TEACHING PHASES OF THE MOON WITH A ROLE PLAY

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Abstract. This paper provides an example of an innovative science activity applied in a science methods course of 48 future science teachers at a small university in northeastern Turkey. The aim of the activity is to help prospective science teachers understand the phases of the moon in a simple way bay using a role play teaching techniques and see an innovative teaching example implemented by the instructor.

Keywords: phases of Moon; demonstrations and analogies; role play; learning activities; elementary and middle school science

Introduction

Science educators see teachers' professional development as the most critical variable in science education reform (Moore 1997; Wheeler, 1998; Moreno, 1999, as cited in Karakas, 2008; 2010; 2012; 2018). The National Research Council (NRC, 1996) standards call for "substantial change in how science is taught". Teacher education programs should educate teachers to reason soundly and scientifically about their teaching as well as to perform skillfully (Fenstermacher & Soltis 1986, as cited in Karakas, 2010; 2012; 2018). Better-prepared teachers are more effective in developing higher-order thinking skills in their students and meeting the needs of diverse students through different learning approaches (Begle 1979; Fenstermacher & Soltis 1986, as cited in Karakas, 2010; 2012; 2018). Science educators recommended conceptual teaching of problem solving and thinking skills, life relevancy, and life experiences (Rutherford & Ahlgren, 1990, as cited in Karaka, 2012; 2018). Problem solving and thinking skills that revolve around life experience may be better taught through student-centered classrooms that emphasize process-oriented learning (Cachapuz & Paixao, 2002, as cited in Karakas, 2012; 2018). Furthermore, in constructivist learning theory, every learner constructs knowledge individually. Students do not accumulate all the knowledge that is presented to them as it is. In this learning an individual's prior knowledge, individual capabilities, and learning environments are very important (Ausubel 2000, Driver & Bell, 1986). A new knowledge has to be connected with an individual's prior knowledge so that it can have some meaning to the individual. Thus, students' prior knowledge has a great role both in accumulating and in putting in context the new knowledge that they are learning (Ausubel, 2000, Naylor & Keogh, 1999). Instructional strategies that "allow the integration of a variety of approaches such as hands-on activities, visualization, writing, demonstrations, role play, and guided inquiry are important in bridging the gap between concrete and abstract understanding of scientific concepts" among students (Cherif et al., 1997, as cited in Karakas, 2012; 2018). Learning is more likely to occur on a deeper level, if teachers would 'provide prompts and contextualized scaffolding and encourage students to ask questions, predict, and explain during activities' (Chin & Brown, 2000). Opposing beliefs serve to challenge our own ideas and thus compel us to rethink, gather additional facts, reevaluate our stance, and either confirm or reform our understanding (Sherrod & Wilhelm, 2009). 'Classroom discussion, when freed of its confrontation frame, can play an important role in learning, particularly when it concerns problematic situations where students' ideas are strongly engaged and where the impact of reformulation may be mostly clear' (Smith et al., 1993). Bruner (1986) expressed his belief that students learn by coming to terms with scientific knowledge within a community that shares a common culture.

This paper is the result of an innovative introductory science activity (a role play) planned, designed and implemented by the instructor in a science methods class for elementary science teachers with an aim to achieve the above mentioned science teacher education goals. The main objective was to teach prospective science teachers concepts in a simple but novel way.

Understanding the phases of the Moon is included in the National Science Education Standards (NRC, 1996). Additionally, 'teaching for understanding', as Wiggins & McTighe (1998) advocated, 'has to be every teacher's purpose in teaching' (as cited in Karakas, 2012; 2018). Scientific conclusions have to be artfully interpreted by teachers and applied to particular educational situations (Dewey, 1963). In particular, students should be able to "interpret physical phenomena from a phenomenological or macroscopic, point of view and from a microscopic perspective, and to relate one to the other" (Borges & Gilbert, 1999, as cited in Karakas, 2012; 2018). Based on this philosophical stance, the instructor incorporated a role-play analogy for easy understanding by the student teachers. Analogies "are used because they have the power to evoke rich, almost instantaneous, mental pictures that serve to challenge the hearer to transfer knowledge from a familiar to unfamiliar domain" (Harrison & Treagust 1993, as cited in Karakas, 2012; 2018). Moreover, this analogy could help future science teachers understand what the term "teaching for understanding" means by experiencing an example of teaching for understanding implemented by their instructors (Karakas, 2012; 2018). A number of researchers have noted that analogies can be seen as a 'two-edged sword' in that they help students to understand difficult scientific concepts, but if not used properly they can engender alternative conceptions (Harrison & Treagust, 1993, as cited in Karakas, 2012; 2018). There are also limitations to using this instructional method. Models, visual aids, role-plays are all great strategies for teaching complex science concepts, but they can never really replicate all essential components of the concept. The instructor was aware of this possibility.

