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Full Length Research Paper

Determining students' mental models about the sun, earth and moon celestial objects for sustainable learning in astronomy education in Libya

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ABSTRACT

The study aims to reveal students' mental models and perceptions regarding the concept of the celestial bodies, for instance, earth, sun, and moon. This research study was conducted as a case study focusing on qualitative data. This study also has used a sample formed of 5th-grade students, in the 2018–2019 academic year; the target sample is formed from 50 students at an elementary school in Libya. This study aimed to use the data collection tool, in addition, a test with three open-ended questions was used. Also, according to primitive, synthesis as well as scientific models, the data classification was used and analyzed. The result of this practical study has demonstrated that all the target samples have a synthesis of mental models that are not sufficiently compatible with scientific knowledge.

Keywords: Astronomy education, Libyan students, mental models, sustainable learning, sun, earth, moon.

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INTRODUCTION

In all areas and levels of education, it is desired that young generations be responsible individuals and these are being studied in schools. The school is an important context where students can better understand the complex world they live in and develop their competence (Perret-Clermont et al., 2016). Here, students develop a stance that is constantly on the lookout, combining respect for others and the environment and different resources, cultural traditions and natural resources (UNO, 2013). At the same time, they gain knowledge and skills about human welfare and the basic requirements of economic development. They are educated to understand and promote sustainable development in our world. This is a process and science education, like other fields, has contributed to this process. However, in many studies focusing on students' perspectives, it is emphasized that students associate science teaching with traditional teaching with passive roles (Freire et al., 2016). In our opinion, although some correct and qualified practices are carried out in science teaching in schools, the problem is that it is not sustained. That is, those correct and qualified practices have been carried out on a short-term basis. However, effective teaching processes should be highlighted and applied all the time. Therefore, a sustainable approach to learning and teaching in education based on the academic research results can be considered as a solution.

Sustainable education is constructed with social constructivist, context-based, self-regulated and collaborative learning, and empathizes for all stakeholders with iterative processes to solve problems (Geitz, 2016; Geitz and Geus, 2019). Thus, Misra and Khurana (2017) are proposed that a sustainable approach to teaching and learning should be embedded into the curriculum, especially to bridge the gap between the skills and industry's or 21st century's required skills. A sustainable approach to teaching and learning does not aim to accept students as passive and inactive, and as an academic content that requires them to memorize information (Geitz, 2016). Sustainable teaching requires a rethinking of the education and training program, its objectives and processes. Sustainable teaching also

requires re-thinking the learning process. Sufficient knowledge and competencies need to be created for sustainable learning, and this requires knowledge of existing realities and challenges. Especially in countries like Libya, which are in a difficult situation and whose restructuring efforts have begun. Libya also focuses on difficult educational cases after the civil war. In Libya, as in all areas of education, there are efforts in science teaching. One of the things that must be done in Libya for sustainable teaching is to know the realities and challenges in every subject area.

Some concepts are the basis for the concepts to be learned. Accurate teaching and learning of these basic concepts are essential for sustainable teaching and learning processes. As in many countries, astronomy education is offered under the umbrella of science education. When the education programs for astronomy education are examined, it is noted that the celestial bodies are taught with the principle of the distance away (Kurnaz, 2012a). In this sense, Earth, Moon, and Sun appear as basic celestial bodies for the teaching of faraway celestial objects. These concepts are given at an early age in the curriculum of many countries and are essential for sustainable education and learning processes in astronomy education. The main focus of this study is to determine the mental models of students about Earth, Moon and Sun concepts, and to expose the existing reality and challenges of astronomy education in Libya for these basic concepts.

