to person. In other words, students learn in various ways, therefore, the teaching strategy must also be varied to meet the needs of the students. He suggested that the origin of learning is through social interaction. The transfer of learning could be best manifested through a series of group activities wherein each student is open for new ideas and collecting the ideas in the process of dialogue between student- student and student-teacher.

A classroom setting of a constructivist institution is compared to a mini-society which is composed of community of learners engaged in activity and discussion (Cobb, 1991). Learners are encouraged to view objects, events and phenomena with an objective mind which is assumed to be separated from cognitive process such as imagination, intuitions, feelings, values and beliefs (Johnson, 1987). The teacher is a mere facilitator (Gray, 2007). Hence, the discussion must have consisted of a variety of activities for students to interact with each other promoting peer or group discussion in order to learn a new concept (Yürük, 2007). Teachers, students and instructional materials used play an interactive role in a constructivist learning environment (Kroasbergen & Van Luit, 2005). Teachers guide and help learners in connecting prior knowledge with new learning. Students can construct the information by participating themselves in the activities inside the classroom. However, students may develop misconceptions if there is a conflict between their previous learning and scientific realities (Ürey & Çalik, 2008). Therefore, students pre-existing learning and misconceptions about the subject must be determined to provide teachers time to analyze the students' incomplete understanding. This analysis includes a thorough planning during the implementation of the lesson. It further includes consideration as to which appropriate method and instructional materials (IMs) and perhaps learning and teaching style will be used by the teacher prior to the lesson. IMs used can speed up the process of connection between prior and new learning. Proper learning materials must be prepared and used for meaningful learning outcomes (Özalp, 2006).

The theory of multiple intelligences by Howard Gardner (1993) is based on constructivism approach in the sense that it focuses the attention of educators on the reality that each child possesses intelligences. He proposed the seven intelligences that an individual may acquire. One of these intelligences is the spatial intelligence which involves the ability of the child to perceive the visual world appropriately. It also includes the ability to use the patterns in recognizing vague concept. The child who has spatial intelligence performs transformations to the initial perception of a visual experience. It is also commonly related to observation of the visual phenomena. Individuals with spatial intelligence are visual learners. Visual learners prefer the use of images, maps, and graphic organizers to access and understand new information (Fleming & Baume, 2006). Visual learning involves visualization, color cues, picture metaphors, concept maps, sketches, diagrams and graphic symbols (Armstong, 1994).

Another theory which is in line with constructivist approach is the associationist theory of identical elements where simple concrete tasks assist in transfer of complex understanding as suggested by Resnick & Ford (1981). This theory recommends that teachers should engage students in the learning process by mediating between the concrete object and the characteristics of the problem situation (Lehtinen & Hannula, 2006). Woolfolk (2007) stated that when learners can apply the problem solving procedures outside the four walls of the classroom, it is a manifestation that learning is being transferred. This transfer of learning can be easily implemented through the use of manipulative. Manipulative is defined as concrete objects used to help students understand abstract concepts in the domain of Mathematics (McNeil, Uttal, Jarvin,& Sternberg, 2007). Children understand when using concrete materials if the materials are presented in a way that help them connect with existing networks or construct relationships that prompt a reorganization of networks (Kamin & Iyer , 2009). It is important to consider then, the internal networks that students already carry with them and the classroom activities that promote construction of relationships between internal representations (Hiebert, et. al, 2003).

Conceptual Framework

In the light of the theories cited in the review of related literature and theoretical framework, specially the insights from Dewey (1938), Dale (1969), and Kroasbergen & Van Luit, (2005), this study aimed to develop an instructional material and used them during the instruction of photosynthesis topic to hit its ultimate purpose that is to increase the performance of the students.

Figure 1 shows the conceptual framework of the study. Dewey (1938), Dale (1969), and Kroasbergen & Van Luit, (2005) form the bases for using alternative animation and three-dimensional model as instructional materials for teaching photosynthesis topic. It is depicted in the framework the variables under study. The top rectangle is the topic involved in the study. The topic photosynthesis was taught to different groups of students using the same strategies. One was taught using the alternative animation and 3-D model designed and fabricated by the researcher and the other group was taught without the use of the alternative animation and 3-D model. The strategy used in the experimental group was in accordance to the constructivist approach. The effectiveness on the use of alternative animation and 3-D model was determined by comparing the results of students' performance in the written test on photosynthesis. Their performance was analyzed and compared to determine whether or not the use on alternative animation and 3-D model enhances the teaching-learning process, thereby producing better test results of the students who were subjected to it.

