

# Teaching future teachers basic astronomy concepts

*Ricardo Trumper*

*([rtrumper@research.haifa.ac.il](mailto:rtrumper@research.haifa.ac.il)),*

*Faculty of Science and Science Education, Haifa University, Israel*

## **Abstract**

We conducted a series of constructivist activities with future elementary and junior high school teachers aimed at changing their conceptions about the Sun-Earth-Moon relative movements like Moon phases, Sun and Moon eclipses, and others. Students' astronomy conceptions, at the beginning and at the end of the study, were analyzed by means of a written questionnaire containing 21 items. Most activities were performed in class, followed by a group discussion guided by the teacher; some activities were assigned as homework. In the pos-test questionnaire, only the experimental class and one of the control groups showed a statistically significant improvement, with the experimental class making the most impressive progress.

## **Introduction**

High school, college, and university students' notions of astronomy concepts have been investigated far less than those of elementary school students, which have been researched extensively during the last thirty years. Lightman and Sadler (1993) found that high school students shared some of the elementary school children's conceptions. Zeilik et al. (1998) obtained similar results among university majors.

Trumper (2001) assessed students' basic astronomy conceptions from junior high school through university. He summarized the most widespread misconceptions at all educational levels (see Table 1) and found that future elementary school teachers got the lowest correct response rate (32%), even lower than that scored by junior high school students (36%). This suggests that future elementary teachers have more alternative conceptions about basic astronomy concepts than typical junior high school students.

## **Methods**

Bearing in mind the results of the foregoing studies, we examined future teachers' alternative conceptions and created a series of constructivist activities to change future teachers' conceptions about the Sun-Earth-Moon relative movements like Moon phases, Sun and Moon eclipses, and more.

Subject	Misconception	Junior high school	Senior high school	Future primary teachers	Future high school teachers	Non-science university
Day- night cycle	Earth moves around the sun	36	30	51	37	34
Moon's phases	Moon moves into earth's shadow	19	27	16	25	29
	Moon moves into sun's shadow	25	17	29	23	16
Reason for seasons	Earth closer to sun in summer	45	33	37	32	32
Reason for it being hotter in summer than in winter	Earth closer to sun in summer	36	28	20	19	22
	Earth's rotational axis flips back and forth	20	23	31	29	23
Sun overhead at noon	Everyday	35	36	48	44	42
Moon's phase in solar eclipse	Full phase	74	77	71	75	70
Moon's rotation – same side visible	Moon does not rotate on its axis	54	57	51	47	50

*Table 1: Most widespread astronomy misconceptions by groups, in percentages*

The research encompassed 138 university and college students studying introductory courses on astronomy for the first time. The experimental class comprised 19 technology teachers at junior high school taking a semester course in their retraining for science teaching in primary and junior high schools at an academic college of education. There were three control classes following a traditional lecture format. One comprised 83 university students taking a semester course in the Interdisciplinary Department of the Faculty of Humanities. Another was 14 future high school physics teachers taking a semester in the Physics-Mathematics Teaching Department of the Faculty of Science and Science Education in the same university. The third one was made up of 22 future primary school teachers taking a yearlong course in their training for science

teaching in Bedouin primary schools at the same academic college of education as the experimental class.

Students' astronomy conceptions were analyzed by means of a written questionnaire containing 21 items presented at the beginning of the course<sup>17</sup>.

## Results

### *Pre-test results*

Figure 1 shows the scores obtained by the different groups in answering the whole questionnaire, and the questions about phenomena related to Sun-Earth-Moon relative motions, at the beginning of their introductory astronomy course.

In the whole questionnaire, there was a statistically significant difference between the success of the university students and of all the other groups with the largest effect size (Cohen, 1988) for the future Bedouin primary school teachers, as can be seen in Table 2, and for questions related to

