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PRE-SERVICE TEACHERS' CONCEPTUAL UNDERSTANDING IN SPACE SCIENCE

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ABSTRACT

Space science discovery has stimulated interest among Malaysian teachers, students and the society after the success of sending a Malaysian astronaut into space. It has resulted in the incorporation of astronomy education at primary and secondary schools. However, the development of astronomy education is hastened due to the lack of astronomy education research focusing on specialized knowledge among school teachers. Limited astronomy content knowledge in lessons poses detrimental effects on student learning and may form misconceptions, not just among the students but the teachers as well. This study is intended to determine the level of conceptions and misconceptions in space science among the pre service teachers. A set of space science test was distributed to 140 preservice teachers from diverse courses in public university in Malaysia. The result of this study reveals that preservice teachers have moderately (37.86%) conceptual understanding of space science with a number of misconceptions of basic astronomy concepts such as the formation of the seasons, the causes of day and night and the galaxy. Interestingly, gender and major study of pre service teachers do not show any substantial difference in understanding the space science concept. Education was found to be the most important factors which contributed to the pre service teachers' understanding of the space science concepts. This study sheds light into the crucial needs to increase the understanding of pre service teachers on nature, elements in outer space, and philosophy of science to avoid them from teaching the misconception of space science to their students.

Contribution/ Originality: This study is one of the very few studies which have investigated the conceptual understanding of preservice teachers in space science. The findings of the study reveal the needs to integrate more relevant and updated instructional strategies into the classroom to shed light on the misconceptions held by future teachers.

1. INTRODUCTION

Space science is an extensive field which is commonly associated with astronomy, micro gravity sciences, atmospheric science, space weather research and scientific payload onboard spacecraft. In other words, it is a study on the aspects and elements of outer space. Space science and astronomy are among the oldest field of science and

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assumes a significant place in science education due to the nature of its study which concerns the cosmic relationships. In addition, it comprises all science disciplines such as mathematics, physics, chemistry, and biology. Its relation with numerous fields of study and students' interest of the space, space science education has paved its way into the curriculum of many advanced countries such as the United States, Australia, Canada, Israel, Italy and United Kingdom. These countries regarded astronomy as a significant area to develop and have incorporated space science education in every level of their education systems, from primary school up to the university level (Kalkan & Kiroglu, 2007; Türk, Sener, & Kalkan, 2015). Space science education impacts positively on the development of medical research, knowledge and education, as well as other fields. In addition to the provision of work opportunities, space science education helps in boosting technological sector thus creating a leap for the country to achieve its advance status.

Malaysia's commitment towards space science education was first observed through the establishment of the Space Science Studies Division (BAKSA) in 1992, followed by the Malaysia's Center for Remote Sensing (MACRES). These two agencies are responsible in promoting and cultivating public interest towards space science education particularly in the field of space science and astronomy. Following a tireless effort in building an astronaut program by the federal government, Dato' Dr. Syeikh Muszaphar Shukor became the first Malaysian to land onboard the International Space Station (ISS) in 2007 (Zainuddin, 2008). This momentous event had spurred the public interest towards space in general, and astronomy in particular.

School curriculum at primary and secondary level was restructured to engage astronomy education in science subject. In the Integrated Curriculum for Primary School (ICPS), the standard six students are taught aspects pertaining to the earth and the universe. The Integrated Curriculum for Secondary School (ICSS) exposes form three students to the astronomy and space explorations. Though these are steps towards the right direction, school teachers are still lacking specialized knowledge in the area and the only resources that teachers have in teaching are the textbook and related reference books. Science teachers' knowledge of astronomy, specifically, and of space science, generally, needs to be updated from time to time given the changes in the findings of space science studies (Kiroglu, 2015). However, this is hardly the case as the trainings with regard to space science education provided to the school teachers are limited.

Limited conveyance of content knowledge in lessons poses detrimental effects on students' learning. Teachers may resort to teaching entirely from reading texts from books aloud. Content that is supposed to instill fun and creative learning, tapping into both cognitive and affective domains of learning, would just be another subject that is only cognitively relevant. Teachers' pre-existing knowledge may form conceptions or misconceptions. Misconceptions, however, could potentially influence teachers to reject true knowledge and teachers transmit these misconceptions onto their students during the teaching and learning process (Kiroglu, 2015).