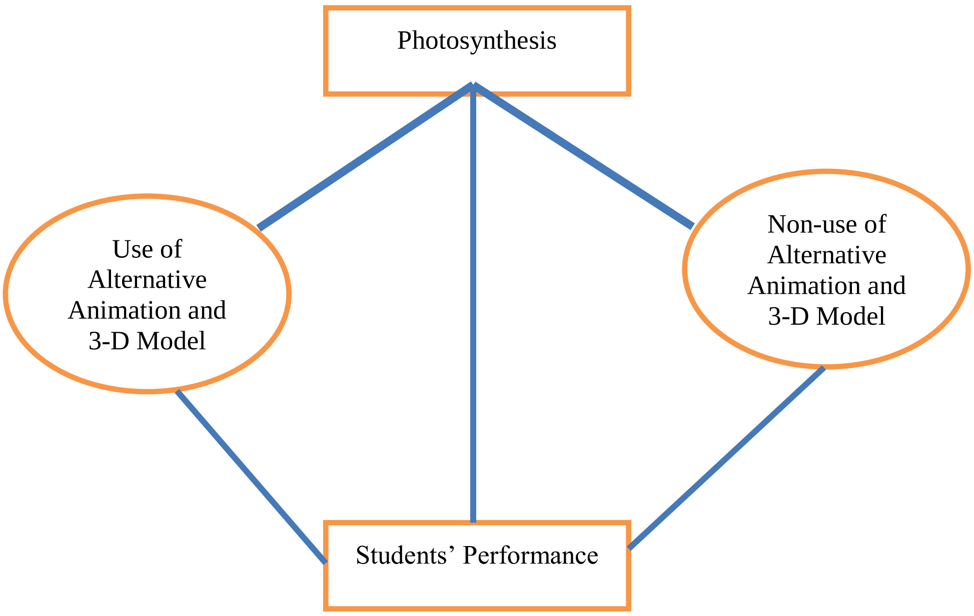

Figure 1. *The Variables and Their Relationship*

Research Questions

Generally, the study aimed to design and use the alternative animation and three-dimensional model in teaching photosynthesis and to determine its effectiveness. Specifically, it sought to answer the following questions:

1. What is the performance of the students in the control and experimental groups in terms of knowledge, process, understanding, and performance?
2. Is there a significant difference between the performance of the students in the control and experimental groups in terms of knowledge, process, understanding, and performance?

The hypothesis is that there is no significant difference between the performances of the students in the control group and experimental group as revealed by their test scores after teaching photosynthesis.

Scope and Limitations

The study aimed to design instructional materials as an alternative to computer animations depicted on computer monitors and to create a three dimensional model in teaching photosynthesis. The materials used were the available materials found in school and electrical supplies store. The alternative animation was limited to light independent and dependent reaction of photosynthesis since these reactions need movement of the raw materials involved in photosynthesis.

The creation of a three dimensional model was also restricted to the chloroplast only since the process of photosynthesis occurs mainly in the chloroplast. Since photosynthesis is a complex process, this study focused only as to how glucose is made by plants as their source of food for growth and survival.

Significance of the Study

School administrators may reproduce and recommend the use of the chloroplast model and alternative animation to other Science teachers. They may encourage their teachers to design or fabricate more instructional materials that use alternative animation and 3D model which may deem fit for certain topics.

This study may inspire and encourage teachers to use the instructional materials in the discussion. It also gives teachers a variety of ideas to make IMs best suited for a certain topic. Knowing the influence of instructional materials in the learning process, parents can extend their support to their children through their initiative in looking for the best models available in the educational supplies that would help increase the performance of their respective children. Moreover, this study may encourage the students to create their own model not only for photosynthesis but also for other subjects. Finally, the findings of the study may serve as guide or baseline for comparison for future research that aims for the betterment of students' performance.

Research Design

This study employed a quasi-experimental design to examine the effectiveness of the fabricated instructional materials used during the actual teaching process. The selection of which group is assigned in experimental and control group was randomized. To minimize the threats to internal validity, many of the variables were controlled such as teacher's skill in teaching, the topic during the instruction and time of administration.

Research locale, Ozamiz City National High School is located at the centre of the city specifically in Barangay Lam-an. The population of the school is approximately 2,696 who are enrolled in the 60 sections from first to fourth year levels regardless of the type of curriculum. It offers four (4) types of curriculum. They are the Regular, Special Science, Strengthened Technical and Vocational Education Program, and Special Program of the Arts. Each curriculum is composed of students from first year to fourth year level. The Regular

Curriculum is composed of the basic subjects namely; English, Science, Math, Edukasyon sa Pagpapahalaga (EsP), Filipino, Araling Panlipunan (ArPan), Technology and Livelihood Education (TLE), and Music, Arts, Physical Education (MAPEH). Likewise, the Special Science Curriculum (SSC) offers the basic subjects with the addition of Environmental Science, Biotechnology, Geometry, Research I and II, Advanced Physics, Advanced Chemistry, Advanced Algebra and Differential Calculus. Indeed, this curriculum focuses on the Sciences and Mathematics subjects. However, the "Strengthened Technical and Vocational Education Program" (STVEP) carries the basic subjects found in the regular curriculum with the inclusion of commercial cooking, industrial arts and electricity. Certainly, STVEP concentrates on livelihood. Lastly, the curriculum that hones individual talents such as dancing, singing, visual arts and playing instrument is the Special Program of the Arts (SPA).

Respondents

Sixty (60) students coming from two (2) sections of the grade 8 class who are officially enrolled in OCNHS academic year 2014-2015 were the respondents of this study. These sections were SSC-RNA and St. Therese which belonged to the Special Science Curriculum and Regular Curriculum respectively. Moreover, SSC-RNA and St. Therese were the sections handled by the researcher. The students to be assigned either in the control and experimental group were randomly selected. Drawing of lots was used in randomization. Below, there is the table depicting the results of random selection.

