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THE EFFECTS OF SIMULATION-BASED AND MODEL-BASED EDUCATION ON THE TRANSFER OF TEACHING WITH REGARD TO MOON PHASES

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Abstract. *Several researchers have investigated the knowledge of the causes of moon phases and how to promote the scientific understanding of these phases. However, these scholars did not determine whether this learning was transferred to the following education. The purpose of this study was to investigate the effectiveness of two different types of education on the transfer of learning with regard to astronomy content. No significant change in the understanding of the moon's phases was observed between the groups, but a significant change in the transfer scores of the groups was observed. This result could indicate that the education increased the participants' understanding of moon phases and that the participants in the simulation group were able to more adequately transfer their knowledge. The alternative conceptions of the causes of the moon phases were transferred to the context of the earth's phases. In other words, alternative conceptions are transferred to new learning situations. Therefore, the alternative conceptions that the participants hold should be carefully observed when new learning is transferred.*

Key words: *earth phases, moon phases, pre-service teacher, simulations, transfer.*

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Introduction

The phases of the moon are among the topics to which most children are exposed in elementary school in addition to the other topics, such as the seasons and the cycle between day and night (Sadler, 1998; Stahly, Krockover, and Shepardson, 1999). The conceptual understanding of lunar phases is considered one of the most complicated topics in science teaching. Children, teachers, and adults have difficulty in understanding the causes of the moon's phases and hold various conceptions related to this topic (Bell and Trundle, 2008). To understand lunar phases, a learner should possess knowledge of the reflection of light, shadow, and the constantly changing relative positions of several celestial objects, such as the moon, the earth, and the sun. Understanding of the causes of lunar phases has been investigated in several studies. Some studies reveal the existence of alternative conceptions regarding the causes of the moon phases (Dove, 2002; Jones, Lynch, and Reesink, 1987; Klein, 1982; Nussbaum, 1979; Sadler, 1998; Sharp, 1996; Summers and Mant, 1995; Suzuki, M. 2003; Trumper, 2001; Zeilik, Schau, and Mattern, 1998), whereas the other studies have applied interventions (Abell, George, and Martini, 2002; Barnett and Morran, 2002; Bell and Trundle, 2008; Hobson, Trundle, and Sackes, 2010; Ogan-Bekiroğlu, 2007; Stahly, Krockover, and Shepardson, 1999; Taylor, Barker, and Jones, 2003; Trundle, Atwood, and Christopher, 2002; Trundle and Bell, 2010; Trumper, 2006; Zeilik, Schau, and Mattern, 1998) to promote the scientific understanding of the causes of moon phases. In these studies, traditional education, which involves daily moon observations and three-dimensional models, was frequently compared with computer-supported education.

Traditional education on lunar phases (Bell and Trundle, 2008) includes observing the moon on a daily basis; analyzing data (Abell, George, and Martini, 2002; Trundle, Atwood, and Christopher, 2002); and using three-dimensional models to demonstrate the relative positions of the sun, the moon, and the earth (McDermott, 1996). Trumper (2006) developed a teaching unit that is based on homework assignments and in-class discussions. He reported that the experimental group members described a greater increase in their understanding of basic astronomy concepts compared with the control group. The collection of data pertaining to moon phases at different times of the month renders the task of traditional moon education as time-consuming and gener-

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ates data sets with missing observations (Bell and Trundle, 2008). Despite these limitations, studies have reported an increase in students' scientific understanding following this education and a decrease in the number of alternative conceptions (Abell, George, and Martini, 2002; Trundle, Atwood, and Christopher, 2002).