Misconceptions are often cited as an issue particularly when the knowledge imparted to students are in contrast to the universal truth. Efforts to address teachers' existing knowledge and misconceptions, if any, and working towards rectifying the misconceptions are crucial. Unlike the curriculum at university level which focuses on specialized content, teachers at primary and secondary school levels are expected to deliver a wide ranging contents in the science curriculum and these include biology, chemistry, physics as well as earth and space science concepts at varying levels of complexity.

In ensuring effective instruction of space science, it is important to ensure that the pre-service science teachers are equipped with sufficient content knowledge and the pedagogical know-how. Studies involving pre-service science teachers' knowledge of space science, however, have illustrated low understanding of space science concepts among these pre-service teachers primarily because these concepts are difficult to visualize (Chen, 2015; Trumper, 2001; Trundle, Atwood, & Christopher, 2002).

Given the importance of space science education, the study focuses on the conceptions towards space science among the trainee teachers at one of public universities in Malaysia. It is interesting to note that studies which

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explore trainee teachers' conceptual understanding of space science concepts are limited, yet astronomy and space sciences are aspects addressed by the curriculum at primary, secondary and tertiary level, particularly within the context of teacher training in science education.

Following this idea, the researchers are interested to investigate the level of understanding, to identify the misconceptions of the space science concepts among pre service teachers, and to determine factors which influence the formation of space science knowledge among the pre-service teachers. Therefore, this study is conducted with the following research questions:

1. What is the level of preservice teachers' conceptual understanding of space science concepts?
2. What are the misconception hold by the preservice teachers in space science concepts?
3. What are the factors that contribute to the understanding of the space science concept among preservice teachers?
4. Is there any significant difference between science and non-science major related to space science concepts?
5. Is there any significant difference between genders related to the understanding of space science concepts?

2. LITERATURE REVIEW RELATED TO TOPIC

2.1. Introduction

Space science and astronomy is science subjects that people most rapidly lose interest in and do not pursue at a deeper level of understanding (Bergstrom, Sadler, & Sonnert, 2016; Sadler., Sonnert, Hazari, & Tai, 2012). Studies have shown that learners often prefer to stay at a superficial level and tend to have misunderstandings of astronomy and space science because their teachers have lesser content knowledge. Although the concepts of astronomy and space science are taught and introduced at primary level even in preschool, most of the findings in the related studies indicated that some mistakes are made every level of education.

2.2. Conception and Misconception in Space Science among Preservice Teachers

Cox, Steegen, and De Cock (2016) as cited in Halim and Meerah (2002) reported that pre-service teachers who have less content knowledge are also less aware of potential misconceptions of students and, in consequence, are unable to propose different teaching strategies. Sometimes, even after years of intensive training and education, some misconceptions remain unchanged.

Many prior discussions in the misconception literature addressed how misconceptions make learning difficult. A study of second-grade students found that many knew that the Sun was "on the other side of the Earth" at night, but showed no clear preference for whether it was the Earth or the Sun that moved (Klein, 1982). Both Baxter (1989) and Vosniadou and Brewer (1987) found that students have several naïve explanations for daily changes. The Sun is obscured (going behind a hill or covered by clouds), the Sun physically moves around the Earth, or the Earth orbits the Sun in 24 h (a conflation of the day and the year). Sadler (1992); Sadler (1996) showed that grade 8–12 students failed to understand the reason for day and night because they believed that the Earth orbits the Sun in a day. Furthermore, with confusion about orbiting and spinning, it is nearly impossible for learners to understand the galactic rotation, using spectroscopy.

In recent years, study on the basic concepts of space science and astronomy have been intensively carried out by many researchers around the world (Baybars, 2018; Brunsell & Marcks, 2005; Taşcan, 2013). Brunsell and Marcks (2005) conducted a study on 142 science teachers and employed an astronomy concepts recognition test as a data collection tool. They revealed that the teachers have some deficiencies in understanding the concepts of astronomy. Iyibil (2010) also found that the preservice teachers could not provide enough explanations about the concepts of Earth, sun, moon, planet and satellite.