The table presents that 56.67 % of the students are in Grade 8-SSC RNA section and the remaining percentage (43.33) are the students in Grade 8-St. Therese.

Table 1. *Distribution of Randomly Selected Students*

	Experimental Group		Control Group		Total	
	Male	Female	Male	Female	Freq.	(%)
Grade 8 SSC RNA	7	13	3	11	34	56.67
Grade 8 St.Therese	1	9	8	8	26	43.33
Total	8	22	11	19	60	100

Instrument Used

Chloroplast 3D model

Making the model of the chloroplast requires a skeleton to anchor the shape of the model. In this case, a metal screen was used. It was moulded into C-shape since it depicts the crosssection of the chloroplast. Two C- shape models of different sizes were made. These represent the inner and outer membrane of the chloroplast. It was covered by green modelling clay to emphasize the colour of the chloroplast. The C- shape model was assembled and connected to each other using a tie wire.

For making the thylakoid model, green modelling clay was used. Each granum was composed of at least ten thylakoids. The granum was connected through its lamella. The parts of the chloroplast were labelled properly. The finished model was enclosed by acetate for protection against mechanical damage.

The Alternative Animation

This animation model was for the illustration of light independent and light dependent reactions of photosynthesis. The animation focused on the making of one thylakoid only emphasizing the parts of its membrane. Metal screen was used to anchor the model. Two strips of metal screen were cut and moulded into oval shape to represent the phospholipid bilayer. It was covered by modelling clay for strong suspension of the structures embedded in it. Tie wire was still used for the suspension of the heads and the tail of the phospholipid representatives. Beads of average sizes were utilized as phospholipids' head and the tie wire was embedded partially to its head showing the rest of its part as tail of the phospholipid. In its membrane, the protein complexes were suspended in it. The protein complexes such as photosystem I, photosystem II, cytochrome b6f, NADP reductase and ATP synthase are represented by different colours of modelling clay to differentiate one from the other.

In making the mobile carriers, a small piece of metal strips was used. The entire thylakoid was suspended in a piece of plywood to represent the inner membrane of the chloroplast. Behind the plywood were the strings with its assigned numbers that were manipulated for movements.

Teacher-made Test

The data gathering instrument was a teacher-made questionnaire. It was a teacher-made test on "photosynthesis" with a total of 50 points. This was validated by three experts who are master teachers in Science at OCNHS. Below is the table for the distribution of points in the different levels of assessment based on the K12 curriculum of the Education Department.

To ensure reliability and credibility of the materials, eleven (11) Science teachers of Ozamiz City National High School were asked to evaluate the fabricated IMs using the Instructional Materials Survey Tool adapted from Division Memorandum no. 61 series of

2013. Teacher's skill in delivering the instruction was assumed constant since it is the researcher who handled/taught both experimental and control groups. To determine the effectiveness of the fabricated instructional materials, the performance of the students from experimental and control groups were compared. The gender of the students was not considered in this study.

Table 2. *Distribution of Points in the Levels of Assessment*

Level of Assessment	Number of Points	Grading System (%)
Knowledge	8	15
Process	12	25
Understanding	15	30
Performance	15	30
Total	50	100

Administration of the Model

The models were evaluated by eleven (11) Science teachers of OCNHS to ensure its content validity and reliability using the IMST before the administration and the models got the rating of 85.27 points. The finished models were used for instruction on the second week of December 2014. The lesson plan was made following the 5E model, one of the constructivist approaches. The 5E signifies Engage, Explore, Explain, Elaborate and Evaluate. The information from the assessment was the total scores of the respondents in Knowledge, Process, Understanding and Performance; thus, the data were of interval level. Frequency, percentage distribution and mean were used to describe the data gathered. In the interpretation of data, scales were adapted to measure the variables used in the study. The scales and verbal equivalent of the scores are shown in Appendix C. To test the significant difference between the performance of the students in the control and experimental groups, t-test was used.

The experimental group and control group had the same lesson plan except that the experimental group used the fabricated model made by the researcher and the control group used the picture model in each activity. The lesson plan was validated by the three master teachers of Ozamiz City National High School.

Results and Discussion

Table 3 shows that ten out of thirty or (33.33%) students in the experimental group had Advance mastery level compared to their peers in control group having only 2 out of thirty or 6.67%. It means that many students exposed to the alternative animation and three dimensional models of light and dark reaction demonstrated an excellent competence in substantive content, facts and information and can support other students' improvement.

Table 3. *Students' Performance in Knowledge Level of Assessment*

Performance		**Experimental Group**		**Control Group**	
Score	Rating	Frequency	Percentage (%)	Frequency	Percentage (%)
7-8	A	10	33.33	2	6.67
6	P	4	13.33	5	16.67
5	AP	9	30	8	26.67
4	D	5	16.67	8	26.67
0-3	B	2	6.67	7	23.33
Total		30	100	30	100

Legend: A-Advanced AP-Approaching Proficiency B-Beginning P-Proficient D-Developing

Just as important, however, is the lower end of the score which belongs to beginning level. Six point sixty- seven percent (6.67%) of the students in the experimental group scored 3 or below while twenty-three point thirty-three (23.33%) of the students of the control group got this score. This data show that many students taught using pictures have difficulty in memory retention and in recalling information or facts; hence, these students lack competence in substantive content, facts and information and require urgent improvement. Another interesting result is the number of students who passed the knowledge assessment. Ninety-three point thirty-three (93.33%) of the students in the experimental group got 4 out of eight items while 76.67% in the control group got this score. This data imply that the improvised animation model help students in grasping the content facts and information easily.