Computer-supported intervention is the other major type of education that is used to assess participants' understanding of the causes of moon phases. In a meta-analysis of 42 studies, Bayraktar (2002) reported that computer-supported education is more effective than traditional education. Similarly, in another review study, Rutten, Joolingen, and van der Veen (2012) stated that simulations can enhance traditional education. Ucar and Trundle (2011) found that the use of web-based data and simulation increase students' understanding of tides. Trundle and Bell (2010) conducted a quasi-experimental study to investigate the effect of a computer simulation on the teaching of lunar phases. These authors found that the use of computer simulation increased conceptual understanding when compared with the use of observation or the combination of observation and simulation. Hobson, Trundle, and Sackes (2010) found that the use of computer simulation to teach various lunar concepts was effective with second- and third-grade children. De Jong and Van Joolingen (1998) reported that students could easily focus on the targeted content because of the simulations that simplified the natural world. Furthermore, computer simulations could facilitate learning more effectively than direct experience (Winn et al., 2006). The use of computer simulations in science teaching successfully increased reasoning skills (Geban, Askar, and Ozkan, 1992) and supported inquiry (Monaghan and Clement, 1999). However, some studies have reported disadvantages that are associated with the educational use of computer simulations. Such technology use hinders deep reflection and understanding of complex scientific content (Olson and Clough, 2001). Marshall and Young (2006) reported that simulation hindered the testing and refinement of tentative theories by secondary pre-service teachers. Similarly, Waight and Abd-El-Khalick (2007) found that technology can restrict the enactment of inquiry by limiting student discourse and engagement in scientific thinking.

Neither the traditional interventions nor the computer-based intervention followed the level of transfer of new learning with regard to the causes of lunar phases. Studies of traditional and computer-based education have reported positive increases in the achievement scores of the targeted content. However, concluding that students learned the causes of the lunar phases solely based on increased achievement scores would be misleading for educators. In addition to achievement scores, other factors should be observed to conclude that learning has occurred, as some high-achieving students do not retain or continue to use the material that they learn (Pugh, 2004). Billing (2007) indicated that material that is truly learned can be transferred easily, whereas memorized material cannot be transferred. Newly learned material can be used effectively in different contexts only if this material is transferred. Therefore, one of the major shortcomings of the previous studies was that these researchers did not ascertain whether the transfer of learning occurred after education.

The transfer of learning has been viewed as the major goal of education (Marini and Genereux, 1995) but has been given different definitions in the literature. For instance, Gagne, Yekovich, and Yekovich (1993) defined the transfer of learning as "the application of knowledge learned in one setting or for one purpose to another setting and/or purpose" (p. 235). Ripple and Drinkwater (1982) defined the transfer of learning as "a fundamental assumption of educators. We trust, that whatever is learned, will be retained or remembered over some interval of time and used in appropriate situations" (p. 1947). Perkins and Salomon (1996) defined the transfer of learning as follows: "In a sense, any learning requires a modicum of transfer. To say, that learning has occurred, means that the person can display that learning later" (p. 423). Marton (2006) defined this transfer as the manner in which "what is learned in one situation affects or influences what the learner is capable of doing in another situation" (p. 499). The commonality among the various definitions of the transfer of learning is that this concept refers to contexts in which new knowledge is used in another situation, in other school subjects, or in other life experiences.

Different levels and types of transfer are cited in the literature, including "positive and negative transfer, simple versus complex transfer, near and far transfer, automatic and mindful transfer, low and high road transfer" (Leberman, McDonald, and Doyle, 2006, p. 4-5).

There are many similarities among the definitions of these different types of transfers. One of the major similarities is that all of these definitions refer to transfer as a dichotomous concept. One of these levels or categories involves a type of transfer that is shallow or easy to achieve, and the other level involves a type of transfer that is deep and difficult to achieve. Therefore, only one type of transfer (i.e., "near and far transfer") is used in this study to ensure simplicity. Perkins and Salomon (1992) described near and far transfer as follows:

> *"Near transfer refers to transfer between very similar contexts, as for instance when students taking an exam face a mix of problems of the same kinds that they have practiced separately in their homework, or when a garage mechanic repairs an*

engine in a new model of car, but with a design much the same as in prior models. Far transfer refers to transfer between contexts that, on appearance, seem remote and alien to one another. For instance, a chess player might apply basic strategic principles such as take control of the center to investment practices, politics, or military campaigns."

Detterman (1993) reported that there is no empirical evidence of the existence of far transfer; however, near transfer is easily observable in controlled settings. Supporting this assumption, Schoenfeld (1999) argued that "transfer is ubiquitous" (p. 7) and emphasized the difficulties of detecting transfer in experimental designs. Forsyth (2011) reported the difficulties of identifying far transfer, which is less frequent; therefore, near transfer must be studied in depth to model how the minds of students function when they are transferring knowledge to attempt to generate a model for far transfer using the data pertaining to near transfer. Our knowledge of the transfer of learning and its nature is limited. Barnet and Ceci (2002) stated that "there is little agreement in the scholarly community about the nature of transfer, the extent to which it occurs, and the nature of its underlying mechanisms" (p. 612). Therefore, additional research in different subjects is necessary to reveal the nature of this transfer and identify educational designs that promote the transfer of learning. It could be learned more about the transfer of learning and its nature by determining which types of learning environment are more effective in facilitating the transfer of learning.