Astronomy education

Astronomy which can be defined as the oldest of all sciences is an attractive and interesting field to the majority of people all over the world especially the young students (Abusamra et al., 2007). The perception of pupils on celestial bodies has always been a research field that has always attracted the attention of scientists. This interest in the universe may increase the efforts to deep understanding and connection between astronomical events or objects as well as people. Since the 1970s several studies concentrated on the recognition of the perceptions of a student in basic astronomy concepts (Kurnaz, 2012a). In recent years, the interest in identifying the cognitive structure of students about certain scientific concepts has been developed before they enter the preparatory school, especially in developing countries like Libya. Numerous studies have emphasized the importance significant of pre-learning knowledge, for the reason that they may be non-scientific. These perceptions were called with different names, for instance, preconceptions, alternative frameworks, alternative ideas, children science, alternative science, or misconception (Redish and Steinberg, 1999). The existence of these perceptions among students can lead to a negative influence on the means of learning because the concept of learning remains accompanied by some difficulties for many students. Consequently, teachers may ignore perceptions and interpretations that students have before they know these concepts (Kurnaz and Emen, 2014), and this may disrupt sustainable teaching and learning in astronomy education at least countries like in Libya. Thus, astronomy education is currently exposed to development and progress at the curriculums for sustainable teaching and learning, because of the importance in our lives, as in scientific research (Trumper, 2006). This is also the case in Libya. Since it was noted that the basic concepts were important for sustainable teaching and learning in astronomy education in Libya, in the early stages of education, especially for 5th-grade students, it has taken great importance to the fundamental concept of astronomy by the curriculum developers. Although there has been a variety of studies investigating student, teacher as well as prospective teachers' understandings about basic astronomy concepts, however, the Libyan schools and curriculums still lack such studies about this issue. So one of the things that must be done in Libya for sustainable astronomy teaching and learning is knowing current realities and challenges about the basic concepts of astronomy education. In this manner, the main purpose of this research is to make clear the current realities and challenges on the issue by revealing the students' mental models on the concepts of the sun, earth and moon.

Mental models

Since the learning process also involved the process of constructing the mental model (Hanke and Huber, 2010), studies on the emerging of mental models of students are also one of the current researches topics about students, conceptual configurations. A person uses a mental model to evolve and facilitate coping with the environment by creating semiotic systems (Hestenes, 2006). Here, semiotic systems are used in the meaning of representational systems such as symbols, diagrams, tokens, icons. Mental models are internal symbolic representations, and they construct according to the personal observation of the phenomena and/or events (Doyle and Ford, 1998). Thus, it is argued that any child's mental models are influenced by their environs (Hestenes, 2006); and as noted above, schools are good examples to influence students' mental world. Since the lack of learning or alternative ideas could also be derived from the learning environment (*e.g.* from schools) (Kurnaz and Saglam Arslan, 2010), students may improve wrong mental models about the concepts (Kariper, 2013).

Mental models give a description of the contents of memory for difficult concepts, including the comprehension of scientific principles and theories

(Rapp, 2005). According to Ornek (2008), mental models can be investigated to understand and learn how the students participate effectively in the physical world. Meanwhile, determining mental models may help to uncover non-scientific ideas of children. So that, we can achieve important data for teachers and researchers about students' perceptions to facilitate the knowledge acquisition process (Vosniadou, 1994). We are believed that to emerge current realities and challenges about sustainable teaching and learning in astronomy education in Libya, the determination of the mental model will also be functional to understand conceptual configurations.

METHOD

This research was conducted descriptively. Descriptive studies are efficient and effective in detecting the condition examined, illustrating the situation studied, evaluating it in accordance with standards, and detecting the relationship between events (Cohen et al., 2007). In the study, the design of the survey study was used within the scope of the descriptive approach (Yin, 2003). This design lets a chance to obtain information in a short time and is in line with the purpose of the study.

Study group

The study group of the research has consisted of 50 volunteer students in 5th grade selected using the purposeful sampling method in the academic year 2018–2019 in Ghiryan in Libya. In Libyan, in 5th grade, students begin to learn about celestial objects academically. So, the study group was formed with 5th grade to identifying what students know about celestial objects after they study this topic at school.

In this article, researchers also focused on ethical issues for the whole research process. However, since there was no formal institutional review board or equivalent committee(s) due to civil war nowadays in Libya, a written consent could not be obtained by the researchers before the research. However, verbal consent was obtained from the participants and the research was conducted only with volunteers. Therefore, it is stated by the researchers that the information given about the study group does not indicate their identity, and the paper does not include an identifier, or potentially identifying, information about the study group. It is not aimed to categorize humans by any socially constructed groupings in the paper.