The findings above are in consonance with the work of Buchanan, et. al (2005) who found out that 96% of the students in animation group scored higher than 5 out of ten items whereas, 75% from the control group got this score. They concluded that even at the level of lower-order skills, animation can facilitate students.

Table 4. *Performance of the Students in Process Level of Assessment*

Performance		**Experimental Group**		**Control Group**	
Score	Rating	Frequency	Percentage (%)	Frequency	Percentage (%)
11-12	A	12	40	11	36.67
9-10	P	2	6.67	3	10
7-8	AP	7	23.33	5	16.67
6	D	1	3.33	0	0
0-5	B	8	26.67	11	36.67
Total		30	100	30	100

Legend: A-Advanced AP-Approaching Proficiency B-Beginning P-Proficient D-Developing

Table 4 shows that both groups have quite similar number of students (12/30 and 11/30) who are in the Advance mastery level. It denotes that students taught with or without the alternative animation have excellent competences on the skills or cognitive operation on facts and information specifically in organizing the steps in light and dark reaction of photosynthesis and are able to help other students to improve this skill. Another interesting figure in the data above is that 8/30 or 26.67% of the students who are exposed to the given instructional materials have Beginning proficiency level which is lesser than their counterparts who were taught with pictures only (36.67%). It indicates that a few number of students in the experimental group lack competence in process specially in organizing skills. These findings corroborate with the previous study of Buchanan, et. al (2005) who investigated the students ability to convey the pathway signal transduction events, and found out that all students in animation group had a passing score. On the other hand, 79% of the students in the traditional group got the same score which further suggested that many veterinary students taught in traditional diagrams do not see the pathway as a cascade of events.

Table 5. *Students' Performance in Understanding Level of Assessment*

Performance		**Experimental Group**		**Control Group**	
Score	Rating	Frequency	Percentage (%)	Frequency	Percentage (%)
14-15	A	0	0	0	0
12-13	P	4	13.33	0	0
10-11	AP	15	50	3	10
8-9	D	8	26.67	13	43.33
0-7	B	3	10	14	46.67
Total		30	100	30	100

Legend: A-Advanced AP-Approaching Proficiency B-Beginning P-Proficient D-Developing

As depicted in the table 5, 13.33% of the students in the experimental group are Proficient in the understanding level of assessment compared to the control group which has zero percent. It implies that alternative animation produces students who are very competent on enduring big ideas, principles and generalizations and can support other students in improving the skill specifically in the interpretation and explanation of the diagram in the light and dark reaction of photosynthesis. It can be gleaned from the table that nobody from both groups reached the Advance level. However, it is worth noting that 19 out of 30 or 63.33% of the students in the experimental group are in the approaching proficiency and proficiency level compared to the control group which is only 3 out of 30 or 10%. This outcome signifies a substantial high performance in interpretation and explanation skills in favor of the experimental group.

These finding is parallel to the results of Barak, et. al (2011) which reveals that the students exposed to animated movies had higher percentage of correct explanation skills. This result is also supported by the study of Simsek (2009) which reveals that students who were taught by active animation had significantly higher understanding conceptual scores than the traditional group.

Table 6. *Distribution of the Students in the Performance Level*

Performance		Experimental Group		Control Group	
Score	Rating	Frequency	Percentage (%)	Frequency	Percentage (%)
14-15	A	0	0	0	0
12-13	P	2	6.67	3	10
10-11	AP	5	16.67	4	13.33
8-9	D	13	43.33	13	43.33
0-7	B	10	33.33	10	33.33
Total		30	100	30	100

Legend: A-Advanced AP-Approaching Proficiency B-Beginning P-Proficient D-Developing

Table 6 displays almost equal achievement in the experimental and control group in each level of proficiency development. Thirteen (13) out of 30 or (43.33%) and 10 out of 30 or (33.33%) of the students in both groups are in Developing and Beginning level of proficiency respectively. This data indicate that the same number of students in the treatment and control groups lack the competence in demonstrating their knowledge and skills through the performance. It further implies that the instructional materials used did not contribute much in gaining deep understanding of the lesson by transferring their learning through performing or solving real-world tasks or problems. This result may be attributed to the type of assessment employed in this study since the GRASPS model in assessing authentic performance task of the students is newly introduced to them.

Table 7 shows that 1 out of 30 or 3.33% of the students who were exposed to the instructional materials has Advance mastery level in the over-all achievement in photosynthesis assessment compared to the control group which has zero percent. This data denote that the alternative animation can produce students who exceeds the core requirements in terms of knowledge, skills and understanding and can transfer them automatically and flexibly through an authentic performance tasks.