Transfer occurs less frequently than educators hope (Alexander and Murphy, 1999). The task of applying the material that is learned in school to other similar tasks is difficult (Detterman, 1993; Nickerson, Perkins and Smith, 1985; Reed, Ernst and Banerji, 1974). However, if the nature of transfer is understood and education is well designed, then the transfer of learning is possible (Marini and Genereux, 1995; Perkins and Salomon, 1988), especially immediate transfer. Thus, the transfer problem arises immediately following education, although the solution has clearly been scaffolded during education (Gick and Holyoak, 1983). Therefore, in the current study, the transfer problem was presented to the participants after one week.

In this study, the transfer of the conceptual understanding of content into another similar context was investigated in two different settings. One setting involves a traditional approach known as modeling, and the other setting involves a computer-supported approach that is known as simulation. This content is especially important because the phases of the earth and the moon occur in three-dimensional spaces. The transfer of knowledge regarding lunar phases to the phases of the earth is considered a *near* transfer because these phases are similar concepts. Both concepts involve the same physics, such as the reflection of light from the surface of a spheroid and the positions of the moon and the earth relative to the sun. As a result of effective educational designs that promote the transfer of learning, the amount of subject matter to be taught could be reduced to ensure that larger parts of the traditional curriculum could be omitted from science lessons.

Marini and Genereux (1995) discussed key issues in teaching to encourage the transfer of learning and identified the three basic elements of this transfer: "Learner, Training and Transfer Task, and Training and Transfer Context" (p. 3). These authors do not advise the consideration of all three elements during lesson preparation because each element plays a different role in the transfer. Among these three elements of transfer, the task is the element on which the current study focused.

Purpose

The purpose of the study was to investigate the effectiveness of two different types of education on the transfer of learning with regard to the causes of lunar phases.

The following research questions guided this study:

RQ1: How do the achievement scores of pre-service teachers on a lunar phase test differ between simulation-based and model-based education?

RQ2: How do the degrees to which pre-service teachers transfer knowledge differ between simulation-based and model-based education?

Methodology Research

Context and Participants

The teachers who participated in this study were pre-service lower-secondary science teachers in their second year of training in a four-year program at a major research university in southeastern Turkey. The study was

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conducted during the spring semester of 2011. All of the students were enrolled in a scientific method course during the term in which they were asked to participate in the study, and all of the students in the class served as participants in this study. A total of 72 pre-service teachers (56 females and 16 males) from two science method classes participated in the study. Although the students who were enrolled in the two existing sections of the class were not randomly assigned to each section, the two course sections were randomly assigned to each treatment. Thirty-four participants were assigned to the modeling group, and 38 were assigned to the simulation group.

Educational Intervention

Simulation Group

The participants were randomly assigned to the simulation group. The participants were exposed to 45 minutes of education pertaining to lunar phases that was provided by the researcher. The education included a short lecture that was supported by questioning and a demonstration of moon phases using a simulation that was developed by the University of Nebraska-Lincoln astronomy education group (http://astro.unl.edu/naap/lps/animations/lps.html). A short discussion pertaining to the orbit of the moon and the earth occurred initially. A short discussion regarding light and shadow also occurred. After these discussions, the researcher provided a short lecture with a PowerPoint presentation pertaining to the orbit of the moon and the causes of the lunar phases. The moon's phases were explained as follows: 1) the moon orbits the earth in a counter-clockwise manner and completes a rotation in approximately 29.5 days; 2) half of the moon is always facing the sun and is thus always lit, and the other half of the moon is not facing the sun and is thus always dark; 3) the position of the moon relative to the earth and the sun changes; and 4) it could be observed a portion of the lit part of the moon from the earth. After the presentation of this short lecture, the "lunar phase simulator" (Lunar Phase Simulator, 2014) was shown to the participants. A screen shot of the "Lunar Phase Simulator" is presented in Figure 1. Using this simulator, the participants had the opportunity to accelerate or decelerate the movement of the moon, observe the angle between the moon and the sun, observe the time at which the moon rises and sets, view the rising and setting of the moon, observe the relative positions of the moon and the sun in a separate window, and view the lit portion of the moon as it waxes or wanes in another window. All of the images on the screen were synchronized to ensure that the participants can observe the relative positions of the earth, the moon, and the sun as well as the phases of the moon.

