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THE EFFECT OF DUAL SITUATED LEARNING MODEL ON STUDENTS' UNDERSTANDING OF PHOTOSYNTHESIS AND RESPIRATION CONCEPTS

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Abstract. *The purpose of this study was to investigate the effect of Dual Situated Learning Model (DSLM) on teaching photosynthesis and respiration concepts. The subjects of the study were 61 8th grade students who enrolled in a primary school in İzmir, Turkey. In this study, a quasi-experimental pretest-posttest control group design was utilized and two instruction methods were employed. Two groups were assigned randomly as experimental and control groups. Dual Situated Learning Model instruction was employed in experimental group whereas traditional one was employed in control group. A photosynthesis and respiration concept achievement test (17 items) and open-ended questions (6 items) were used as a measurement tools. The results indicated that there were significant differences between the groups in favor of the experimental group. In parallel, DSLM has been found to be more effective in eliminating misconceptions than traditional method.*

Key words: *dual situated learning model, photosynthesis and respiration concept, misconceptions.*

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Introduction

Understanding how learners acquire knowledge is always an important issue in science education (Wu & Tsai, 2005). There are a lot of studies and theories on how students perform learning. Of these, constructivist theory has received a great attention recently. Researchers and theorists maintain that the key element of constructivist theory is that people learn by actively constructing their own knowledge, comparing new information with their previous understanding and using all of these to work through discrepancies to grasp the new understanding (Brooks & Brooks, 2000; Hodson & Hodson, 1998; Bettencourt,1993; Bodner,1986). Three decades, science educators and researcher have strongly advocated the perspectives of constructivism on learning and teaching (Wu & Tsai, 2005). There are a lot of studies based upon the assertions of constructivism to promote students' learning science (Wu & Tsai, 2005; Venville, 2004; Marss, Blake & Garvin, 2003; Alparslan, Tekkaya, & Geban, 2003; Palmer, 2003; Tsai, 2000; Zietsman & Hewson, 1986; Arnaundin, Mintzes, Dunn, & Sbafer, 1984). Most of these studies utilized conceptual change model based on constructivist view and this model is one of the important model in learning.

The model of conceptual change developed by Posner, Strike, Hewson, and Gertzog (1982) suggest that there are three conditions which a new conception has to satisfy before it can be integrated with existing knowledge.

> "Firstly, a new conception has to be intelligible (able to be understood). Secondly, a new conception has to be plausible (makes sense). Thirdly, a new conception has to be fruitful (having the potential to solve the new problems). Teacher has to ensure that students find new content to be intelligible, plausible and fruitful and this can only be done by taking account of prior knowledge" (Hewson & Hewson, 1983).

From this point of view, learning involves an interaction between new and existing conceptions with the outcomes being dependent on the nature of the interaction. If these conceptions can be reconciled, learning proceeds without difficulty. If, however, they cannot be reconciled, then learning requires that existing conceptions be restructured or even exchanged for the new. The recognition that changes of this nature may have to occur forms the basis of the conceptual change model of learning (Zietsman & Hewson, 1986). Up until now, several studies have reported the effectiveness of conceptual change model or strategy on creating conceptual change and promoting meaningful learning in students regarding many science concepts (Özkan, Tekkaya & Geban, 2004; Alparslan, Tekkaya,& Geban, 2003; Palmer, 2003; Mikkila-Erdman, 2001; Hynd, 2001; Wang & Andre, 1991; Hewson & Hewson, 1983).

Most of the researchers above conducted a lot of studies based on conceptual change texts, refutational texts and concept maps. Differently, She (2002, 2003, 2004a, 2004b) developed a Dual Situated Learning Model (DSLM) by taking students' ontological and epistemological beliefs into consideration. Developing this model, she considers Posner and his friend's suggestions such as intelligible, plausible and fruitful situation for conceptual change. This model is based on the constructivist view.