Data collecting tool and analysis

For the present study, data were collected through the use of a test consists of three open-ended questions for each celestial object developed by Kurnaz (2012b) (Appendix). The questions can be defined as three-tier questionnaires for the Sun, Earth and Moon objects. In the questionnaire, the first question requires explaining these concepts. This was questioned to understand what the pupils used to highlight when they heard each celestial object. The second question included drawing the shapes of the celestial bodies, and this question aims to reveal the shapes information of pupils on the given objects. The third question involves drawing the Sun, Earth and Moon objects as a system. In the third question, it is also wanted to show the whole movements/rotations of the Sun, Earth, and Moon on the picture. This was done to elicit the knowledge the pupils in this study used to relate each celestial object. The content validity of the questionnaire was confirmed by an expert holding a Ph.D. in astronomy education.

These research questions included in the study reveal theoretical information that determines the students' mental models about given basic astronomy concepts. In the analysis of data, the participant's responses to each tier were examined separately for the celestial objects. Firstly, the students' descriptions of the given celestial bodies on question 1 were analyzed qualitatively by emerging common categories. Secondly, visualizations of the objects by the students on questions 2 and 3 were analyzed qualitatively by observing similar patterns and grouping accordingly. The purpose of presenting the common categories revealed by the qualitative analysis of the questions is to reveal the learning status of the students for each concept based on the categories. The purpose of presenting the common categories that emerged with the qualitative analysis of the questions is to reveal the learning situations of the students for each concept based on the categories.

Then, each student's separately responses to three questions for the objects were compared within themselves. As a result of the comparison, the students' mental models were determined based on their responses to whole questions. In the process of determining mental models, initial, synthesis and scientific models proposed by Vosniadou and Brewer (1992, 1994) were used. Students who provided school (correct) knowledge and correct drawings of the celestial body were considered to have a scientific model. The students were assessed who did not give scientific knowledge and correct drawings about the celestial body, considered to have an initial model. Students who give scientific knowledge information to one or both of the above (or other) cases have a synthesis model.

RESULTS

In the first question, the students were asked to elucidate what they remembered when they heard the given celestial objects separately. The purpose is to reveal the learning status of the students for the Sun, Earth and Moon objects. The student's responses to the first

question (*What comes to your mind when you hear the concept of the (respectively) Sun, Earth, Moon? Explain it*) are summarized in Table 1.

As seen in Table 1, there are two common perceptions among students about the Earth. According to this, more than one-third of the students (38%) percent the earth as round celestial objects. About one-third of the students associated the earth with the idea that the earth is where humans live (30%). The main perception between students -except one student- for the sun is that it is a source of light. Also, approximately one-fourth of students answered that the sun as an object comes in the daytime (26%). There are two prevalent perceptions among students too. According to this, about three-quarters of the students (72%) defined the moon as a circle, and approximately half of them (44%) express that the moon as an object comes at night. It is also understood that several of the students have some alternative ideas for the given celestial objects.

In the second question (*Could you please draw the shapes of the Sun, Earth, Moon?*), the students were asked to depict the shapes of the celestial objects separately. Table 2 shows the characteristics of the student drawings on the given objects.

Table 1. Students' responses to the earth, sun, and moon.

Celestial body	Students' responses	f	%
Earth	It is round.	19	38
	It is where humans live.	15	30
	It is colored blue.	4	8
	It is the 3rd largest planet in the solar system and is the only astronomical object known to harbor life.	2	4
	It divides into water and land.	2	4
	It is a celestial body.	2	4
	It is valid for living because of gravitation, oxygen, and the atmosphere.	1	2
	It has a comet around it.	1	2
Sun	It is a source of light.	49	98
	It comes in the daytime.	13	26
	It is a star that radiates light.	6	12
	It is a celestial body.	4	8
	It is a planet that burns everything.	2	4
	It is medium-sized, radiates light and heat, and does not move.	2	4
Moon	It is round.	36	72
	It comes at night time.	22	44
	It is a dark place and it reflects light from the sun.	8	16
	It is a small celestial body that revolves around the earth.	2	4
	It consists of ice, gas, and dust.	2	4
	It has a glowing solid body.	1	2

Table 2. Students' responses to the sun, earth, and moon.