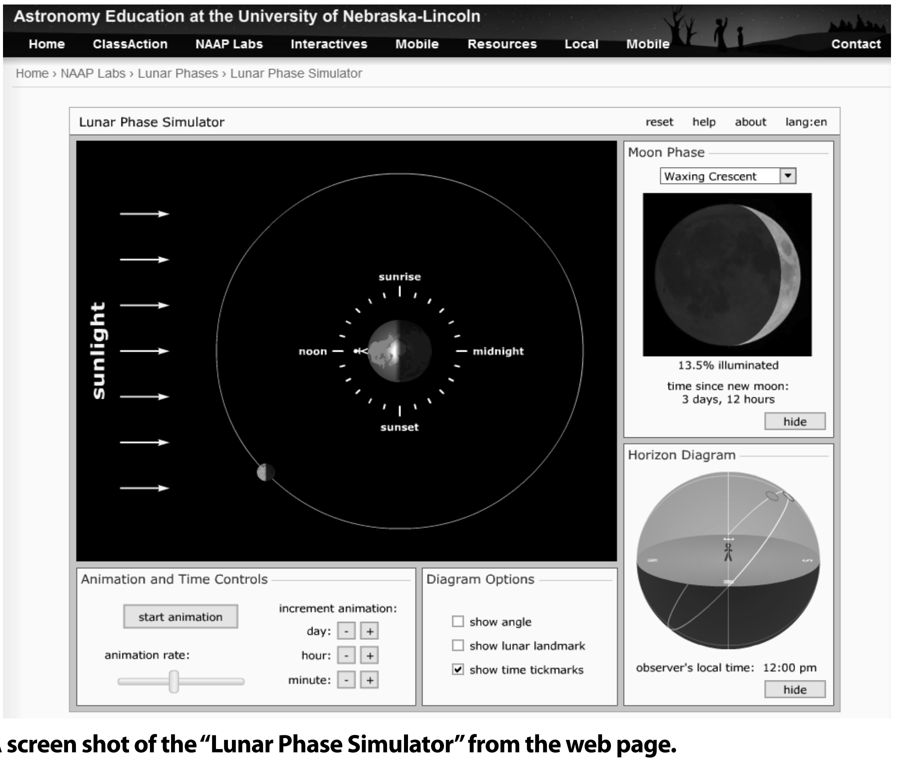

Figure 1: A screen shot of the "Lunar Phase Simulator" from the web page.
http://astro.unl.edu/naap/lps/animations/lps.html

Modeling Group

This group served as the control group for the study. The participants were exposed to 45 minutes of education, which included two parts. In the first part, the participants were exposed to a short lecture that included the same sequence and material as described above for the simulation group. However, the modeling group did not observe any computer simulation activity following this lecture. Rather, this group participated in a three-dimensional modeling activity following the lecture portion of the education (Trundle, Atwood and Christopher, 2007, p. 4). The psychomotor modeling activity requires the students to use their own bodies and small balls that are attached to sticks. In this modeling activity, a participant's head represents the earth, a small ping-pong ball that is attached to a stick represents the moon, and a light bulb that is located in the middle of the room represents the sun. The participants experienced an earth-centered view of the lunar phases. The participants stretch their arms and hold the ping-pong ball pointing toward the ceiling at an angle of approximately 45˚ from the horizon (Foster, 1996). Students then begin to turn themselves around their vertical axis. When they complete a full rotation, they are able to observe the entire moon cycle and the accompanying phases.

Data Collection

Lunar Phases Concept Inventory

The knowledge of pre-service teachers with regard to the moon phases was measured using an instrument that is known as the "Lunar Phases Concept Inventory" (Lindell and Olsen, 2002). This instrument was developed to assess student knowledge of lunar phases. The original instrument contained 29 items; the first 20 items related to moon phases, and the remainder of the items focused on demographics. Three items from the instrument were eliminated because of their incompatibility with the social context in Turkey. The remaining 26 items, including 19 items related to content and seven items related to demographic data, were retained from the original instrument.