Table 7. *Over-all Performance of the Students*

Performance		Experimental Group		Control Group	
Score	Rating	Frequency	Percentage (%)	Frequency	Percentage (%)
45-60	A	1	3.33	0	0
40-44	P	7	23.33	4	13.33
36-39	AP	9	30	7	23.33
30-35	D	9	30	11	36.67
0-29	B	4	13.34	6	26.67
Total		30	100	30	100

Legend: A-Advanced AP-Approaching Proficiency B-Beginning P-Proficient D-Developing

It is also interesting to note that 26 out of 30 (86.67%) of the students taught with alternative animation and 3D model in light and dark reaction of photosynthesis passed the assessment while only 22 out of 30 (73.33%) in the control group passed . This finding indicates that more students in the experimental group performed better than the control group. The above findings corroborate the results of previous studies conducted by Nwike and Onyejegbu (2013), Nsa, Ikot and Udo (2013), and Marbach-Ad, Rotbain and Stavy (2008). Their findings concluded that instructional materials, visual materials and dynamic animation enhanced the performance of the students. Likewise, this result is also supported with the findings of Oladejo, et. al (2011). They found out that improvised instructional materials enhanced the achievement of the students.

Table 8. *t-test Result of Both Groups in The Knowledge Level*

	Mean	**SD**	**df**	**t**	***p***
Experimental	5.53	1.737	58	2.261	.022
Control	4.63	1.159			

Table 8 shows that the p value (0.022) is lesser than the α which is 0.05 in the knowledge level of assessment; therefore, null hypothesis is rejected. It means that there is a significant difference between the performance of the experimental and control groups of the students in the knowledge level of assessment. It can also be gleaned from the table that the experimental group scored higher (5.53) than the control group. It further implies that the use of alternative animation and 3D model of light and dark reaction of photosynthesis greatly affect the retention of content, facts and information.These findings are supported by the earlier studies conducted by Ausman, et. al (2008) whose finding reveals that still visual and visual animation were equally effective in activities necessary to hold information in working memory and enable its movement into long term memory for factual and for simple concepts. Likewise, the data also were reinforced by the findings of Copolo and Hounshell (1995) and

Wu, Krajcik & Soloway (2000) who concluded that 3D physical and 3D computational model scored significantly higher in retention test and students acquired content knowledge at the macro and microscopic level and were able to translate various chemical representations respectively.

Table 9. *t-test Result of Both Groups in terms of Process Assessment*

	Mean	SD	df	t	*p*
Experimental	8.20	3.662	58	.569	.571
Control	7.63	4.038			

The table above shows that the p value (.571) is greater than α value of 0.05 in the process level of assessment. It implies that there is no significant difference between the mean score of the experimental and control groups. It further denotes that the instructional materials used have no effect in enhancing the process level of the students. This result is supported by Ausman, et. al (2008) who found out that animated sequences were ineffective in facilitating the level of processing information necessary for students to successfully interact and comprehend the information presented by the animation.

The findings above indicate that not all animated and 3D model instructional materials are equally effective in facilitating different kinds of learning objectives. Although, the primary goal of these instructional materials is to enhance the performance of the students, positive results are not always recognized. According to Ausman, et. al (2008), there may be another independent variables that need to be embedded into the instruction to complement the animation to scaffold the learners to appreciate and relate more deeply to the process.

Table 10. *t-test Result of Both Groups in the Understanding Level*

	Mean	SD	df	t	*p*
Experimental	9.73	1.461	58	5.730	.000
Control	6.97	2.205			

The table above depicts that there is a significant difference between the mean score of the two groups in the understanding level of assessment since the significant value (0.000) is lesser than the value which is 0.05. It connotes that the alternative animation model affects the understanding level of the students. The data above is parallel to the results in Table 5 that there is a substantial higher performance in interpretation and explanation skills to those students who were exposed to the alternative animation. This result is analogous to the findings of Barak, et. al (2011) which revealed that there is a significant difference between the mean score of the animated group and the control group and further concluded that animated movies developed thinking skills such as science understanding, implementing and reasoning. Moreover, Gabel and Sherwood (1980) indicated that manipulating physical models had a long-term cumulative effect on students' understanding. Therefore, there is a general consensus that the alternative animation and 3D model enhances the skills to develop understanding of concept.

Table 11. *t-test Results in the Performance Level of Assessment*

	Mean	SD	df	t	*p*
Experimental	8	2.259	58	-0.875	.385
Control	8.53	2.46			

Table 11 shows that the p value (.385) is greater than the α 0.05 which implies that there is no significant difference between the mean score of experimental and control groups. The data further indicate that instructional materials used do not enhance the competence of the students on real-life application of the knowledge gained. These findings confirmed with the findings shown in Table 6 that the two groups have almost equal number of students in the different levels. According to the unstructured interview gathered from the students, authentic performance task assessment requires enough time to think, organize and relate the concept to the present situation in the community of which this skill is very lacking and needs to be developed and improved. The scores they obtained may be attributed to this deficiency.

Table 12. *t-test Results in the Performance of Both Groups*

	Mean	SD	df	t	*p*
Experimental	31.47	5.30	58	2.632	0.011
Control	27.77	27.77			

Table 12 reveals that there is a significant difference between the mean score of experimental group and control group in the over-all performance since the significant value (0.011) is lesser than the α value which is 0.05. It means that the alternative animation and 3D model of light and dark reaction has a significant effect in the achievement of the students. These findings are supported by the previous studies which concluded that instructional materials have greatly influenced in the achievement of the students (Nwike and Onyejegbu, 2013, Nsa, Ikot and Udo, 2013, and Marbach-Ad, Rotbain and Stavy, 2008).