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Taşcan (2013) conducted the study to determine the level of the science teachers about the basic astronomy concepts and to identify whether the basic knowledge of astronomy vary significantly depending on gender, faculty, department, teaching experience, and some other variables. Based on the findings, it was concluded that the science teachers have some misconception in basic astronomy such as eclipses, the moon and periods of the moon and formation of seasons which resulted to low interest in astronomy. The findings also showed that all the variables do not emerge in teachers' knowledge. In another study conducted by Baybars (2018), the conclusion made was that the middle school students also encounter some misconceptions about the basic concepts of astronomy such as the universe, solar system, star, planet and constellation.

3. METHODOLOGY

3.1. Sample and Population

A total of 140 respondents from diverse courses in public university in Malaysia participated in the study. The respondents were randomly selected from science and non-science major.

3.2. Instruments

This study was carried out through the utilization of a survey method, specifically through the use of test as the main instrument. Students' understanding of space science was assessed using the Space Science Test, a multiple-choice test designed to assess students' conceptual understanding of the most basic concepts in space science and did not require mathematical operations or calculations. The test contained 15 questions related to star, earth, planet, season, day and night, galaxy and constellation. The respondents were also requested to respond to a set of questionnaire aimed to ascertain factors which contributed to the conceptual understanding of space science among the pre-service teachers. The questionnaires consisted of two sections. The first section (four items) attempted to gather the respondents' demographic information. The second section (20 items) was developed to identify contributing factors which shaped these pre-service teachers' understanding and conceptions, ranging from education, media, interest and surrounding. Five-point Likert scale was employed ranging from '0' (strongly disagree) to '4' (strongly agree).

3.3. Method of Data Collection and Data Analysis

Table 1 shows the marks and level of conceptual understanding of space science according to the respondents' score. Descriptive analysis such as mean and standard deviation (SD) are employed in determining the level of conceptual understanding and the factors which contributed in enhancing the knowledge of space science. T-test analysis was further conducted to determine the influence of gender and major of study on conceptual understanding in space science.

Table-1. Level of conceptual understanding in space science.

Marks (%)	Level
80-100	Excellent
60-79	Good
40-59	Moderate
20-39	Low
0-19	Very Low

Source: Adapted from Hestenes, Wells, and Swackhamer (1992).

4. RESULT

4.1. Level of Preservice Teachers' Conceptual Understanding in Space Science Concepts

In this study, the test score were transformed to the percentage (%) and the mean score were calculated. Overall, the mean score is M= 8.06 (53.33 %), with SD= 2.652. Based on Table 1, the respondents' understanding level of

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space science concepts is at moderate level. The analysis of the level of understanding based on the distribution of respondents can be seen in Figure 1.

Figure 1 illustrates the distribution of respondents according to five category levels of understanding. It can be seen that 37.86% of respondents had acquired moderate level of understanding of space science concepts. 36.43% of respondents were good and 17.14% respondents demonstrated low level respectively. Only 8.57% respondents had acquired excellent level of understanding. No respondents showed extremely low level in their understanding of the space science concepts.

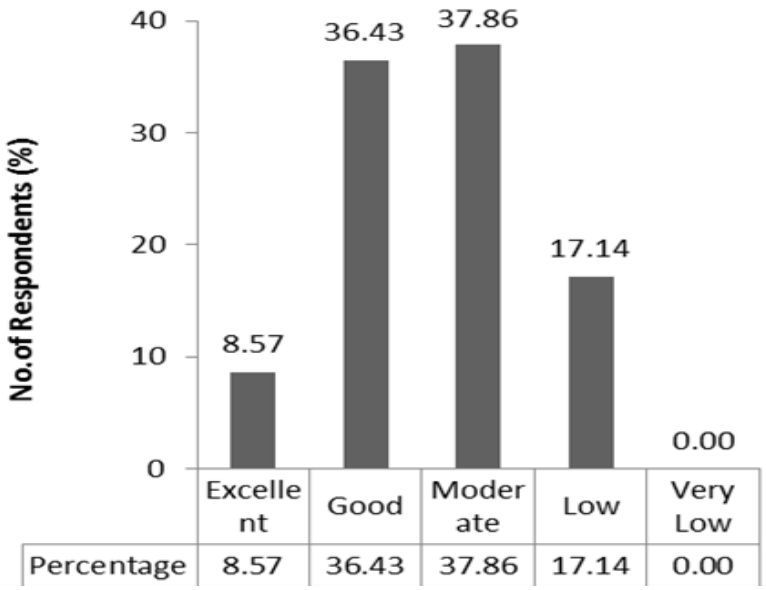

Figure-1. Respondents' level of conceptual understanding

4.2. Misconception of pre service teachers in space science concepts

The analysis of data derived from the test items is presented in Table 2. As observed in the table, there are a few items exhibited the highest percentage of incorrect answers. Thus, the existence of the misconception in space science among preservice teachers can be identified.