Transfer Instrument

The transfer instrument was developed by the researcher to measure the level of transfer from the moon's phases to the earth's phases. This instrument includes four questions that instruct the participants to draw the earth's phases from the perspective of the moon. In the education section, the participants were asked to imagine themselves sitting on the moon and observing the earth. Subsequently, the participants were asked to draw the space below the relative positions of the earth, the moon, and the sun from the perspective of the North Pole when the earth is viewed as full, new, quarter, and crescent. No specific quarter or crescent was requested in an attempt to prevent confusion. A copy of the instrument is presented in Appendix 1.

Data Analysis

The Lunar Phases Concept Inventory was employed by assigning a score of "1" for the correct answer and a score of "0" for incorrect answers to each question. All of the scores were then summed to obtain a total achievement score for each participant. The total scores were used for all of the analyses. The highest possible score on this achievement test is 19, and the lowest possible score is 0.

The transfer instrument was also employed by assigning a score of "1" for the correct answer and a score of "0" for incorrect answers to each question. Partially correct drawings were considered incorrect and given a "0". The highest possible score on this achievement test is 4, and the lowest possible score is 0. A second trained coder scored ten percent of the drawings to verify inter-rater agreement. According to Cohen's kappa (Cohen, 1960), the inter-rater agreement between the two coders was κ=0.72, which indicates a "substantial" (Landis and Koch, 1977, p. 165) level of agreement between the two raters.

All of the data were analyzed using the SPSS statistical software package. Descriptive statistics and an ANOVA were performed. An alpha level of .05 was used for all statistical tests.

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Results of Research

Moon Achievement (Lunar Phases Concept Inventory)

The covariate moon pretest achievement scores were significantly related to the moon post-test achievement scores (F [1, 69] =16.37, p<.05). There was no significant effect of the type of education on the moon post-test achievement scores after controlling for the effect of the moon pre-test achievement scores (F[1, 69]=3.26, p>.05). The corrected mean score for the simulation group (M=9.35) was slightly higher than the corrected mean score for the modeling group (M=8.25). These results indicate that both groups demonstrated equal increases in their conceptual understanding of lunar concepts. The descriptive statistics that are provided in Table 1 show the changes in mean scores after they were adjusted.

Table 1. Descriptive scores for the simulation and modeling groups.

Group	N	Uncorrected scores		Corrected scores	
		M	SD	M	Std. Error
Simulation	38	9.79	2.60	9.35	0.40
Modeling	34	7.77	2.71	8.25	0.43

Transfer of Learning (Transfer Instrument)

The abilities of the participants in both groups to transfer learning did not significantly differ before these groups were exposed to either type of education (t_{70}=-0.02, p>0.05, $M_{simulation}$=1.29, SD=1.25, M_{model}=1.29, SD=1.26). After participating in two different types of educational activities, the abilities of the participants to transfer their learning to a new situation changed significantly (t_{70}=2.23, p<0.05, $M_{simulation}$=2.76, SD=1.32, M_{model}=2.03, SD=1.47). The participants in the simulation group received higher scores on the transfer test; thus, the members of this group demonstrated a greater ability to transfer their conceptual understanding of lunar phases to the context of the earth's phases. As shown in Table 2 below, the members of the simulation groups performed better in terms of transferring their knowledge following the interventions.

Table 2. Descriptive statistics for the pre- and post-test transfer instrument scores.

Group		Pre-Test		Post-Test	
	N	Mean	SD	Mean	SD
Simulation	38	1.29	1.25	2.76	1.32
Modeling	34	1.29	1.36	2.03	1.47

A comparison of the answers to questions 1 and 2 on the pre-test indicates that there were no significant differences between the simulation and modeling groups. However, a comparison of the post-test scores indicates that the participants in the simulation group performed significantly better than those in the modeling group based on the post-test scores for the first and second questions. Independent t-test results are presented in Table 3.

Table 3.7 Independent t-test results of the pre-test and the post-test of the Transfer Instrument for questions 1 and 2.

Pre- and Post-Tests	t	df	p
PreQuestion_1	-1.480	70	0.143
PreQuestion_2	0.552	70	0.583
PreQuestion_3	0.273	70	0.786
PreQuestion_4	0.269	70	0.789

PostQuestion_1	2.115	70	0.038
PostQuestion_2	2.426	70	0.018
PostQuestion_3	0.818	70	0.416
PostQuestion_4	1.220	70	0.227

Questions 3 and 4 pertained to the first and third quarters of the moon's phases from the perspective of the moon. Although small variations were found, no significant difference between the scores of either group for the third and fourth questions was observed. In other words, transfer was performed similarly by both groups. A sample student drawing is presented in Figure 2.