Celestial body	Students' answers	f	%
Sun	Round drawing	44	88
	Pointless drawing	4	8
	No response	2	4
Earth	Round drawing	26	52
	Geoid drawing	20	42
	No response	4	8
Moon	Round drawing	39	78
	Crescent moon	5	10
	No response	6	12

It was noted in Table 2 that the majority of the students (88%) the sun as a round object. For the earth, while more than half of the students (52%) showed a rounded shape (40%), about half had drawn the shape of the geoid. The majority of students (78%) depicted the moon round, and other students (10%) were depicted the moon as crescent-shaped. However, a few of the students did not draw the shape of the sun, earth, and moon. Sample drawings of the students for the celestial objects are given in Figure 1.

In the 3rd question (*Could you please draw the shapes of the sun-earth-moon system, consisting of showing their movements?*), it was asked the students to draw the sun, earth and moon system by showing the movements of them on the picture. Table 3 shows the characteristics of the student drawings on the system.

Figure 1. Sample drawings of students.

Table 3. Students' answers for the movement of the Sun, Earth and Moon system.

Students' answers	f	%
Rotation of the Earth around the Sun	31	62
Rotation of the Moon around the Earth	25	50
Rotation of the Earth around itself	23	46
Rotation of the Moon around itself	10	20
The Sun revolves around itself	0	0
Not showing the movement of celestial bodies	30	60

As seen in Table 3, more than half of the students (60%) were unable to visualize the movements of the celestial bodies, and surprisingly, none of the students showed that the sun revolves around itself. With regard to the movement of the Earth around the Sun, most of the students (62%) reported that the earth wandered around the sun. As for the Moon's movement around the Earth, half of the students (50%) found that the Moon wandered around the Earth. Surprisingly, with regard to the movement of the Moon around itself, only a few (10%) of the students say that the moon revolves around its axis. Considering the fact that from an early age to teach the day-night phenomenon based on the revolving of Earth on its own axis, again surprisingly, nearly half of the students (46%) showed that the Earth revolved around its axis. Sample drawings of the students for the sun, earth and moon system are given in Figure 2.

Mental models of students

As a result of the comparison of each student's responses to the whole questions, mental models for students were determined as initial, synthesis and scientific mental models. Table 4 summarizes the mental models of students obtained by comparing the whole responses of students.

As summarized in Table 4, very few students have scientific knowledge that corresponds to school knowledge about Sun, Earth, and Moon. Nearly a quarter of the students have a primitive mental model about the Sun while half of the students have a primitive mental model about the Moon. It is also pleasing that no student has a primitive model about the Earth. As a result, as seen in the table, most students are in the synthesis model category related to celestial bodies. Nearly half of the students for the Sun and the Moon, almost all for the World, have a synthesis model.

DISCUSSION AND CONCLUSION

As noted at the beginning of the paper, since learning the basic concepts meaningfully in the early stages of education is important for sustainable teaching and future learning, knowing current realities and challenges by revealing the students' mental models on the concepts of the sun, earth and moon may be a beginning point to start, in relation to our focus. To this end, we have focused on this issue in this paper. The basic concepts required for advanced learning can be observed directly by students in daily life from an early age. Some