Table-2. Analysis of score distribution.

Item	The Percentage Distribution of Options (%)			
	A	B	C	D
Q1	*15.70*	5.00	**77.90**	1.40
Q2	11.40	*37.90*	**29.30**	21.40
Q3	3.60	**87.90**	3.60	*5.00*
Q4	**55.70**	11.40	7.10	*25.70*
Q5	22.90	11.40	*23.60*	**42.10**
Q6	14.30	8.60	**57.90**	*19.30*
Q7	17.90	15.00	*25.00*	**42.10**
Q8	13.60	5.00	**57.90**	*23.60*
Q9	13.60	6.40	**62.10**	*17.90*
Q10	12.10	**33.60**	*40.70*	13.60
Q11	**32.10**	*32.10*	17.90	17.90
Q12	16.40	**47.10**	*21.40*	15.00
Q13	**47.10**	21.40	10.70	*20.70*
Q14	*26.40*	**51.40**	5.00	17.10
Q15	*5.00*	2.10	4.30	**88.60**

Note: Bold figures are the correct answers and italicized are incorrect answers.

Table 3, on the other hand, presents the percentage of items which were scored incorrectly by the respondents. Item 2, 10 and 11 were found to receive the highest percentage of the incorrect responses. Question 2 'what causes

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the seasons' was scored correctly ("the tilt of the Earth's axis") by only 29.3% respondents. Most of the respondents (37.9%) stated that "the Earth revolves around the Sun in an elliptic orbit". For question 10, although highest number of the respondents (33.60%) provided the correct response ("day and night occur as a result of the Earth's rotation on its axis"), other respondents claimed that day and night are caused by "the Sun going around the Earth". The percentage of the respondents who chose incorrect answer ("Day and night are caused by the Sun going around the Earth") is high (40.7%). For question 11, the percentage of respondents (32.1%) who provided the correct answer ("Galaxies are divided based on their shapes which are spiral, elliptical and irregular") is equal to the number of respondents who chose incorrect answer ("A galaxy consists of millions of planets and their moons only").

Table-3. Items with high percentage of incorrect answers.

Item	Common Incorrect Answer	Misconceptions Identified
Q2	B (37.90%)	The Earth revolves around the Sun
Q10	C (40.70%)	Day and night are caused by the Sun going around the Earth
Q11	B (32.10%)	A galaxy consists of millions of planets and their moons only

4.3. Level of conceptual understanding between science and non-science pre service teachers

Table 4 shows the level of conceptual understanding of space science between science and non-science major preservice teachers. The results pointed out that there was no statistically significant difference in the understanding of the space concepts with t (138) = 0.855, (p > .05) among the pre-service teachers, regardless of the programs that they were enrolled in. The average level of understanding between preservice teachers of science major (M= 8.2375, SD= 2.7844) is significantly similar to that of the non-science major (M=7.8500, SD= 2.4690).

Table-4. Level of conceptual understanding between science and non-science pre service teachers

Courses	N	Mean	SD	t	p
Science	80	8.2375	2.7844	0.855	0.394
Non-Science	60	7.8500	2.4690		

4.4. Level of conceptual understanding in space science between genders

Table 5 shows the finding in relation to the level of understanding of space science concepts among the respondents of different genders. The results disclosed that there was no statistically significant difference in understanding the space concepts t (138) = 1.505, (p > .05) between gender. The average level of understanding between the male respondents (M= 7.3333, SD= 3.2123) was significantly similar to that of the female respondents (M=8.2241, SD=2.5094).

Table-5. Level of conceptual understanding between genders.

