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The Correlation between Pre-Service Science Teachers' Astronomy Achievement, Attitudes towards Astronomy and Spatial Thinking Skills

Cumhur TÜRK[1]

[1] Science Education Program, Faculty of Education, Ondokuz Mayıs University, Samsun, Turkey

Correspondence: Cumhur TÜRK, Science Education Program, Faculty of Education, Ondokuz Mayıs University, 55200, Samsun, Turkey. Tel: 90-362-312-1919. E-mail: cturk@omu.edu.tr

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Abstract

The purpose of this study was to examine the changes in pre-service Science teachers' astronomy achievement, attitudes towards astronomy and skills for spatial thinking in terms of their years of study. Another purpose of the study was to find out whether there was correlation between pre-service teachers' astronomy achievement, attitudes towards astronomy and skills for spatial thinking. The study was conducted with 280 pre-service teachers (freshmen, sophomores, juniors and seniors) studying at the education faculty of a university in Black Sea Region of Turkey. The data were collected through Astronomy Achievement Test, Astronomy Attitude Test and Purdue Spatial Visualization Test: Visualization of Rotations. One way factor analysis (One-Way Anova) technique for independent groups was used for data analysis in order to find out whether pre-service teachers' astronomy achievement, attitudes towards astronomy and skills for spatial thinking differed in terms of their years of study. In order to find out whether there was correlation between pre-service teachers' astronomy achievement, attitudes towards astronomy and skills for spatial thinking, simple linear correlation analysis was conducted and Pearson Moment Correlation Coefficient was checked. The results of the data analysis showed that pre-service teachers' astronomy achievement, attitudes towards astronomy and skills for spatial thinking differed significantly in terms of their years of study. In addition, a low positive correlation was found between pre-service teachers' astronomy achievement and attitudes towards astronomy while a high positive correlation was found between pre-service teachers' astronomy achievement and their skills for spatial thinking. In line with these results, recommendations were made to increase the number of astronomy classes in education faculties and to teach astronomy not only in fourth year but also in the first three years.

Keywords: astronomy education, achievement, attitude, spatial thinking, correlation

1. Introduction

Astronomy includes concepts which require high level of observation and thinking skills. Students have difficulties in interpreting and understanding three dimensional concepts and movements of astronomy since they are shown on two dimensional diagrams. Studies conducted suggest this result (Türk & Kalkan, 2015a; Yu, 2005; Shen, 2006). It has even been stated that it is very difficult to change misunderstandings which take place as a result of this difficulty and that as students' ages advance this situation does not change (Bisard et al., 1994; Schneps & Sadler, 1989). One of the most important problems in astronomy education is the skill of spatial thinking. This problem makes it harder to learn and comprehend the basic concepts of astronomy correctly. However, when astronomy concepts are learned correctly, students' skills of perception and comprehension develop. Thus, it becomes easier to learn other abstract concepts in science teaching. This situation presents the relationship between science teaching and astronomy.

When some studies conducted with pre-service teachers are reviewed, it can be seen that pre-service teachers in general experience similar problems with astronomy subjects and concepts (Türk, Şener, & Kalkan, 2015; Bisard et al., 1994; Kalkan & Kıroğlu, 2007; Trumper, 2001a, 2001b, 2001c, 2003, 2006; Zeilik, Schau, & Mattern, 1998). In his study, Trumper (2001c) administered a test of 19 questions on 433 university students (156 in first year, 122 in second year, 87 in third year and 68 in fourth year) and examined the students' misconceptions and the changes in these misconceptions in terms of the students' years of study. The findings show that science and non-science

oriented college students in pre-service training to become high-school teachers hold a series of misconceptions on several central topics in basic astronomy. Kalkan and Kıroğlu (2007) found in their study that pre-service teachers of science and non-science had misconceptions about a great number of subjects in basic astronomy. The changes in the percentages of correct answers given by pre-service teachers were examined throughout one semester. As a result of the study, it was found that students had difficulties in explaining their location on earth and their abstract-concrete relationships with other heavenly bodies based on their locations by using basic scientific thoughts of today.

On the basis of all these studies, a need was thought to determine the changes during university education in the astronomy achievement, attitudes towards astronomy and spatial thinking skills of pre-service science teachers who will be responsible for teaching astronomy subjects in middle schools in Turkey and the correlations between these. While doing this, it was thought that it would be useful to conduct a cross sectional study which was found not to have been studied too much in literature. In addition, by comparing the changes in pre-service science teachers, the problems in teacher training policies in Turkey about the subjects of astronomy will be presented. Thus, unlike other studies in literature, this study was planned not only to present the current situation about pre-service teachers but also to observe the change, to find out the correlation between achievement, attitude and spatial thinking and to suggest solutions to these problems.

In most of the countries in the world, astronomy is not taught as a separate lesson, it is included in other lessons as a subject. For example, it is included in lessons such as physical sciences, physics and geography. However, astronomy has a special place in other disciplines with its content, deepness, attraction and energy. Astronomy is not taught as a compulsory and separate course in Turkey. In Primary schools, astronomy topics are included in Social Study courses (6-7 years) or Science courses (8-13 years) as separate units. In high schools, astronomy courses are taught as elective courses. However, students often fail to select this course due to teacher shortage (Kalkan & Kıroğlu, 2007). In faculty of education, astronomy courses are included only in Science teaching undergraduate programs (one term, 2 hours a week).