> "DSLM emphasizes starting both with students' ontological view of the concept and with the attributes of the concept, this serves as the basis for the development of dual situated learning events. Each dual situated learning event has two functions: creating dissonance with students' pre-existing knowledge, providing a new mental set with which to construct more scientific concepts" (She, 2002, p.983).

DSLM fundamentally in Piagetain terms is based on cognitive disequilibration, or sometimes, cognitive dissonance. It is fundamental principle of the constructivist approach to learning that cognitive disequilibration is a necessary precursor of learning that learning will not take place unless explanations are sought (Martin, 1997). She (2002) describes DSLM as instructional activities such as analogy, modeling, discrepant events and inquiry activities.

Dual-Situated learning Model (She, 2002, 2003, 2004a, 2004b).

The Dual Situated learning Model involves six stages which described in following (see She, 2002, 2003).

Stage 1: Examining the attributes of science concept. This stage provides information about which essential mental sets are needed to construct a scientific view of the concepts. This stage is very important. Therefore, it is essential to consider experts and teachers' opinion and identify which mental sets are required. The mental sets defined in this stage affect all the following stages, and in case of neglecting any of these mental stages would inevitably affect the success of the model, thus, it should be examined and studied carefully by experts and teachers.

Stage 2: Probing the students' misconceptions of science concept. This stage requires probing students' beliefs concerning the science concepts. There are many ways of revealing students' misconception of science concepts such as, examining the already existing studies, interviewing with students and taking notes during observation.

Stage 3: Analyzing which mental sets students lack according to data collected from stage 2. This would reveal which mental sets students lack especially for the construction of a more scientific view of the concepts. In fact, this stage might be considered as an indicator of why students' make mistakes about science concepts.

Stage 4: Designing dual-situated learning events. The fourth stage is to design a series of dual-situated learning events according to the Stage 3 results. Each dual-situated learning event has two functions: creating dissonance with students' pre-existing knowledge; providing a new mental set for

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them to construct more scientific concepts. Moreover, the new mental set should enable students to see the new concept as intelligible, plausible, and fruitful. Intelligible, plausible and fruitful are vital components of conceptual change model. If a new concept does not carry these traits, the students will continue on existing wrong belief about the concept. It is documented that students' misconceptions in science education are pervasive, stable, and often resistant to change at least through traditional instruction (Sungur, 2000; Sander, 1993). Dissonance is aroused by presenting the students with events and asking them predict what would happen and provide possible reasons. Then new schema is created by allowing the students to see and experience what actually happens and suggest new explanation. Providing a new mental set for students is deemed necessary for conceptual change to occur. If two mental sets are needed to help students to construct a more scientific view of the concepts, it might be necessary to design at least two dual-situated learning events (She, 2002).

Stage 5: Instruction with dual-situated learning events. These emphasizes give students an opportunity to make predictions, provide explanations, confront dissonance and construct a more scientific view of the concepts. In each dual-situated learning instruction event, the students are asked to predict what would happen and also to provide the explanation for their prediction before the event presents.

Stage 6: Challenging situated learning events. The last stage is to present the challenging situated learning events which provide an opportunity for students to apply the mental sets they have acquired to a new situation to ensure that successful conceptual change occurred.

In the present study, the effect of DSLM on students' understanding of photosynthesis and respiration concepts was examined. As photosynthesis and respiration concepts are crucial subjects in biology and they have been chosen for the current study. Hence, teaching these concepts correctly helps students learn further topics easily and meaningfully. Additionally, studies revealed that most of the students from primary school level to university level and even teachers have difficulty and misconception about these two concepts (Tekkaya & Balcı, 2003; Aşçı, Özkan, &Tekkaya, 2001; Çapa, 2000; Canal, 1999; Çakıcı, 1998; Songer & Mintzes, 1994; Sanders, 1993; Anderson, Sheldon, & Dubay, 1990). For example, a study conducted by Şahin (1996) showed that primary students of 4^{th} and 5^{th} classes believe that water is food for plants and photosynthesis occurs in the root of a plant. Another study, Aşçı et al. (2001) revealed that students of high school and university believe that plant takes up O_2 and gives off CO_2, the aim of respiration only is to take up O_2 and give off CO_2 and plants respire only at nights. Another example of such studies about misconception is Anderson et al.'s study (1990), to this study, university students believe that respiration is a change of CO_2 and O_2 gases, and water is food for plants. When all these points are considered, it is clear that photosynthesis and respiration are difficult concepts to grasp for students. Lazarowitz and Penso (1992) stated that even these two topics are important in biology; students are in a difficulty of learning them. Additionally, science teachers find the two topics difficult to learn and teach as well (Aşçı et al., 2001).