Courses	N	Mean	SD	t	p
Male	24	7.3333	3.2123	-1.505	0.135
Female	116	8.2241	2.5094		

Table-6. Factors in shaping space science knowledge.

Factors	Mean	SD
Education	17.125	2.812
Media	13.050	3.234
Interest	15.100	4.700
Surrounding	4.625	2.168

4.5. Factors in shaping space science knowledge

Of the four contributing factors identified in shaping space science knowledge among the pre-service teachers, the finding presented in Table 6 indicated that Education played the most significant role with the highest mean score (M = 17.125, SD= 2.812). This was followed by Interest with a mean score of (M= 15.100, SD= 4.700).

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Meanwhile, both Media and Surrounding were with the mean score of (M = 13.050, SD=3.234) and (M = 4.625, SD=2.168) respectively.

5. DISCUSSION

5.1. Level of pre-service teachers' conceptual understanding in space science concepts

The findings in this study showed that the pre-service teachers have moderate level of conceptual understanding in space science. The awareness of pre-service teachers' conceptions about space science appears to be important, however, there is a gap in the body of knowledge given the limited interests researchers have paid. Studies involving pre-service teachers (Trumper, 2001; Trundle et al., 2002) and college students (Libarkin, Anderson, Science, Beilfuss, & Boone, 2005) found that many students did not have adequate scientific understanding about earth and space science concepts. This was attributed to the low number of astronomy courses offered as core and elective options at tertiary institutions. In addition, students who attended such courses were exposed to teaching and learning processes that were largely ineffective, with limited opportunities in learning the most fundamental and unifying aspects of science subjects (Kiroglu, 2015).

5.2. Misconception of pre service teachers in space science concepts

As observed in Table 3, pre service teachers have misconception about the causes of the seasons (Q2). They stated that the causes of the seasons were due to "the Earth revolves around the Sun in an elliptic orbit". In fact, the "tilt of the Earth's axis" was the cause for the seasons. Similar results were also reported by Trumper (2000) in previous studies. There are several other studies on misconception of the causes of the seasons in the literature (Atwood & Atwood, 1996; Brewer, 2008; Cox et al., 2016; Galperin & Raviolo, 2015; Kiroglu, 2015; Philips, 1991). The most common misconception about the causes of the seasons was the students' belief that the seasons are caused by earth's distance to the sun. Earth orbits the sun in an elongated elliptical path and that this is what causes earth's distance from the sun to vary enough to cause the seasons. In reality, earth's orbit, while elliptical, is nearly a perfect circle. Students often claimed that the sun is not in the center of earth's orbit, thus causing earth to be closer or farther away from the sun at different times. While it's true that the sun is at one focus of earth's elliptical orbit, the fact that the orbit is nearly a perfect circle means that the distance from earth to the sun remains nearly constant all year (Brewer, 2008; Cox et al., 2016). In general, study in misconceptions on the cause of the seasons is among of the most studied areas of Earth science and frequently discussed in the research of space science. However, preservice and in service teachers still hold the same misconceptions and demonstrated confusion in earth science study (Atwood & Atwood, 1996; Kikas, 2004).

In this study, pre service teachers have higher misconception in the reason of day-night cycle (Q10). Most of them claimed that day and night are caused by "the sun going around the Earth". The misconceptions identified in this work are parallel with the reported findings from Dove (2002). Previously, the researchers had identified some ideas of misconceptions about day and night such as the sun goes behind hills, the sun goes somewhere else, the sun is the next to other hemisphere, the sun going down to the sea, then the sun cannot reflect its light, clouds cover the sun, the moon covers the sun, the Sun goes behind the Earth once a day, the Earth goes around the Sun once a day and the Earth spins on its axis once a day (Baxter, 1989; Galperin & Raviolo, 2015; Kiroglu, 2015; Mohd, 2000; Zurida & Mohd, 2001). All of these are common misconceptions that have been cited by the students. Some students have different point of views and believed that the sun moves across the sky and the Earth rotates in a clockwise manner. In fact, the cause of day and night occurred because of "the Earth's rotation on its axis". In service teachers also have misconceptions in the cause of day and night during teaching. Most of them believed that the earth's rotates from the North Pole to the South Pole, the Earth orbits the Sun in 24 hours, and the cause of day and night was due to the Moon (Parker & Heywood, 1998; Roslizah, 2003; Summers & Mant, 1995). Roslizah (2003) also reported that the teachers in schools were still unclear about the concept or term of 'orbiting' and 'spinning'.