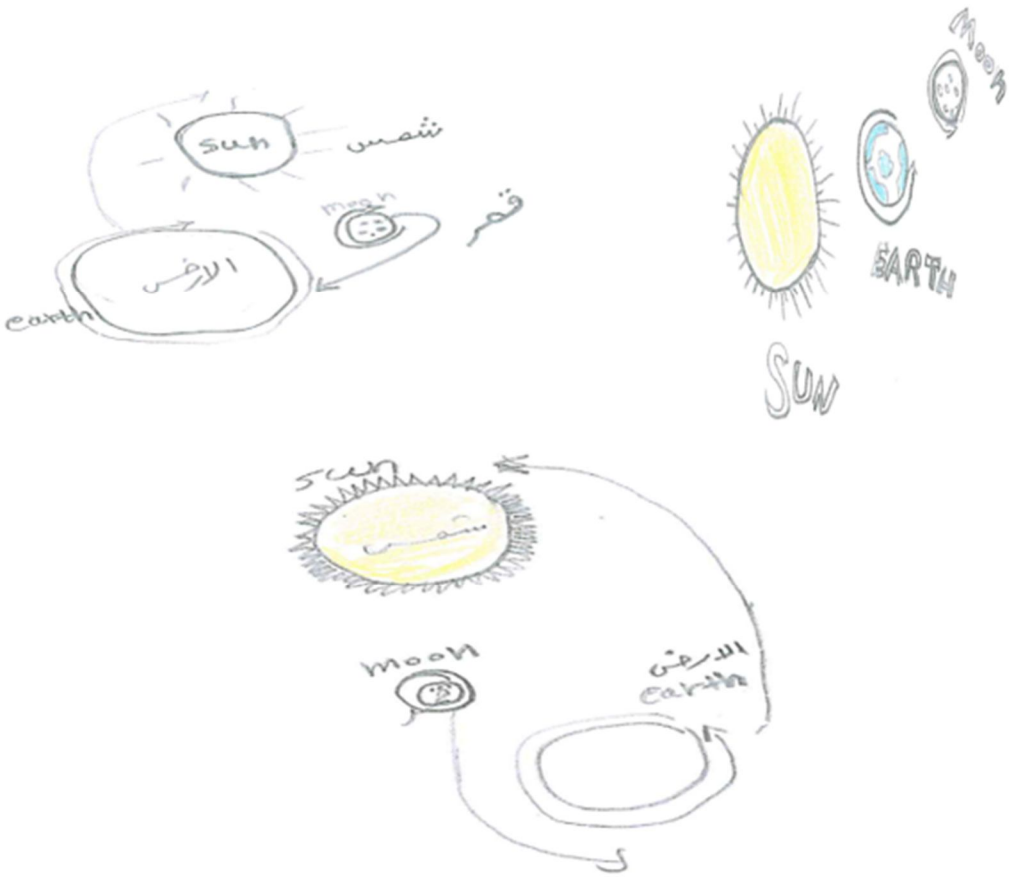

Figure 2. Sample students' drawings for the Sun, Earth and Moon system.

Table 4. The distribution of student mental models.

Celestial body	Initial model		Synthesis model		Scientific model	
	f	%	f	%	f	%
Sun	13	26	33	66	4	8
Earth	-	-	47	94	3	6
Moon	22	44	26	52	2	4

phenomena related to the Sun, Earth, and Moon are the first concepts observed by students and as a result of these observations, non-scientific perceptions can be developed. The results of the movements of these celestial bodies relate to processes such as the interpretation of issues in different disciplines (for example in explaining climate events), facilitating daily life (location-direction determination). Therefore, a sustainable approach to astronomy education that includes repetitive and incremental teaching and learning processes, is very important that students construct correct perceptions of these three celestial bodies. When the students' dominant responses about the Sun, Earth, and Moon were examined, it was seen that the students concentrate on the feature of the Earth being round and liveable, the feature of being the light source of the Sun, and the characteristics of the Moon as a satellite of the Earth and an object which comes at night. In addition, students were generally trying to depict the size and movements of the sun-earth-moon system bodies. However, we cannot say that there is a sound understanding. The students were also lack of enough knowledge about the size and movements of the objects; *e.g.*, some of them thought that the Sun does not move, or some of them depicted the Earth bigger than the Sun. It is understood that student perceptions are limited to the way they are used in daily life. In other words, it can be said that the students did not gain the correct perceptions about the celestial bodies or the students have difficulty in expressing their gains. This is not surprising, according

