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The development of an Astronomy Concept Inventory (ACI)

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Abstract

The aim of this study is to develop an Astronomy Concept Inventory (ACI) to assess undergraduate students' conceptual understanding of moon phases, moon and earth motion. ACI consists of 25 multiple choice questions with four distracters. The inventory was administered to 262 undergraduate students who took introduction to astronomy course. The data were analyzed by ITEMAN software program. The difficulty indices ranged from .45 to .92, and discrimination indices ranged from .21 to .59. The mean P value as difficulty index was found to be .66 for the test while alpha value for whole test was found as .80.

Keywords: Astronomy concept inventory, moon phases; moon and earth motion; conceptual understanding;

1. Introduction

Astronomy is one of the oldest sciences related with stars, halley, satellites, space and solar system (Pena & Quilez, 2001; Osborne, 1991).In recent years the number of studies regarding students' conceptual understanding of astronomy has been increasingly accelerated. Since astronomy includes concepts that are directly related with different disciplines, it has a significant place in curriculum contexts. Countries, United States of America, Australia, Canada, Israel, Italy and United Kingdom, which paid special attention to astronomy, reconstructed their curriculum from primary school to university (Kalkan & Kiroglu, 2007). Students' conceptual understanding of the causes of moon phases was identified as a part of scientific literacy and emphasized as a targeted concept in National Science Education Standards (National Research Council [NRC], 1996).

As developments in science education throughout the world have been continuing, an important step has just been taken in Turkey. Turkish primary science and technology program was renewed in 2005 and the content of astronomy subjects was reconstructed in this new science and technology curriculum. Topics in the new curriculum are: shape and structure of earth (fourth grade), size and shape of sun, earth and moon – moon and earth motion – day and night cycle (fifth grade), orbs, solar system and space probes (seventh grade), and the formation of the universe and the earth (eighth grade) (Turkish Ministry of National Education [TMNE], 2005). Since the content regarding astronomy concepts covered in the high school curriculum was limited "Astronomy and Space Sciences Course" and its content was modified and the new course is being implemented starting from 2010 (TMNE, 2010).

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Studies conducted about students' conceptions in astronomy showed that many misconceptions about astronomy concepts experienced by students in their daily lives are often observed in their from childhood (Vosniadou, 1991; Vosniadou & Brewer, 1990). The topics in which misconceptions were most commonly observed and the studies that identified those misconceptions are summarized in Table 1.

Table 1. The topics regarding the targeted misconceptions and the relevant studies

Misconceptions about	Sources
Moon	Lelliott & Rollnick, 2009; Danaia & McKinnon, 2008; Cin, 2007; Sharp & Sharp, 2007; Trundle, Atwood, & Christopher, 2007; Sharp, Bowker, & Merrick, 1997; Trumper, 2006; Samarpungavan, Vosniadou & Brewer, 1996; Callision & Wright, 1993
Earth	Lelliott & Rollnick, 2009; Danaia & McKinnon, 2008; Cin, 2007; Sharp & Sharp, 2007; Vosniadou, Skopeliti, & Ikospentaki, 2004; Sharp, Bowker, & Merrick, 1997; Trumper, 2006; Samarpungavan, Vosniadou & Brewer, 1996; Callision & Wright, 1993
Moon phases	Bayraktar, 2009; Bailey, Bell, & Trundle, 2008; Danaia & McKinnon, 2008; Trundle, Atwood, & Christopher, 2002; Prather & Slater, 2004; Fanetti, 2001

In previous studies open-ended questions, interview and observation forms were used for assessing students' understanding of astronomy concepts (Bayraktar, 2009; Bell & Trundle, 2007; Blown & Bryce, 2006). Several multiple choice tests (see Table 2) related to astronomy concepts were also developed by researchers in different countries for different contents. However, these kinds of assessment tools are rarely found in Turkey. Because multiple choice tests are useful assessment tools that are easy to construct, edit, and score for teachers and as shown in Table 1 moon phases, moon and earth motion are difficult topics for students to understand, the aim of this study is to develop an Astronomy Concept Inventory (ACI) to assess undergraduate students' conceptual understanding of moon phases, moon and earth motion.

2. Methods

2.1. Participants

The inventory was administered to 262 undergraduate students from four different universities (Ankara University, Gazi University, Amasya University, Kocaeli University) who have taken introduction to astronomy course during the spring semester of 2009-2010 academic year. 173 of participants were enrolled in Department of Primary Education. Apart from these, 89 participants were enrolled in Department of Astronomy and Space Sciences.