Up until now, several studies have reported the effectiveness of DSLM on promoting meaningful learning in students regarding some science concepts (She, 2002, 2003, 2004a, 2004b). In the present study, DSLM was used to help students understand two basic concepts "photosynthesis and respiration". It can be said that the main difference of the present study when compared to other studies is due to DSLM instruction factor on students' understanding of photosynthesis and respiration concepts. Also, it is suggested that the effects of DSLM and its practices in actual classroom teaching be investigated (She, 2002; Akpınar & Ergin, in press).

Methodology of Research

A quasi-experimental pretest-posttest control group design (Campbell & Stanley, 1996) was used in the present study. The subjects of this study were 61 8^{th} grade students who enrolled in a primary school in İzmir, Turkey. The experimental group was a class of 30 students received dual situated learning model instruction and the control group was a class of 31 students received traditional instruction (teacher's usual methods and techniques). Both groups were assigned randomly.

Instruments

The Photosynthesis and Respiration Concept Achievement Test (PRCAT):

This test was developed by researcher to identify students' photosynthesis, respiration and other related concepts. Originally, the test contained 28 multiple-choice items at the knowledge, comprehension, and application levels of Bloom's taxonomy. Each item in the test was examined by a group of experts regarding content validity and format. The test was administered to a pilot study group of 215 students in the five different primary schools. After an item analysis was carried out, a test of 17 items was constructed. The reliability of the test was 0.73. The test was administered to the students in both groups before and after treatment.

The posttest achievement test was identical to the pretest. For each correct answer 1 point and 0 point for wrong answer were assigned.

Open-Ended Questions (OEQ):

Before developing the OEQ, literature was reviewed and 6 open-ended questions were compiled from the revision of relevant studies. Moreover, the views of two experts and three science teachers about the questions were considered. These six open-ended questions were administered to students in both groups at the beginning and at the end of the study.

Sample questions:

How do you define "food" for a plant and an animal?

Do plants make photosynthesis every time (daytime, night and every season)? Please, explain reasons for your answer?

Firstly, these questions were employed to determine students' prior knowledge, ontological beliefs and misconceptions about photosynthesis and respiration concepts because 8th grade students were taught the subject of photosynthesis and respiration concept in the lower grade classrooms. At the end of the treatment, the same questions were administered to both groups. OEQ were graded by the author and the treatment teacher independently, any disagreements were discussed and a joint decision was taken.

All open-ended questions were scored by using rubric in the following way.

2 points were given to the responses that included full part of scientifically accepted answers. 1 point for partially understanding scores was given to the responses that included only a part of scientifically accepted answers. 0 point was assigned to scientifically incorrect responses (misconception), repeat questions, irrelevant or unclear responses. For instance, students' responses to the question "Do plants make photosynthesis every time (daytime, night and every season?)" was evaluated by taking into consider the rubric developed by the author in the Table 1. All of the questions were evaluated in terms of the criteria determined in the rubric by both of the author and the teacher.

Table 1. The Rubric Used in Evaluation of the Students' Answer Giving to Open-Ended Questions.