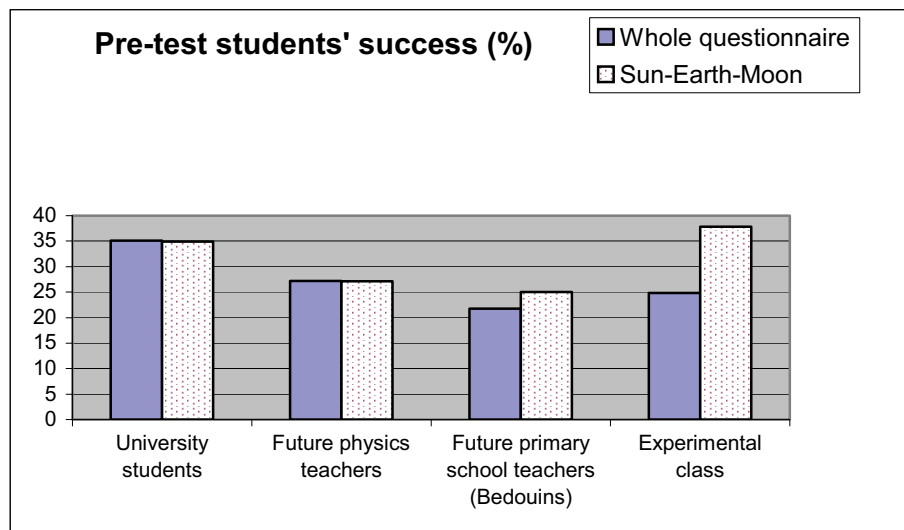


Fig 1. Correct answers percentage of the different groups in the pre-test.

Sun-Earth-Moon relative motions we found a statistically significant difference only between the university students and the future Bedouin primary school teachers ( $t = 2.04$ ,  $p$ -value = .05, Cohen's effect size –  $d = .77$ ).

<sup>17</sup> For a complete version of the questionnaire, see Trumper (November 2006), Teaching future teachers basic astronomy concepts – seasonal changes – at a time of reform in science education. *Journal of Research in Science Teaching*, in press.

	Students' success	t - test	p-value	Cohen's effect size - d
University students	35.1	-	-	-
Future physics teachers	27.2	1.862	.004	.488
Future primary school teachers (Bedouins)	21.8	4.048	< .001	.872
Experimental class	24.8	3.048	.002	.684

Table 2: Statistically significant difference between the university students and all the other groups in the whole questionnaire (pre-test)

### ***Experimental Instructional Activities and Findings***

Most activities were performed in class, followed by a group discussion guided by the teacher; some activities were assigned as homework. At the beginning, students performed an activity concerning *the day and night change in the spinning Earth*, from sunrise to midnight. The light from an overhead projector represented sunlight and the student's head the spinning Earth. Students were asked to look to the right side at the beginning (sunrise) and then to turn counterclockwise and to mark the position of their eyes in each of the situations. Fifteen students marked all the positions correctly, three students forgot to mark the position of their eyes at midnight, and one student marked midnight as if it was noon.

On the same day, the students were assigned a homework activity: They were asked to *predict the Moon phases* during the Hebrew (or Muslim) month, beginning with the New Moon. They had to arrange the pictures seen in Figure 2 on the appropriate squares of Figure 3, writing down the names of the Moon phases according to the Table 3.

Students were asked to watch the Moon phases every night during the next two weeks, to compare their observation with their initial prediction, and to correct it if necessary.

Ten students predicted correctly the order of the Moon phases after watching them for two weeks, and nine students made a wrong prediction.

Afterwards, the students performed an activity intended *to simulate the Moon phases as seen from Earth*. Students stood in front of an overhead projector representing sunlight. Their heads represented the Earth, and they held a Styrofoam ball with a large wooden stick slightly above their heads, representing the Moon.

Phase name	Age of the Moon (in days)
New Moon	1
Waxing Crescent	2-7
First quarter	8
Waxing Gibbous	9-14
Full Moon	15
Waning Gibbous	16-22
Third quarter	23
Waning Crescent	24-29

*Table 3: Names of Moon's phases during a month*

Students had to stand in front of the light and stretch their right arm holding the “Moon” towards the “Sun”. Then they had to move counterclockwise and watch how the illuminated part of the “Moon” changed shape. After completing a whole turn they had to draw the successive phases of the Moon, to compare them with their predictions, and to answer several questions related to the activity, including their causal explanations of the Moon phases: Twelve students gave a correct, or almost correct, answer, such as: “The changing angle between the Moon and the Earth”, “The Moon’s revolution around the Earth and the changing angle between the Sun and the Moon relative to the Earth”, “The position of the Moon in its revolution around the Earth during a period of thirty days, according to the light coming up from the Sun”, “The angle between the Earth and the Moon changes in relation to the Sun’s light”, “The Moon revolves around the Earth, so every night it is positioned at a different angle”, “The changing angle between the Earth and the Moon, and then the amount of light reflected to us changes”. Five students wrote only “The Moon’s revolution around the Earth”, and two wrote “The periodicity of thirty days of the Moon phases”.