2.2.Instrument

In this study, the instrument was developed based on the theory of traditional test construction (Crocker & Algina, 1986). Prior to the beginning of this study, purpose of the inventory was identified and the concept domain was defined by the researchers. For the purpose of content validity, a table of specifications was prepared to ensure that all of the objectives in the curriculum are represented by all test items. 12 questions were taken from eight different sources (see Table 2): Frede (2008), Kalkan and Kiroglu (2007), Gray, (2006), Trumper (2006), Sarranize (2005), Lindell (2001), Trumper (2000), Finegold and Pundak (1991) and 18 questions were developed by the researchers by considering instructional objectives. 12 questions were translated by three researchers, and a fourth researcher checked the linguistic equivalence of the questions. Prior to the field-testing, two experts of astronomy education examined the structure and content of the all questions in the inventory.

Table 2. Distribution of ACI items according to sources

Item	Sources
1,2,3	(Frede, 2008)
4	(Trumper, 2000; Kalkan &Kiroglu, 2007)

5,7,	(Finegold & Pundak, 1991)
6	(Trumper, 2006),
15,16	(Lindell, 2001)
20	(Gray, 2006)
21,23	(Sarranize, 2005)

Table 3 shows the distribution of ACI items according to the topics covered in the test.

Table 3. Distribution of ACI items according to subject matter

Content	Item
Moon Phases	1, 3, 4, **6,**10,11, 12, 13, 21, 22, 25, 26, 28, 29, 30
Moon Motion	2, 8, 15, **16,** 17, 18, **23**
Earth Motion	**5**, **7,** 9,14,19, 20, 24, 27

**Bold questions were eliminated after item analysis*

2.3.Data Analysis

The data were analyzed by ITEMAN (Item and Test Analysis program) software program. The results of item analysis are tabulated in Table 4.

Table 4: The results of ITEMAN

Item No.	Difficulty Index (P)	Discrimination Index (D)
1	0.457	0.320
2	0.777	0.361
3	0.860	0.249
4	0.657	0.321
5	**0.302****	**0.250**
6	**0.291****	**0.143***
7	**0.328****	**1.000**
8	0.494	0.447
9	0.883	0.441
10	0.543	0.494
11	0.592	0.592
12	0.555	0.289
13	0.751	0.483
14	0.913	0.373
15	0.506	0.330
16	**0.638**	**0.160***
17	0.887	0.414
18	0.909	0.433
19	0.857	0.413
20	0.547	0.395
21	0.475	0.536
22	0.732	0.453
23	**0.385****	**0.239**
24	0.426	0.225
25	0.596	0.476
26	0.717	0.516
27	0.592	0.258
28	0.555	0.590
29	0.502	0.405
30	0.615	0.510

*Item is eliminated because of low discrimination index (D<.20)
** Item is eliminated because of low difficulty index (P<.40)

Item discrimination index of .40 or higher indicates that it is an exceptionally good item in terms of its ability to discriminate between high achievers and poor achievers (Van Blerkom, 2009). Ebel and Frisbe (1991) classified items with discrimination index from .30 to .39 is reasonably good but possibly subject to improve, 0.20 to 0.29 is marginal items usually subjected to improvement and below 0.19 is poor items that are to be rejected or further improved by revision. Thus, two items (6, 16) were eliminated due to poor discrimination index (D<.20). Three

items with difficulty index (5, 7, 23) .40 and below were eliminated. After the elimination of the items, item analysis was repeated and the final version of inventory consisted of 25 items. The difficulty indices ranged from .45 to .92, and discrimination indices ranged from .21 to .59. The mean P value as difficulty index was found to be .66 for the test while alpha value for whole test was found as .80.

3. Conclusion

The findings presented in this study show that final version of the ACI consists of 25 multiple choice questions which of 7 was taken from six different sources: Frede (2008), Kalkan and Kiroglu (2007), Gray (2006), Sarranize (2005), Lindell (2001), Trumper (2000), remaining 18 items were developed by the researchers. Fourteen questions are related to moon phases, five to moon motion, and six to earth motion in test. All the findings obtained from the item analysis, validity and reliability analyses of indicate that ACI is a valid and reliable tool to identify undergraduate students' understanding related to astronomy concepts.

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