Understanding level	Criteria	Student s' Sample Answers	Score
Full Understanding	Scientifically, all of the elements and the reasons of the answer are completely correct.	"Plants make photosynthesis in lightened environment (during daytime). Because, they produce food and oxygen using water and carbon dioxide thanks to light (solar) energy.	2
Partial understanding	Most of the answer is acceptably correct, but the explanations are inadequate, there isn't any misconception with the student's answer	"Plants make photosynthesis during daytime (during the light time hours). Light is necessary for photosynthesis.	1

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Understanding level	Criteria	Student s' Sample Answers	Score
No understand-ing	Scientifically, the answer isn't correct, there is misconception or the answer is irrelevant, or the like.	"Plants make photosynthesis during both night and daytime." "Plants generally make photosynthesis during daytime." „I don't know"	0

Similar scale has been used by other researchers (Williamson & Abraham, 1995; Akpınar & Ergin, 2005).

Treatment

This study was conducted over three week periods during which photosynthesis and respiration concepts and other related concepts were covered as part of the regular curriculum in the eight grade general science lesson. The same primary science teacher taught both groups in order to minimize the teacher differences. Before treatment, the science teacher (treatment teacher) was informed on which activities to do, which learning event to use, which explanations to give, which experiments to perform, and which worksheets to deliver etc.

During the period of three weeks, the following activities were made in experimental group and control group:

In the control group, the regular classroom instruction was a teacher-directed strategy . During instruction, discussion, lecturing, experiments were employed with no consideration of the students' misconceptions concerning photosynthesis and respiration. Nevertheless, some of the students had studied the subject in their textbooks before the lesson. While the teacher was lecturing to the class, they took notes. The experiments were done in accordance with the stages mentioned in the textbook verifying the certain results (i.e. they already know the result of the experiment and see this result doing the experiment). Most of the questions were determined by the teacher in the class. What the students know about the subject was not found out. To reveal and get rid of the misconceptions during the process of instruction and before instruction, nothing was done besides the normal course. In short, the teacher used the same methods and techniques in the control group as before during this study.

In experimental group, the application procedures of the DSLM were explained in the following:

Stage 1: Two important and basic concepts, "photosynthesis and respiration" were chosen for this study. A panel of five was involved, including two science educators, one scientist, and two primary science teachers (one of them is treatment teacher). According to the evaluation of the panel experts, in order to construct a more scientific view of the concepts of photosynthesis and respiration, 4 main mental sets are needed. For example, Mental set 1: Elements such as water, light (sun), carbon dioxide and soil are not food for plants. Plants do not get food from outside. Plants make their own food. Animals take ready food from outside and cannot produce their own food.

Mental set 2: In order to make their own food, plants use carbon dioxide, water and solar energy (light) and this process is called photosynthesis. Without water, carbon dioxide and light, plants cannot do photosynthesis. Photosynthesis actualizes in an organelle called chloroplast.

Mental set 3: Plants and animals respire day and night. At the end of respiration, water, energy and carbon dioxide emerge. Respiration is not reverse of photosynthesis. Respiration actualizes in an organelle called mitochondrion. Food and oxygen are essential elements for respiration. Respiration is the process by which all aerobic organisms obtain energy from food.

Mental set 4: Chemical Equation of photosynthesis and respiration are:

$$6\,CO_2 + 6\,H_2O + \text{energy (from sunlight)} \longrightarrow C_6H_{12}O_6 + O_2$$

$$C_6H_{12}O_6 + O_2 \longrightarrow 6\,CO_2 + 6\,H_2O + \text{energy}$$

These mental sets can be considered as something possessed by an individual who can approach a task successfully, based on having the specific set of related knowledge (She, 2002).

Stage 2: In stage 1 after determining the required process for meaningful learning of photosynthesis and respiration, two methods (interview and examining the relevant literature) were utilized to determine students' misconception about these two concepts. To do this, at the first phase of study, the studies related to the subject matter which conducted in primary school level were examined carefully and the misconceptions concluded in these studies were recorded. Moreover, before starting the treatment (instruction), randomly assigned 10 students of 8th class were interviewed about photosynthesis and respiration through semi-structured interview and the rest students in two groups were addressed the same questions (interview questions) as a written exam after some modification. Some of these questions were used as open-ended questions in pre-test and post-test.

Sample Questions:

How do plants and animals feed? How do they obtain their food?