A week after, the students performed a group activity intended to demonstrate that the Moon rotates on its axis once a month, always showing us the same side. One student held the “Moon” in his hand (a Styrofoam ball with a wooden stick on the top and a Bristol paper flag on it). The other students sat down in the middle of the classroom, representing observers on the “Earth”, and the student with the “Moon” had to revolve around them showing the same face of the “Moon” during the whole turn. After several tries he succeeded, and the students had to reach a conclusion about the Moon’s rotation. Next the student with the “Moon” was asked to turn around the “Earth” without rotating the “Moon”, and to complete the rotation of the “Moon” around its axis in less (and in more) than a month in order to confirm the students’

conclusion. All the students reached the right conclusion that the Moon rotates around its axis once a month, the same time it takes the Moon to complete a revolution around the Earth.

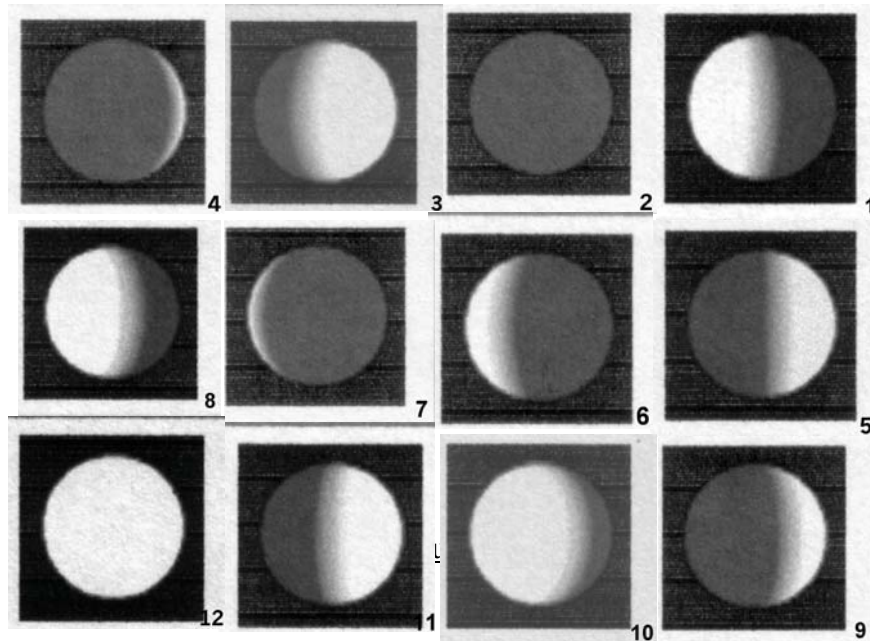


Fig. 2: Moon phases arranged randomly

Day 1: New Moon	Day 2: _____	Day 5: _____	Day 8: _____
Day 10: _____	Day 12: _____	Day 15: _____	Day 17: _____
Day 20: _____	Day 23: _____	Day 26: _____	Day 29: _____

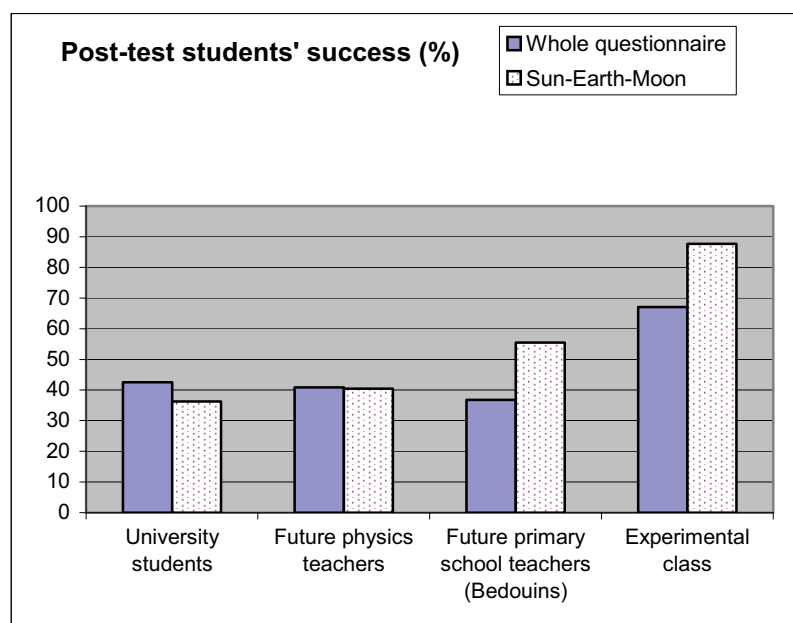
Fig. 3: Paper sheet for the arrangement of students' Moon phases prediction