In summary, the study came up with the following findings: More students exposed to the alternative animation and 3-D model of light and dark reaction of photosynthesis demonstrate excellent competence in the knowledge level than the students who were exposed to 2-D models. Hence, there is a significant difference between the learning outcome of the experimental and control groups in the knowledge level assessment. The students in experimental and control group have excellent competence in the process assessment. Moreover, there is no significant difference between the performances of the students in both groups in the process level of assessment. The performance of the experimental group in the understanding level of assessment is better compared to its counterparts, the control. Hence, there is a significant difference between the mean score of both groups in the understanding level of assessment. Majority of the students in both groups are in the "Beginning" and "Developing" level of proficiency in transferring their knowledge gained in solving real-world problems through the performance of real-world tasks. Hence, there is no significant difference between the mean score of the students in both groups in the performance level of assessment. The experimental group performed better than the control group in the over-all learning outcome. Moreover, there is a significant difference between the mean score of both groups in the over-all learning outcomes of the students.

Conclusion

Based on the findings of the study, it is concluded that the alternative animation and 3D model in light and dark reaction of photosynthesis are effective in enhancing the over-all learning outcome of the students. However, there are only two levels of assessment that these IMs significantly affected the students' academic performance. These are knowledge and understanding levels. The fabricated IMs did not improve the students' achievement in the process and performance levels of assessment.

Based on the findings of the study, the following recommendations are drawn: That the teachers should be encouraged to use instructional materials such as the alternative animation and 3D models in teaching Science topics specially photosynthesis to facilitate the teaching-learning process easily. Seminars and in-service training in making instructional materials specially the physical three-D models for different Science topics should be conducted in the Division level for the benefit of all students. Workshops on formulating questions for Knowledge, Process, Understanding and Performance (KPUP) levels of assessment should be given to all teachers so that students' learning will be appropriately assessed. Similar studies should be undertaken considering other variables that may influence students' academic performance that this present study failed to include.

References

Agun, I. (1992) Importance of Audio Visual Instruction. *West African Journal of Education. 20*(2).

Amir, R., & Tamir, P. (1994). In-depth Analysis of Misconceptions as a Basis for Developing Research-based Remedial Instruction: the Case of Photosynthesis. *The American Biology Teacher,56*(2), 94–100.

Anderson, C.W., Sheldon, T.H. & DuBay, J. (1990). The Effect of Instruction on College Nonmajors' Conceptions of Photosynthesis and Respiration. *Journal of Research in Science Teaching, 27*(8), 761–776.

Andersson, B. (2008). *To Understand School Science. Research Findings and New Ideas*. Student litterature. Elanders Hungary Kft.

Archambault, R. (1964). *John Dewey on education*. Chicago: The University of Chicago Press.

Armstrong, T.(1994). *Multiple Intelligences in the Classroom. Association for Supervision and Curriculum Development (ASCD*).

Ausman, B., Lin, H., Kidwai, K., Munyofu, M., Swain, J., & Dwyer, F. (2008). Effect of Prerequisite Knowledge on the Effectiveness of Animated Instruction. *International Journal of Instructional Media. 35*(3).

Bagaforo, N and Nieto, R., (2001) . *PCs for Students*. Sunstar Davao. Retreived: July 24, 2014 from: http://www.sunstar.com.ph/davao/weekend/pcs-students

Bahar, M., Johnstone, A.H., & Hansell, M.H. (1999). Revisiting Learning Difficulties in Biology.*Journal of Biological Education, 33*(2), 84-86

Barak, M., Ashkar, T., Dori, Y. (2011). Teaching Science via Animated Movies: Its Effect on Students' Learning Outcomes and Motivation. *Journal of Computers & Education. 56*(3), 839-846.

Bruner ,J.(1960) .*The Process of Education*. Cambridge: Harvard University Press.

Buchanan, M., Carter, W., Cowgill, L., Hurley, D., Lewis, S.,MacLeod, J., Melton, T., Moore, J., Pessah, M.,Roberson, M. ,Robertson, T., Smith, M., and Vandenplas, M.(2005). Using 3D Animations to Teach Intracellular Signal Transduction Mechanisms: Taking the Arrows out of Cells. Journal of Veterinary.(32)1 No. 72.

Canal, P. (1999). Photosynthesis And 'Inverse Respiration' In Plants: An Inevitable Misconception? International Journal of Science education. 21: 363-371.

Cobb, P. (1991). Reconstructing Elementary School Mathematics. Focus on Learning Problems in Mathematics, Vol. 13. pp.3-22.

Copolo, C.F., & Hounshell, P.B. (1995). Using Three-Dimensional Models To Teach Molecular Structures In High School Chemistry. Journal of Science Education and Technology, 4(4), 295 - 305.

Daniels, H. (ed.) (1996) An Introduction to Vygotsky. London : Routledge, .

Dewey, J. (1938). Experience and Education. Toronto: Collier-MacMillan Canada Ltd.

Driver, R. & Bell, B. (1986). Students' Thinking and the Learning of Science: A Constructivist View. The School Science Review, 67(240), 443-456.