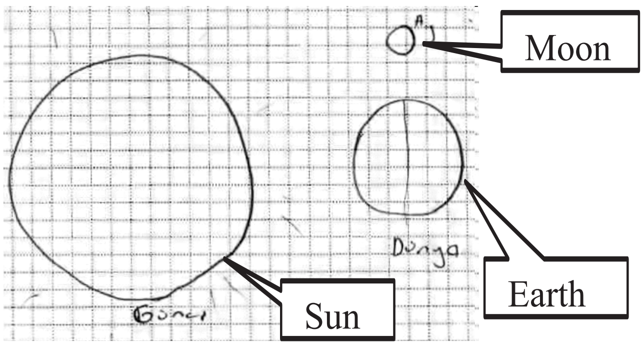
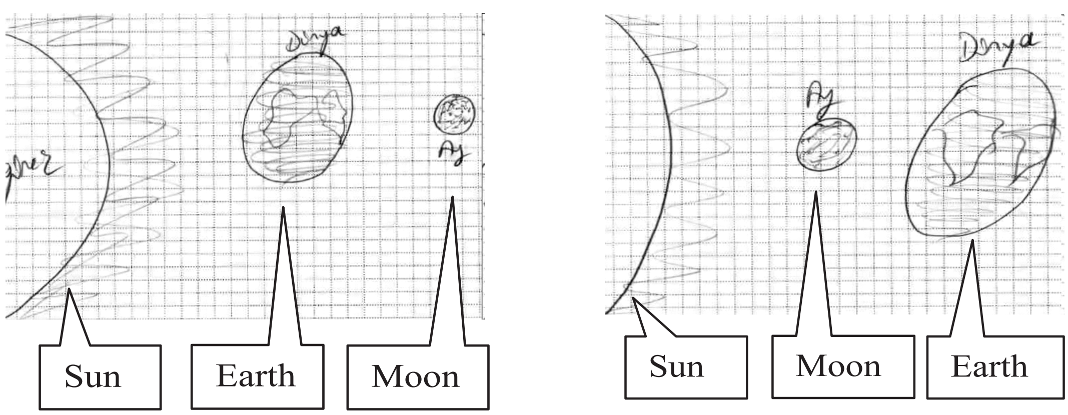


Figure 2: Participant drawing of the half-earth phase.

The most common alternative conception that was drawn by the students was similar to the alternative conception that students typically generate with regard to the new moon and full moon (Trundle, Atwood, and Christopher, 2002). In this conception, the participants place the moon between the earth and the sun to demonstrate the full moon. Similarly, they place the moon in a lunar eclipse position to show the new moon. In the current study, the participants placed the earth between the sun and the moon to demonstrate the full-earth position (Figure3a), and they placed the moon between the sun and the earth to demonstrate the earth in the new-earth position (Figure3b).



a. Full earth (incorrect) b. New earth (incorrect)

Figure 3: Participant drawings of (a) the full-earth phase and (b) the new-earth phase

In another alternative conception that emerged, the sun was placed between the earth and the moon. Drawings of this alternative conception of some participants are shown in Figures 4a, 4b, and 4c. In Figure 4a, the sun is placed between the earth and the moon to demonstrate the full-earth phase. Similarly, the sun is placed between