Are animals able to live in world without plants?

When does animal respire and when does plant respire?

The experiment below (in figure 1) was performed in a lightened environment. Water filled test-tube remained on a funnel for a while. And what does happen next?

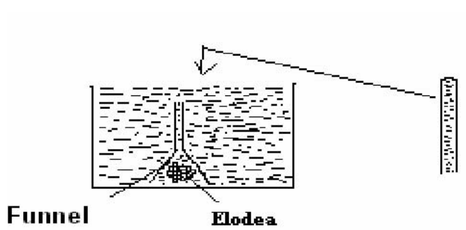

Figure 1. An example of photosynthesis experiments.

Stage 3: According to the results from Stage 1 and 2, nearly 70 % students lack Mental Set 1 (they perceive that soil, water, carbon dioxide or air is food for plants and plants take their foods from outside, animals make their own food and don't need plants.), nearly 68 % students lack Mental set 2 (they believe that plants make photosynthesis without water or sun light, photosynthesis happens in plants' leaves, not in organelle (chloroplast), a plant without chloroplasts can make photosynthesis, plant produces water during photosynthesis etc.), 72 % students lack Mental set 3 (plant can make photosynthesis during day and night, plants respire only during days and do photosynthesis during nights and respiration is reverse of photosynthesis). Nearly 92 % of students lack mental set 4 (students wrote the formula of photosynthesis and respiration wrong). These results were obtained after the instruction based on heavily teachers-centered, in lower grade levels. The results of misconception in this study have similarities with the previous studies mentioned above.

Stage 4: In this stage, the researcher developed some dual situated learning events based on the results from previous stages. In this study, eight dual situated learning events were used to help students construct mental sets. Some questions of Stage 2 which include experiments were shown as a learning event with demonstration. For example, the students were asked to do an experiment about elodea (plant). Moreover, in this study, a conceptual change text concerning photosynthesis developed by Mikkila-Erdman (2001) was used to help students understand that light or sun is necessary for photosynthesis and eliminate misconceptions about the issue (such as plants use water, soil, and air as food). The relation between animals and plants was shown through computer presentation as a last learning event. In this presentation, there are some examples of 1, 2 and 3 learning event. For example, a presentation of a cell picture and chloroplast, carbon dioxide and water in it, and through sun light obtaining food and oxygen were demonstrated. While preparing the computer presentation, science education experts and the scientists' opinions were considered.

Stage 5: All learning events were conducted as a group work of five. In the first stage, students

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were asked to predict what would happen and also provide the explanation for their prediction before the dual situated learning events. In the second stage; students were shown what actually happened during events. Additionally, in this stage, students did experiments, watched computer presentations and read conceptual text. Afterwards, students compared the obtained results with their previous assumptions and were asked to explain their opinions about the issue. This process was seen to be in accordance with conceptual change.

Stage 6: In this stage, the challenging situated learning event served to check whether students had acquired the mental sets required for understanding the notion of photosynthesis and respiration. In the following figures, the challenging events were presented.

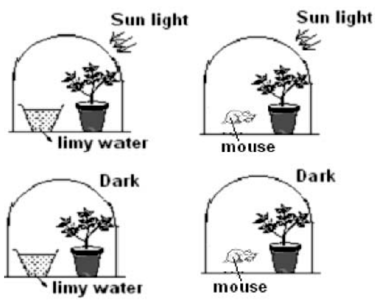

Figure 2. **An example of challenging situated learning events.**

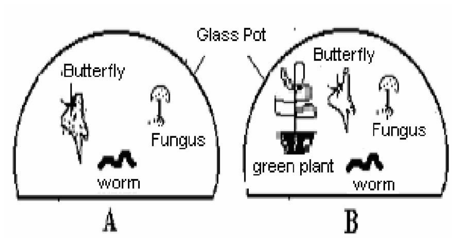

Figure 3. **Another example of challenging situated learning events.**

In the figure 2, there are the same plants and a mouse in the same two glass pots and in others as well, there are the same plants and limy water in them. Students were asked to explain in which pots, mouse can live longer in dark and light environments and if any change happen in the limy water pot and the reasons of this change. In the third figure, students were asked in which pots animals could live longer and to explain the reasons. The aim of these challenges is to have students see the applications and adaptations of mental sets newly learned and their functionality in different contexts.