to Trumper (2001, 2003). Trumper states that students make explanations for celestial objects that can be observed with the naked eye from their own observations and experiences and that these do not generally correspond to scientific knowledge. Considering cognitive development, students may be anticipated to obtain a broader sense of understanding. Although uncovered perceptions of the students for the target concepts may accept stoically as true; however, they are mostly anthropocentric. That is, Libyan students probably came to school with daily life knowledge based on their own experiences and they reunite them with school -scientific-knowledge. After all, it is understood that students are gain a synthesis of everyday knowledge and school knowledge, and thus, most of the students constructed a synthesis mental model in their mind for the celestial bodies. On the other hand, it is expected from learning processes at school that students should be reconstructed their daily life knowledge with school knowledge. This means that it has not been adequately provided. In that case, a deep change in the way of teaching is needed to target concepts for sustainable astronomy teaching.

As noted above, students generally have synthetic mental models. Here, this should be discussed: what is the meaning of having synthetic mental models of Libyan students for target concepts? The internalized status of Sun, Earth, and Moon by the Libyan students are cognitive structures; and in fact, these structures do not need procedural correctness (Clement, 1993). But when planning teaching processes, benefiting from mental models of the students may be more effective for a holistic approach (Vosniadou, 1994). In astronomy education, generally, it is often noted that the principle of teaching the close celestial bodies and then teaching distant celestial bodies draws attention. Earth, Moon and Sun basic celestial bodies are close celestial bodies learned from an early age. Knowing mental models of the Libyan students on the Sun, Earth, and Moon may propose occasions for evaluation, estimation, and explanation for sustainable astronomy education; and this proposal is supported by Vosniadou (1994), Rapp (2005) and Örnek (2008). Teachers are advised to verify student mental models about the celestial bodies and their motion characteristics. In addition, it is recommended that teachers be interested in students' mental models before teaching scientific concepts about the sun, the earth, and the moon.

Recently, we have become aware of student mental models about basic concepts of astronomy. It is clear that students' synthesis mental models are important barriers to effective and sustainable learning and we have to overcome this as science educators. The findings of this study confirm the need for reform of astronomy education in Libya. Therefore, this study has implications for teachers, researchers, curriculum developers, and policymakers to see some of the barriers and opportunities in Libya. This study was conducted with a limited participant; thus, the claims may not be interpreted from a broad perspective. Of course, this study has its limitations. Therefore, on the one hand, further work is needed to uncover student clutches to assess the current situation in Libya. On the other hand, more work is needed to overcome the underlying causes of students' unscientific mental models and to achieve sustainable astronomy education.

Because students have observational data about daily events in the sky, students may have different ideas than scientific ones. Students can come to the classroom with non-scientific mental models that are built with everyday experiences, and in fact, they can be strong frameworks for teachers to interact with students. For effective teaching, teachers need to consider non-scientific mental models. In this context, the results of this study provide teachers with useful information in structuring learning and teaching environments. If a teacher has a better understanding of the student's mental models about research concepts, teachers can perhaps edit their teachings by discussing alternative ideas with students. Thus, further research on mental models should be developed to develop more effective teaching strategies in teaching the basic concepts of astronomy.

The results of this study also have implications for students. It is necessary to encourage students to change their own learning activities in which they can create or produce new knowledge in science (Kurnaz, 2012a, 2012b). When students become aware of unscientific mental models, they can challenge their alternative ideas and change their learning processes. Therefore, the results of this study may provide an opportunity for meaningful learning to Libyan students with reflective skills.

Finally, these and similar studies can provide insight into the realities and challenges of each subject area. Sustainable teaching also requires rethinking the learning process. Adequate knowledge and competencies need to be established for sustainable learning, which requires knowledge of current realities and challenges. Especially in countries like Libya that are in a difficult situation and where restructuring efforts are underway. Every effort should be made to help stakeholders in Libya and similar countries gain confidence in sustainable astronomy education.

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APPENDIX

1. What comes to your mind when you hear the concept of the (respectively) Sun, Earth, Moon? Explain it.
2. Could you please draw the shapes of the Sun, Earth, Moon?
3. Could you please draw the shapes of the sun-earth-moon system, consisting of showing their movements?