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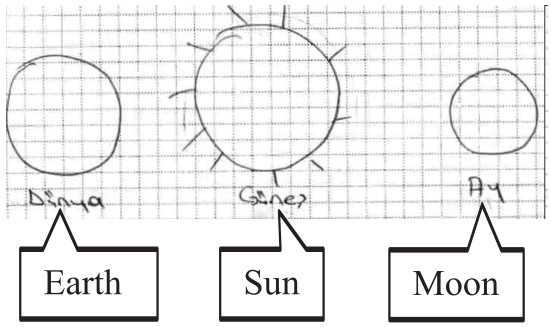
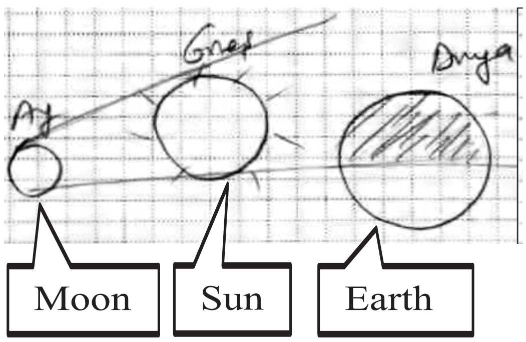
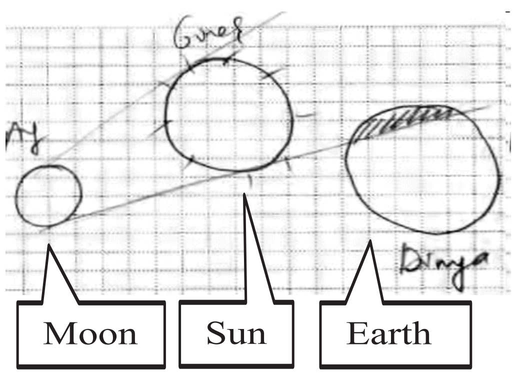
the earth and the moon to demonstrate the half- and crescent-earth phases in Figures 4b and 4c, respectively; in this view, the sun is obstructing the view of the earth.



a. Full earth (incorrect) (the sun was placed in the center illuminating the earth)



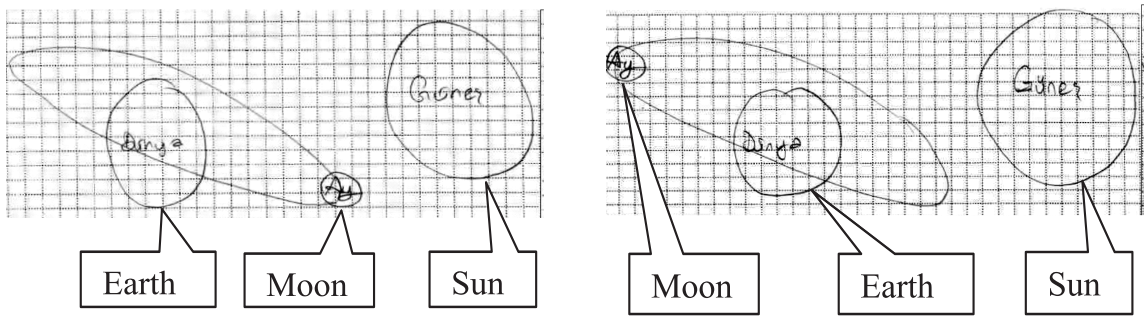
b. Half earth (incorrect)



c. Crescent earth (incorrect)

Figure 4: Participant drawings of the (a) full earth, (b) half earth, and (c) crescent earth.

Some participants submitted a correct drawing of the earth's new and full phases (Figure 5). As shown in this figure, the moon orbits around the earth rather than on a horizontal plane.



a. Full earth b. New earth

Figure 5: Correctly drawn (a) full earth and (b) new earth.

Discussion

Similar to other studies that applied traditional methods, computer simulations, or both types of methods (Abell, George, and Martini, 2002; Barnett and Morran, 2002; Bell and Trundle, 2008; Taylor, Barker, and Jones, 2003; Trundle, Atwood, and Christopher, 2002; Trumper, 2001), the current study found an increase in moon test achievement scores after both the simulation and modeling education. This finding implies that student test scores would increase following either type of education (White, Kahriman, Luberice, and Idleh, 2010). In this context, the participants in both groups increased their scores to an equal extent; therefore, both types of education have an equal contribution to student learning. However, this finding could be misleading in the absence of an examination of the level of transfer.

No significant difference in the understanding of the moon was observed between the groups, but a significant difference in the transfer scores of the two groups was observed. This result could indicate that both types of education increased student understanding of the moon phases, but that the participants in the simulation group demonstrated a greater ability to transfer this knowledge. Georghiades (2000) reported that students with a deep understanding of content should be able to transfer knowledge successfully and that the duration of the retention of learned material is longer. Billing (2007) stated that rote learning of facts discourages transfer, whereas the learning of principles and concepts facilitates transfer. The rate of transfer may have been higher in the simulation group either because those students demonstrated greater learning or because those in the modeling group demonstrated less learning but compensated with memorization. Learning was transferred more effectively in the simulation group; thus, the students in the simulation group demonstrated a greater understanding of the lunar phases than the students in the model-based learning group. The reason for this result may be that the simulation enabled the participants to gain a more general view (a bird's-eye view) of the causes of the phases of the moon and the earth, whereas modeling did not facilitate this view. In the simulation, the earth-moon-sun system is observed from the North Pole view, from which the relative positions and movements of all three objects can be observed in the same frame simultaneously. However, in the modeling activity, the participants could observe only the earth's view of the sun and the moon.