Duckworth, E. (1987). "The Having of Wonderful Ideas" and Other Essays on Teaching and Learning. New York: Teachers College Press.

Eisen Y. & Stavy R. (1992). Material Cycles In Nature, A New Approach To Teaching Photosynthesis In Junior High School. The American Biology Teacher, 54(6): 339–342.

Falvo, D. (2008). "Animations And Simulations For Teaching And Learning Molecular Chemistry.," International Journal Of Technology in Teaching and Learning, vol. 4, no. 1, pp. 68–77,

Fleming, N., and Baume, D. (2006) Learning Styles Again: VARKing up the right tree! Educational Developments, SEDA Ltd, Issue 7.4, Nov. 2006, p4-7. Retrieved: July 14, 2014 from: http://www.varklearn.com/documents/Educational%20Developments.pdf

Gabel, D., & Sherwood, R. (1980). The Effect Of Student Manipulation of Molecular Modelson Chemistry Achievement According To Piagetian Level. Journal of Research In Science Teaching, 17(1), 75 - 81. Retrieved: August 3, 2004 from http://deepblue.lib.umich.edu/bitstream/handle/2027.42/34515/1033_ftp.pdf

Gage, N., & Berliner, D. (1992). Educational Psychology (5th ed.), Princeton, New Jersey: Houghton Mifflin Company. Retreived:August 3, 2004 from http://www.edpsycinteractive.org/papers/modeltch.html

Gardner, H. (1993). Frames of Mind: The Theory of Multiple Intelligences. New York: Basic Books.

Gray, A. (2007).Constructivist Teaching and Learning. Retrieved: July 2, 2014.from http://saskschoolboards.ca/research/instruction/97-07.htm.

Hiebert, J., R. Gallimore, H. Garnier, K. Bogard Givvin, H. Hollingsworth, J. Jacobs, A. M.Y. Chui, D. Wearne, M. Smith, N. Kersting, A. Manaster, E. Tseng, W. Etterbeek, C. Manaster, P. Gonzales, and J. Stigler (2003). Teaching Mathematics in Seven Countries: Results from the TIMSS 1999 Video Study. Washington, DC: National Center for Education Statistics: US Department of Education. Retrieved: July 4, 2014 from:http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid

Johnsons, M. (1987). The Body in the Mind. Chicago:University of Chicago Press.

Kamin, P. and Iyer, N (2009). From Concrete to Abstact: Teaching for Transfer of Learning When Using Manipulatives. Northeaster Educational Research Association annual Conference. Retreived: September 2, 2014. From http://digitalcommons.uconn.edu/cgi/viewcontent.cgi?article=1023&context=nera_2009

Kroasbergen, E. H. & Van Luit, J. E. (2005). Constructivist Mathematics Education for Students with Mental Retardation. European Journal of Special Needs Education, 20(1).107-116.

Lehtinen, E. & Hannula, M. M. (2006). Attentional Processes, Abstraction And Transfer In Early Mathematical Processes. Instructional Psychology: Past, Present And Future Trends (Pp.39-55). Amsterdam:Elsevier

McIlrath, D., & Huitt, W. (1995). The Teaching-Learning Process: A Discussion Of Models. Educational Psychology Interactive. Valdosta, GA: Valdosta State University. Retrieved: July 22,1014 from http://www.edpsycinteractive.org/papers/modeltch.html

McNeil, N. M., Uttal, D. H., Jarvin, L., & Sternberg, R. J. (2007). Should You Show Me The Play Money? Concrete Objects Both Hurt And Help Performance On Math Problems.

Nsa, S. O., Ikot A. S. & Udo, M. F.(2013). Instructional Materials Utilization And Students' Performance In Practical Agriculture. Journal of Educational Research and Reviews .Vol. 1(4), pp. 49-54, December 2013 ISSN: 2315-9859. Research Paper.Retreived: August 12, 2014 from http://www.sciencewebpublishing.net/jerr/archive/2013/December/pdf/Nsa%20et%20al.p df

Nwike, M., Onyejegbu, C.(2013).Effects of Use of Instructional Materials on Students Cognitive Achievement in Agricultural Science. Journal of Education and Social Research. Vol 3, No 5. Retrieved: July 25, 2014 from http://mcser.org/journal/index.php/jesr/article/viewFile/645/667

Oladejo, M., Olosunde, G., Ojebisi, A., Isola, O. (2011). Instructional Materials and Students'Academic Achievement in Physics: Some Policy Implications. European Journal of Humanities and Social Sciences.Volume 2, no.1. Retrieved: January 4, 2015. from: http://www.journalsbank.com/ejhss_2_4.pdf.

Özalp, I. (2006). A Study on Implementing the Technique of Caricature in Science and Environmental Education, University of Celal Bayar, Manisa.

Piaget, J. (1977). The Development of Thought: Equilibration of Cognitive Structures. (A.Rosin, Trans). New York: The Viking Press.

Rabago, L., Joaquin, C., Lagunzad, C., Carvajal, J., (2003). Functional Biology Modular Approach., Quezon City .Vibal Publishing House, Inc.

Resnick, L. B., & Ford, W. W. (1981). The Psychology Of Mathematics For Instruction. Hillsdale, NJ: Lawrence Erlbaum Associates.