Results of Research

Before and after treatment, the achievement test and open-ended questions were administered to both groups. Comparisons were made in terms of the experimental and control groups' pre-post achievement test and open-ended questions score means and collected data were analyzed through t-test.

Table 2. **Comparison of Mean Scores of Control Group and Experimental Group in PRCAT (pre-test)**

Groups	N	$\overline{X}$	SD	t	p
Experimental	30	3,60	1,81	-0,682	0.498
Control	31	3,90	1,66		

Table 2 shows that there was no statistically significant difference between the mean scores of students in control and experimental groups with respect to PRCAT before the instruction ($p>.05$). The mean of the test with 17 questions in both groups is about 3,6 and this indicates that both groups were at the same and low level of knowledge about photosynthesis and respiration before the treatment.

Table 3. Comparison of Mean Scores of Control Group and Experimental Group in PRCAT (post-test)

Groups	N	$\overline{X}$	SD	t	p
Experimental	30	9,43	2,40	3.778	0.000*
Control	31	7,09	2,42		

*Significant at the .001 level

The results of the table above showed that there was a significant difference between post-test mean scores of the students taught by DSLM instruction and those taught by traditional instruction with respect to photosynthesis and respiration concepts. This results indicated that DSLM based instruction improved students' success more than the traditional one.

Table 4. Comparison of Mean Scores of Control Group and Experimental Group in OEQ (pre-test)

Groups	N	$\overline{X}$	SD	t	p
Experimental	30	3,90	1,49	0.882	0.381
Control	31	3,51	1,87		

Table 4 indicated that in pre test of OEQ, the mean scores of both groups were equal and no significant difference between the scores of groups. Students were asked six questions. When they give correct response to the questions the highest score is 12. As it was indicated before students will get 2 points for completely understanding and 1 point for partial understanding. Considering this scoring, it can be concluded that the score of students' responses to open-ended questions was low. This result indicates that students have misconceptions about photosynthesis and respiration as well. Some examples from students' misconceptions are given below.

Plants respire through hole on the leaves.
Respiration is a gaseous exchange process (O_2 and CO_2)
Water, soil and others (such as minerals, CO_2, O_2) are plants' food.
Photosynthesis is reverse of respiration.
Plants take food form outside.

Table 5. Comparison of Mean Scores of Control Group and Experimental Group in OEQ (post-test).

Groups	N	$\overline{X}$	SD	t	p
Experimental	30	7,93	2,42	2.902	0.005*
Control	31	6,29	1,98		

*Significant at the .05 level

In the post test, there was a significant difference between the means of control and experimental groups in favor of experimental group. The results of the OEQ showed that DSLM helped primary school students understand the concepts correctly and eliminate misconceptions and it is more effective than the traditional instruction. For instance, when students' responses to question "How do you define "food" for a plant and an animal" was analyzed the results displayed that in the control group, 82 % of the students responded correctly, whereas in the control group, this ratio was 60 % after the treatment. The rest percentages in both groups still have misconception about this question. When students' responses to the question "When do animals and plants respire" were analyzed, 70% of both group students in pre test

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have misconception. In the post test, 30% of experimental group and 50% control group were carried on the same misconceptions. For instance, some students believe that photosynthesis occur during day and night, some believe that plants respire at nights but make photosynthesis during day.