Understanding the cause of lunar phases is difficult for learners (Abell et al., 2001; Baxter, 1989; McDermott, 1996; Barnett & Morran, 2002; Bryce & Blown, 2013; Chastenay, 2016; Hansen et al., 2004; Kavanagh et al., 2005; Küçüközer, 2008; Nielsen & Hoban, 2015; Parnafes, 2012; Plummer, 2009; Sadler, 1987; Schoon, 1995; Skamp, 1998; Sherrod & Wilhelm, 2009; Trundle et al., 2002; 2007; Zeilik & Bisard, 2000). Learners must grasp multiple concepts such as perspective, light, and angles as well as the waltzing motion of two astronomical bodies in order to adequately comprehend how the Moon's phases occur (Sherrod & Wilhelm, 2009). To complicate matters, learners bring a hodge-podge of ideas to the classroom with which to weave their understanding (Sherrod & Wilhelm, 2009). Therefore, instruction of this complex phenomenon has proven to be challenging and there are several alternative explanations documented in the literature; such as moon phases are caused by clouds covering parts of the moon, by the Earth casting a shadow on the moon, by planets casting a shadow on the moon (Baxter, 1989), and by the viewer's location on Earth (people in different geographic locations see different moon phases) (Schoon, 1995; Trundle et al., 2007).

The most prevalent misconception regarding the cause of lunar phases is that moon phases are the result of the Earth's shadow. Another common misconception is drawing a shaded Moon like one might see on a calendar, without regard to the position of her sketched Sun. This is not only common among children but also many adults still hold to it. This information is valuable to teachers and curricula designers when creating units of study to disrupt this common student misconception. National Science Education Standards (NRC, 1996) state:

> [A]s a result of their activities in grades 5–8, all students should develop an understanding of ... the relative positions of the earth, sun, and moon. Nevertheless, more than half of the students will not be able to use these models to explain the phases of the moon, and correct explanations for the seasons will be even more difficult to achieve (p. 159)

This warning by the National Research Council is further confirmation of the past failures to dispel students' long held misconceptions regarding the cause of lunar phases.

Finally, the focus of this activity was both to teach the concept of lunar phases in order for the pre-service science teachers to understand the concept and dispel the common misconceptions mentioned above, and to show the pre-service science teachers how to teach the concept of lunar phases to the middle school children in a novel way. Because they took very few science lessons on the phases of the Moon in school, students in the science methods course had limited understanding of the concept of the phases of the Moon; this is something that needs to be pursued as we train prospective science teachers. All the 48 students in the science methods class were senior students in the seventh semester of their study of science teaching in Fall semester of 2018 in a small university in northeast of Turkey.