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Failure to replace a misconception with a scientifically accurate concept can have negative consequences beyond understanding one concept or performance in one course. For example, a lack of understanding of the reason for day and night (Q10) may well have serious repercussions for the comprehension of other ideas in astronomy and space science. An understanding of the reason for day and night is a prerequisite for many concepts in introductory Earth science courses. Students without an accurate understanding of day and night generally do not gain an understanding of the motion of the Sun or the cause of the seasons (Q2).

Majority of the respondents in this study were confused in choosing the correct statements of the galaxy (Q11). The respondents in this study claimed that the statement "A galaxy consists of millions of planets and their moons only" is a correct statement without the awareness of the prevalence of this misconception. The correct statement of the galaxy is "Galaxies are divided based on their shapes which are spiral, elliptical and irregular". Previously, Sadler et al. (2010) reported that there was misconception about galaxy among grades 9-12. Students believed that "Galaxies are held together by electromagnetism". In fact, the "galaxies are held together by the gravity".

5.3. Level of conceptual understanding between science and non-science pre service teachers

As observed in Table 4, the results pointed out that there was no statistically significant difference in the understanding of the space concepts among pre service teachers regardless of the programs that they were enrolled in either science or non-science major. This result was substantially different from the findings by Kalkan and Kiroglu (2007) which reported that misconceptions held by the non-science major were far greater as compared to their science major counterparts.

5.3. Level of conceptual understanding between genders

From Table 5, it can be deduced that there was no statistically significant difference in understanding the space concepts between genders. The average level of understanding between the male was significantly similar to that of the female respondents. This result was contrastively different from Trumper (2001) who reported that male respondents scored significantly higher than female respondents in all levels of education.

5.4. Factors in shaping space science knowledge

In the present study, there are four factors identified in shaping space science knowledge among the pre-service teachers. Education contributed to the predominance factors in shaping space science knowledge. Trumper (2001) asserted that space science education has a favorable impact on a better understanding of the world in which one lives in as well as in demonstrating knowledge growth. New discoveries in astronomy and space science create heightened interest and can be manipulated to enhance students' motivation in science learning.

5.5. Suggestion for Future Research

It would be interesting to use other space science concepts in carrying out similar studies and these concepts include solar and lunar eclipses, the universe and moon phases in order to develop high level conceptual understanding in space science. The test used should be appropriate and systematic in order to focus on conceptual understanding in astronomy and on the most commonly held misconceptions. For example, in administering and validating diagnostic questions of the Astronomy Diagnostic Test (ADT) (Brunsell & Marcks, 2005). A standard diagnostic test can be a powerful tool in assessing preservice teachers' conceptual understanding of concepts.

Also, the employment of a mixed-methodology design would enable for a more rounded and comprehensive view on the acquisition of space science concepts among the pre-service teachers. The use of well-proven strategies is important in ensuring effective space science learning. In particular, astronomy instruction can be delivered through the utilization of the constructivist approach: direct experiences and observations, representative-symbolic

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language, organized knowledge, and formal strategies are directly applicable. This would allow the students to gradually construct a logical and coherent understanding of science, particularly the space science concepts.

6. CONCLUSION

The study focuses on identifying pre-service teachers' understanding of space science concepts, in particular, examining the conceptions and misconceptions of these concepts. The level of respondents' understanding is moderate with a number of misconception of basic astronomy concepts. The responses obtained from a test consisted of 15 multiple-choice items shows that the pre-service teachers in both science major and non-science major misconceived the scientific facts for the formation of seasons; and day and night. These misconceptions are consistent with the findings of other studies with similar focus. The third misconception, however, is not supported by the findings derived from past studies: the pre-service teachers believed that a galaxy consists of enormous number of planets with individual moon. It is interesting to note that the pre-service teachers' conceptions and misconceptions of the space science concepts are not influenced by the type of programs that they were enrolled in (science major and non-science major) as well as their gender. Education was found to be a major influencing factor in shaping the pre-service teachers' conceptions towards the space science concepts.

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