The typical alternative conceptions of the causes of the moon phases were transferred to the causes of the earth's phases. In other words, the same alternative conceptions were transferred to a new situation. Alternative conceptions are typically resistant to change even when effective education is offered (Wandersee, Mintzes, & Novak, 1994). The participants who held alternative conceptions did not change their conceptions to scientific views and thus transferred these alternative conceptions to other situations. The alternative conceptions that were previously reported in the literature for the full moon and the new moon, in which the moon is located between the earth and the sun during the full moon and the earth is located between the moon and sun during the new moon (Trundle, et al. 2002, Trumper, 2001), were drawn by the participants for the full earth and the new earth positions, respectively. Similar results were observed for the crescent and half moon. Therefore, the alternative conceptions that students hold should be observed carefully when a new lesson is transferred.

Lave (1988) and Billing (2007) have reported that transfer is likely to be successful if the principles that are

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shared between two tasks are indicated explicitly. Contrary to this argument, none of the similarities between the moon and the earth phases was identified for the learners in either group; however, this transfer was more successful in the simulation group. Therefore, it may not be necessary to identify the similarities between the tasks to enhance transfer when using a simulation to teach moon phases.

Billing (2007) summarized the literature and concluded that "specificity of context, in which principles are learned, reduces transfer". Because transfer was found to be more successful in the simulation group, the modeling activity is more context-specific than the simulation activity. In other words, the modeling activity involved the use of a 3-D model to render the education as specific, whereas simulation is a two-dimensional activity that is more general and involves no interaction with 3-D models.

The current study did not examine the long-term effects of transfer of learning, but the long-term retention of information is assumed to be high, as reported in the literature. Jacobson and Archodidou (2000) investigated how hypermedia tools assist in promoting significant learning outcomes, such as deep conceptual understanding and knowledge transfer. These authors found that students who used hypermedia systems changed their problem-solving models and continued to use expert-level models even one year after using the system to solve other problems.

Conclusions and Implications

1. More simulation should be included in the teaching of complex scientific subjects to promote learning.
2. Modeling activities increase achievement, but do not produce deep learning. Teachers should more carefully determine whether students can transfer new knowledge.
3. Because alternative conceptions are also transferred, alternative conceptions should be identified before transfer occurs to ensure that the development of new alternative conceptions can be prevented.

Transfer of knowledge is an important outcome of learning. Teachers and researchers should be aware that without observing learners' competence to transfer the new material, they should not reach the conclusion that learning has occurred. Similarly, researchers and teachers should watch carefully what has been transferred to prevent the transfer of alternative conception because the current study showed that alternative conceptions could be transferred to new situations. Instructional method, which is the simulation in this case, is proved as an effective tool to promote learning and transfer of the knowledge.

Appendix 1: Transfer Instrument

A person who is standing on the **earth** observing the moon views the different shapes of the moon on different days. Sometimes he/she may observe a crescent moon, sometimes a full moon or other shapes.

If a person is standing on the **moon** and observing the earth on different days, would he/she view the phases of the earth (such as a crescent or full earth)? Please draw the moon, the earth and the sun for the following questions.

1-An astronaut who is standing on the surface of the moon observes that the earth is completely lit by the sun (similar to a full moon). Please draw the relative positions of the moon, the earth, and the sun in the space below.

2-An astronaut who is standing on the surface of the moon observes that the earth is completely dark (similar to a new moon). Please draw the relative positions of the moon, the earth, and the sun in the space below.

3-An astronaut who is standing on the surface of the moon observes that half of the earth is lit by the sun (similar to a quarter moon). Please draw the relative positions of the moon, the earth, and the sun in the space below.

4-An astronaut who is standing on the surface of the moon views the earth in a crescent shape (similar to a crescent moon). Please draw the relative positions of the moon, the earth, and the sun in the space below.

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