Simsek, U.(2009). The Effects of Animation and Cooperative Learning on Chemistry Students Academic Achievement And Conceptual Understanding About Aqueous Solution., World Applied Science Journal, 7 (1) , 23-33, http://uir.unisa.ac.za/bitstream/handle/10500/10351/thesis_tesfaye_demissie_hailgebreal.pdf?sequence=1

Twomey, F.C. (1989). Enquiring Teachers, Enquiring Learners: A Constructivist Approach for Teaching. New York: Teachers College Press.

Ürey, M. & Calık, M. (2008). Combining Different Conceptual Change Methods Within 5E Model: A Sample Teaching Design Of 'Cell' Concept And Its Organelles. Asia- Pacific Forum On Science Learning And Teaching, 9(2), Article 12.

Vikström, A. (2008). What is Intended, What is Realized, and What is Learned? Teaching and Learning Biology in the Primary School Classroom. Journal of Science Teacher Education, 19, 211-233.

Vygotsky, L.S. (1978). Mind in Society. Cambridge, MA: Harvard University Press.

Woolfolk, A. H. (2007). Educational Psychology (10 Ed.). Boston: Pearson Education Inc.

Wu, H., Krajcik, J., Soloway, E. (2000). Promoting Conceptual Understanding of Chemical Representations: Students' Use of a Visualization Tool in the Classroom. Educational Research and Improvement. Educational Research and Information Center: New Orleans, LA.

Yürük, N. (2007). The Effect Of Supplementing Instruction With Conceptual Change Texts On Students' Conceptions Of Electrochemical Cells. Journal of Science Education and Technology, 16, 515-525.

Appendix

Knowledge Assessment

Range Score	Verbal Equivalent	Descriptive Interpretation
0-3	**Beginning (below 75)**	Lacking competence in the substantive content, facts and information and require urgent improvement.
4	**Developing (75-79)**	Fairly competent in the substantive content, facts and information and need further improvement.
5	**Approaching proficiency (80-84)**	Competent in the substantive content, facts and information and need a little improvement.
6	**Proficient (85-89)**	Very competent in the substantive content, facts and information and can support other students in improving the skill.
7-8	**Advance (90-100)**	Having an excellent competence in the substantive content, facts and information and can support other students' improvement.

Process Assessment

Range Score	Verbal Equivalent	Descriptive Interpretation
0-5	**Beginning (below 75)**	Lacking competence on the skills or cognitive operation on facts and information and require urgent improvement.
6	**Developing (75-79)**	Fairly competent on the skills or cognitive operation on facts and information and need further improvement.
7-8	**Approaching proficiency (80-84)**	Competent on the skills or cognitive operation on facts and information and need a little improvement.
9-10	**Proficient (85-89)**	Very competent on the skills or cognitive operation on facts and information and can support other students in improving the skill.
11-12	**Advance (90-100)**	Having an excellent competence on the skills or cognitive operation on facts and information and can support other students' improvement.

Understanding Assessment

Range Score	Verbal Equivalent	Descriptive Interpretation
0-7	**Beginning (below 75)**	Lacking competence on enduring big ideas, principles and generalizations and require urgent improvement.
8-9	**Developing (75-79)**	Fairly competent on enduring big ideas, principles and generalizations and need further improvement.

10-11	**Approaching proficiency (80-84)**	Competent on enduring big ideas, principles and generalizations and need a little improvement.
12-13	**Proficient (85-89)**	Very competent on enduring big ideas, principles and generalizations and can support other students in improving the skill.
14-15	**Advance (90-100)**	Having an excellent competence on enduring big ideas, principles and generalizations and can support other students' improvement.

Performance Assessment

Range Score	Verbal Equivalent	Descriptive Interpretation
0-7	**Beginning (below 75)**	Lacking competence on real-life application of the knowledge gained and requires urgent improvement.
8-9	**Developing (75-79)**	Fairly competent on real-life application of the knowledge gained and need further improvement.
10-11	**Approaching proficiency (80-84)**	Competent on real-life application of the knowledge gained and need a little improvement.
12-13	**Proficient (85-89)**	Very competent on real-life application of the knowledge gained and can support other students in improving the skill.
14-15	**Advance (90-100)**	Having an excellent competence on real-life application of the knowledge gained and can support other students' improvement.

Over-all Achievement

Range Score	Verbal Equivalent	Descriptive Interpretation
0-29	**Beginning (below 75)**	The student at this level struggles with his/her understanding; prerequisite and fundamental knowledge and/or skills have not been acquired or developed adequately to aid understanding.
30-35	**Developing (75-79)**	The student at this level possesses the minimum knowledge and skills and core understandings, but needs help throughout the performance of skills and core understandings, but needs help throughout the performance of authentic tasks.
36-39	**Approaching proficiency (80-84)**	The student at this level has developed the fundamental knowledge and skills and core understandings, and with little guidance from the teacher and/or with some assistance from peers can transfer them independently through authentic performance tasks.
40-44	**Proficient (85-89)**	The student at this level has developed the fundamental knowledge and skills and core understandings, and can transfer them independently through authentic performance tasks.
45-60	**Advance (90-100)**	The student at this level exceeds the core requirements in terms of knowledge, skills and understanding and can transfer them automatically and flexibly through an authentic performance tasks.