Several weeks after, students performed their last activity in pairs, in order to simulate *Moon and Sun eclipses*, using the same “Sun”, the same “Moon”, and the same “Earth” as in activity of the Moon phases. They

were given a simple explanation about eclipses and were asked: (a) what has to be the relative Sun-Earth-Moon position in a Moon and Sun eclipse: seven students answered that they have to be in the same plane, six answered that the angle between the Sun, the Moon, and the Earth has to be  $180^\circ$ , and three students answered that they have to be positioned in the same straight line, and (b) what is the Moon phase during a Moon (Sun) eclipse: Fourteen students answered that the Moon is in its Full (New) phase, and four students answered that it happens in the middle (at the beginning or end) of the month.

### ***Post-Test Results***

The post-test (the same as the pre-test) was presented to the experimental class and to the control groups on their examination day. Figure 4 shows the extent of success of the different groups in answering the whole questionnaire, and the questions about phenomena related to the Sun-Earth-Moon relative motions.



*Fig. 4: Correct answers percentage of the different groups in the post-test.*

In the whole questionnaire, we found a statistically significant improvement in all the groups with the largest effect size for the experimental class as can be seen in Table 4. For the Sun-Earth-Moon relative motions' questions we found a statistically significant difference only for the future Bedouin primary school teachers ( $t = 5.64$ ,  $p$ -value  $< .01$ , Cohen's  $d = 1.81$ ) and for the experimental class ( $t = 9.89$ ,  $p$ -value  $< .01$ , Cohen's  $d = 3.34$ ). The significant improvement in the future Bedouin teachers' conceptions may be explained by their very low scores in the pre-test and by the fact that they were the only group having an annual course. Nevertheless, the experimental class showed the most

impressive improvement with a very large normalized gain of  $g = 0.8$  (Hake, 2002) and the greatest effect size.

	Pre-test total success	Post-test total success	t	p-value	Cohen's effect size - d
University students	35.1	42.5	2.003	.025	.37
Future physics teachers	27.2	40.9	2.222	.023	.95
Future Bedouin primary school teachers	21.8	36.8	4.607	< .001	1.63
Experimental class	24.8	67.0	10.19	< .001	4.20

*Table 4: Comparison of the total success in the pre- and post-test for all the groups*

## **Conclusions**

Understanding the solar system involves a number of related conceptual areas that are clearly of importance in relation to students' existing conceptions and are difficult to explain since they do not match their daily observations. They include a perception of spatial aspects of the Earth, a conception of day and night, of seasonal change, etc., which include compound movements of the Moon, the Sun, and the stars. In this study, we can see clearly that many students are not post-Copernican in their notions of planet Earth in space, and hold alternative notions to the accepted scientific concept in various basic astronomy subjects.

Students in the experimental class conducted both individual activities at home and in the classroom; the paired and group activities were conducted in the classroom. They also participated in guided discussions, arguing about their different notions and continuously assessing their significance, and checking their validity. The students were active constructors of their own knowledge, while the process of knowledge acquisition was greatly assisted by interactions with peers and in particular, with the teacher.

The findings of this study show that both the experimental class and the control groups improved their basic astronomy concepts in a statistically significant way. Moreover, regarding the subjects relevant to this study only the future Bedouin primary school teachers and the experimental class showed a statistically significant improvement. In both cases, the experimental class made the most impressive improvement of all.

These findings support the constructivist approach in teaching, in which students are confronted with their alternative conceptions in a conceptually centered learning environment that actively engages them.

### **Bibliography**

- Cohen, J. (1988) *Statistical Power Analysis for the Behavioral Sciences*, N.J.: Erlbaum Hillsdale.
- Hake, R. (2002). Assessment of Physics Teaching Methods. Proceedings of the UNESCO-ASPEN Workshop on Active Learning in Physics, University of Peradeniya, Sri Lanka, 2-4 December 2002.
- Lightman, A. & Sadler, P. (1993). Teacher predictions versus actual student gains. *The Physics Teacher* 31, 162-167.
- Trumper, R. (2001). Assessing students' basic astronomy conceptions from junior high school through university. *Australian Science Teachers Journal* 41, 21-31.
- Zeilik, M., Schau, C. & Mattern N. (1998). Misconceptions and their change in university-level astronomy courses. *The Physics Teacher* 36, 104-107.