Explaining the instruction

In the science methods class students choose one science concept and try to teach it to their peers in 30 minutes. One student we will call him Kadir chose Phases of the Moon. He draws the usual figure on the board (Fig. 1) and tried to explain the phases of the Moon through this figure. After he finished his explanation the instructor asked the question: when the light source is over there, which side of the sphere will be lit up, the side facing the light or the opposite side? How come you put shadow on the left side of the first quarter (6-o'clock) moon (drawing a shaded moon misconception is presented here) is not the sun light coming from the left side, isn't the left side supposed to be alight? Kadir had hard time explaining it the instructor asked the same question to the whole class. Now everyone was confused. The instructor was aware of Parnafes's (2012) claim that drawings work like mental models but operate in cases that are too complex to manage all the details internally and drawings are conversational objects around which students can negotiate meanings. In this case Fig. 1 was the main anchor for an explanatory activity and played a 'significant role in shaping the conceptual dynamics of the activity: once a drawing is constructed it becomes part of the conceptual dynamics; students refer to aspects of the drawing, gesture on it, draw attention to its details, and so forth' (Parnafes, 2012, p. 366) This question attracted students' attention. They started arguing among themselves how come the left side is not alight. The instructor then said you are thinking in two dimensions (2D) you should start thinking in 3D and imagine the space in 3 dimensions. Most of the students had hard times imagining in 3D the positions of the moon. Instructor said it is hard to imagine in 3D the phases of the moon let think about how we can represent the 2D Fig. 1 in 3D space. Students started thinking and one student said we could use small ball for Earth, orange for the Sun and very small marble for the Moon. Instructor said but your friend (Kadir) did not bring any of them now what should we do. The instructor then said see it is very hard to explain 3D concepts with 2D drawings and when we use 2D drawings to explain 3D concepts we usually cause misconceptions in students' minds (trying to address the drawing of a shaded moon misconception). Instructor said: let's see what we have here in the classroom; I have a cell phone with a flash light this can be our sun, Kadir can be a guy looking at the moon from the Earth and I want one student to represent the moon. Kadir picked up one of his friends to represent the moon we will call him Samet. Instructor said the Sun stays still and rotates only around itself and sheds light to the space in all directions. The Earth rotates around the Sun in one year and around itself in 24 hours. The instructor and Kadir showed these rotations in front of the board to the students. Then Samet enters these rotations and starts revolving around Kadir (The Earth guy), but it was still hard to see the shadings of the moon where the light hits the moon. Instructor explained that we see the light that is reflected off the Moon and toward the Earth. Instructor said let's make Fig. 1 now I am going to stay on the left side of Kadir and light my flashlight on him, Samet will stand on the first quarter (6-o'clock) phase. Now, let's see which part of Samet face is lit. Kadir turns toward Samet and looks at his face, and all of his left side are lit. Instructor said see that is not what you draw on the board in Figure 1. How we can light the right side of Samet. The instructor arranged the angles by putting Samet little bit further away from Kadir so that only his right side of his face gets some light from the flashlight (Fig. 2). Kadir (staying on his position without moving and just turning his face) now saw that only the right side of Samet's face is lit. Instructor said to Samet to move to full moon phase (3-o'clock) position and Kadir now saw how his all face is getting light (the instructor was holding the flashlight little bit up so the light passes over Kadir's head and lights Samet's all face) and then to third quarter (12 o'clock) position so that Samet's left side gets light now. Then instructor says to Samet to move to new moon phase (9-o'clock) position with his face facing Kadir and back of his head facing the instructor. Now the back of his head is lit and face is dark and instructor asks; dose this look like something you know? One student said it look like solar eclipse. Instructor said so we will have solar eclipse every month. Students did know that there are only 2 to 5 solar eclipses every year so this cannot be true. So how we can explain these discrepancy asks the instructor. Students are thinking but no answer. The instructor explained that because of the angles between the Earth and the Moon we have the new moon and when the 3 celestial bodies form a straight line we have the solar eclipse and asked Samet (the moon guy) to bend down a little bit and now Kadir looking down sees the new moon (the dark face of Samet) when they are not in a straight line. The instructor explained that shaded parts of the moon are not caused by clouds covering parts of the moon or by the Earth and planets casting shadow on the moon, but by the angle alignment of the 3 celestial bodies, to address the common misconceptions mentioned in the literature. The instructor asked everyone to form a group of 3 and make the same role play among themselves. Students were laughing and giggling, talking to each other, and having fun while performing the role play and some had eureka moments and said Aha now I understand it.