Conclusions and Discussion

The aim of the current study was to reveal the effects of DSLM on students' understanding of photosynthesis and respiration concepts in real science classroom environment. Two groups which received the instruction from the same teacher were formed. Respiration and photosynthesis concepts were chosen for the instruction. The control group received traditional instruction whereas the experimental group received instruction with DSLM. Results showed that there were significant differences between two groups in favor of the experimental group. Although students in the experimental group have less misconception about respiration and photosynthesis when compared with the control group after the treatment, some students in the experimental group still have misconception regarding these concepts. This situation shows how difficult the complete eradication and change of some misconceptions. Related to these two concepts, most of the studies reveal that students have misconceptions and at the same time teachers have difficulty in teaching both of the concepts (Tekkaya & Balcı, 2003; Sanders, 1993; Anderson, Sheldon, & Dubay, 1990). Although the students in the experimental group have some misconceptions after the instruction, the plenty more rate of misconception in the control group shows that DSLM based teaching that gives much importance to students' most basic principles and misconceptions eases learning concepts scientifically to a considerable extent. Shortly, instructing students in the passive learning setting provided within traditional teaching could not be influential for eradicating students' misconceptions and misunderstandings. Therefore, providing students' active participation in class and putting new teaching approaches such as DSLM considering students' most basic principles and misconceptions might contribute to the science teachers for getting rid of misconceptions. For instance, in this study, in order to show the effect of light on photosynthesis, the same experiment was done in both experimental and control groups. However, each of the experiments was implemented with a different approach. The control group students did the experiment whose results had been given by the teacher beforehand and did not predict anything during the experiment. Just at the end of the experiment, they realized that a leaf whose a certain part was closed could not produce food and make photosynthesis. The experimental group students determined the problems before doing the experiment, asked questions, and most importantly, predicted the result of the experiment, and wrote their reasons for their predictions on experiment study sheets, then did the experiment and compared their predictions with the result, discussed in the classroom and finally they understood that light was necessary for photosynthesis by themselves. During this process, the experimental group students realized that they had had wrong knowledge and corrected it. All learning activities used in this study including computer simulations do not transfer information, but form students' lacking mental sets determined in this study and eliminate misconceptions. The aim of all learning activities is to make students realize their own lack or inadequacy of knowledge and try to get rid of them. In addition, the aim is to help students to learn the subject better by means of using the knowledge in new situations.

Studies indicate that DSLM is effective in eliminating misconceptions and teaching them correctly. She (2002) conducted a study on 9th classes and revealed that DSLM is effective in teaching air pressure and buoyancy concepts. She stated that the model will be much more effective when social factors are considered in actual classroom teaching. Nevertheless, She (2003) in the study entitled "DSLM instructional approach to conceptual change involving thermal expansion", she explained that DSLM is effective in eliminating misconception and the results showed that instruction with DSLM has contributed successfully to more than 60 % of the students' conceptual change concerning thermal expansion. Another study related to DLSM carried out by (She, 2004b) demonstrated that the use of DSLM facilitated students' conceptual change involving science concepts with both invisible and process attributes. In her study, the analysis of the students' ontological view of dissolution and diffusion showed that more that 90% of the students originally held misconceptions before using DSLM. The use of DSLM successfully brought about conceptual change with respect to dissolution and diffusion for between 76%-90% of the students. The results of current study and others also revealed that this model helps students learn concepts correctly and eliminate misconception in a very short time.

Recommendations

When the results of current study and those of preceding studies are considered, it is expected that the use of DSLM in teaching basic science concepts will enhance learning. However, since there was limited time during my study, the effects of DSLM model on retention of learning concepts was not investigated. Therefore, retention can be the subject matter of further studies. Furthermore, the efficacy of this model on the subject of upswing of the students' success and the downturn of the misconceptions should be examined on the long-term works and, moreover, it must be studied whether does the model decrease misconception or not in a long time. Besides, students' misconceptions should be taken into account in order to produce an effective science teaching and students should be provided opportunity to rethink and revise their prior knowledge and reconstructed new conceptions.

In the current study, semi-structured interview and written exams were used to identify the students' misconceptions about photosynthesis and respiration. Other procedures such as observation, group interviews and two-tier test could also be used to collect data in future studies. In addition, similar studies should be conducted for different science concepts and with different grade levels. In future studies, DSLM should be compared with other instructional methods.

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