Later, the instructor familiarized student teachers with the concept as it was described in the textbook. And explained that as the moon orbits the Earth it changes position. This change in position is insignificant compared to the vast distance between the moon and the sun; therefore, the moon is illuminated similarly regardless of its position and that the half of the moon that is visible from Earth and the other half is invisible. The visible half contains sections of both the illuminated half and dark half of the moon. An observer viewing the moon from Earth will therefore see different shapes of the moon (Fig. 1). The moon in 3 o'clock position in Fig. 1 is an interesting case because many people assume the Earth blocks the light from the moon. In fact, the moon orbits the Earth in a plane that is oblique to the plane formed by the three bodies: sun, Earth and moon. According to this geometry, the Earth usually does not block the light from the moon (except on the occasion of a lunar eclipse) (Parnafes, 2012). The objective of using an alternate explanation with simple terms and role play was to use language and play known to student teachers that will explain the meaning of the concept and to give them an example of teaching with role-play so that they can use it in their future classrooms.

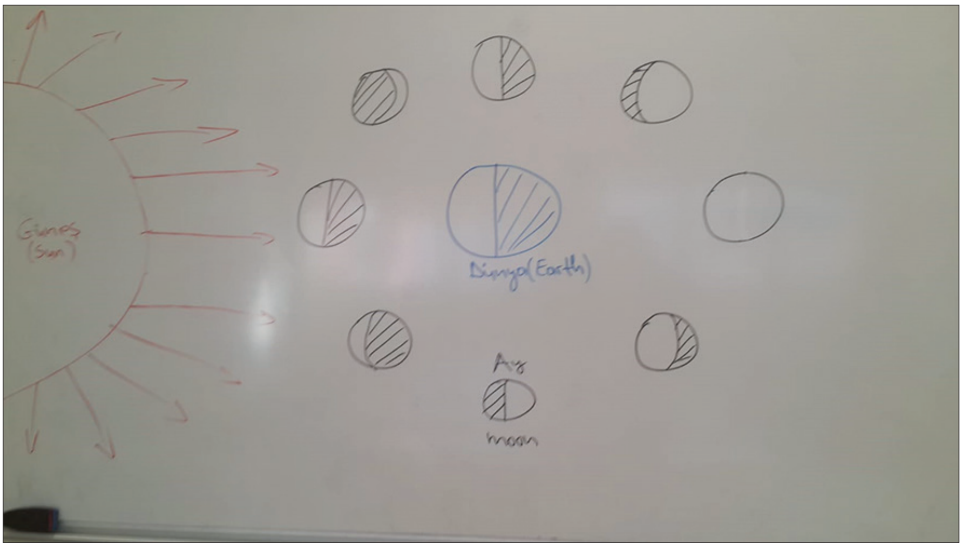

Figure 1. Phases of the Moon drawn by Kadir on the board

Evaluation

No formal evaluations, such as tests or open-ended exam questions, were conducted with students. However, informal interviews with a few students were conducted and most of them said "for the first time I understood the phases of the moon" and they were "surprised to see role play incorporated in a science class." Moreover, how much the prospective science teachers understood the phases of the moon concept was not formally evaluated, because the main objective of the activity was to show future teachers an innovative teaching example, so that they can incorporate it in their future classrooms.

Conclusion

The instructor described the mechanisms of the phases of the moon by arousing the curiosity of the students (by asking questions that show discrepancies in Figure 1.), by sustaining their interest throughout the topic (by relating 2D drawing to 3D role play), and by using simple language (appropriate to their level of understanding) (Karakas, 2008; 2010; 2012; 2018). The way of explaining the phases of the moon used in this article could also be used in junior high and elementary schools and maybe even in science teacher education classes. Many science educators recommend connecting hard to understand science concepts to real life experiences. Teaching in ways described in this article supports the National Research Council's call for "substantial change in how science is taught" and also contributes to teachers' professional development practices (NRC 1996, 56). The teaching example presented here could help science educators educate future science teachers to reason soundly about their teaching as well as to perform skillfully (Fenstermacher & Soltis, 1986, as cited in Karakas 2012; 2018). It also supports Cachapuz & Paixao's (2002) call for student-centered classrooms that emphasizes process-oriented learning, thinking skills that revolve around life experience, and presents pre-service teachers with teaching strategies that challenge their thinking and encourage them to ask questions.

Figure 2. Right side of the face gets light from the flashlight

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