1.1 Spatial Thinking Skill

In its most general sense, spatial ability can be defined as the skill to rotate two or three dimensional objects in various ways and to visualize the changing shapes of these objects in mind. Researchers have defined spatial ability as rotating objects, visualizing shapes and putting the parts of a whole to their places correctly (Hartman et al., 2006; Orde, 1997). Spatial ability is defined as "representing, rotating, generalizing symbols, remembering and non-linguistic information" (Linn & Petersen, 1985). Spatial ability is a cognitive factor related with high performance in the areas of science and mathematics (Lord & Rupert, 1995). Two sub-dimensions as spatial visualizing and orientation were mentioned firstly about spatial ability which began to be seen in educational studies after the first quarter of 19th century. Later, although a series of spatial abilities were found, researchers could not agree on naming and defining these abilities (Linn & Petersen, 1985).

In their study, Linn and Petersen (1985) grouped spatial ability in three. The first one was mental rotation, the second one was spatial perception and the third one was spatial visualization.

Mental rotation: It is the ability to rotate a two or three dimensional shape in a fast and correct way (A Gestalt like cognitive process).

Spatial perception: It is the ability to be able to find out spatial associations despite disturbing or distracting information and the ability to overcome distracting situations.

Spatial visualization: It is the complicated and multi staged spatial orientation process such as visualizing the parts of a whole object in the mind and it includes abilities of mental rotation and spatial perception, too.

1.2 The Purpose and Research Questions of the Study

There are two purposes of this study. The first one is to examine the changes in pre-service science teachers' astronomy achievement, attitudes towards astronomy and skills for thinking three dimensional in terms of their years of study. The second one is to find out whether there is correlation between pre-service teachers' astronomy achievement, attitudes towards astronomy and skills for thinking three dimensional. The problem statements of this study, which was planned in line with these purposes, are as follows:

"How are the changes of pre-service teachers' astronomy achievement, attitudes towards astronomy and skills for thinking three dimensional in terms of their years of study?"

"What is the correlation between pre-service teachers' astronomy achievement, attitudes towards astronomy and skills for thinking three dimensional?"

In accordance with these research questions, it is sought for answers to following sub-questions;

– Is there a significant difference in pre-service teachers' astronomy achievement in terms of their years of study?

– Is there a significant difference in pre-service teachers' attitudes towards astronomy in terms of their years of study?

– Is there a significant difference in pre-service teachers' spatial thinking abilities in terms of their years of study?

– Is there a correlation between pre-service teachers' astronomy achievement and their attitudes towards astronomy?

– Is there a correlation between pre-service teachers' astronomy achievement and their spatial thinking skills?

2. Method

This study is a survey study which was conducted to determine the differences in pre-service science teachers' astronomy achievement, attitudes towards astronomy and skills for thinking three dimensional and to present the correlation between pre-service teachers' astronomy achievement, attitudes towards astronomy and skills for thinking three dimensional. Survey research designs are procedures in quantitative research in which investigators administer a survey to a sample or to the entire population of people to describe the attitudes, opinions, behaviors, or characteristics of the population (Creswell, 2012). In this research the data collected at just one point in time using cross sectional survey which is one of the survey designs. The cross sectional survey collects information from a sample that has been drawn from a predetermined population (Fraenkel, Wallen, & Hyun, 2012).

3. Sample

The sample of the study consists of pre-service science teachers (Note 1) studying at a university chosen from the Black Sea region of Turkey during the academic year 2014-2015. Simple random sampling method was used to determine the sample in the study. The information about the sample is given in Table 1.

Table 1. The distribution of the research sample according to year level

Gender	Pre-Service Science Teacher				Total
	1st Year	2nd Year	3rd Year	4th Year	
Female	47	38	37	37	159
Male	23	32	33	33	121
Total	**70**	**70**	**70**	**70**	**280**

3.1 Data Collection Instruments

Three different data collection tools were used in the study. These are "Astronomy Achievement Test (AAT)", "Astronomy Attitude Scale (AAS)" and "Purdue Spatial Visualization Test: Visualization of Rotations (PSVT-R)". AAT is a reliable and valid test developed by Türk and Kalkan (2015b) to measure students' achievement about basic astronomy concepts. The test consists of 32 items with four choices, its average difficulty is 0,51, its average distinctiveness is 0,51 and KR-20 reliability coefficient is 0,87.

AAS is a reliable and scale developed by Türk and Kalkan (2015c) to measure students' attitudes towards astronomy. AAS is a 5-Likert type scale with 5 sub-factors and 27 items, with a reliability of (Cronbach's Alpha) 0,912.

In order to measure the pre-service teachers' skills for thinking three dimensional, PSVT-R used by Bodner and Guay (1997) was translated and prepared by the researcher. This item has 30 questions and its reliability coefficient was found as 0,80 by Bodner and Guay (1997) by using KR-20. The questions in PSVT-R have two stages. First, an object and the rotated shape of this object is given. In order to be able to get the rotated shape of the object, one must find out in which direction the object is rotated. Secondly, another object is given and one must find out how this object will look like if it is rotated as in the first step. An example of the questions in PSVT-R is given below.

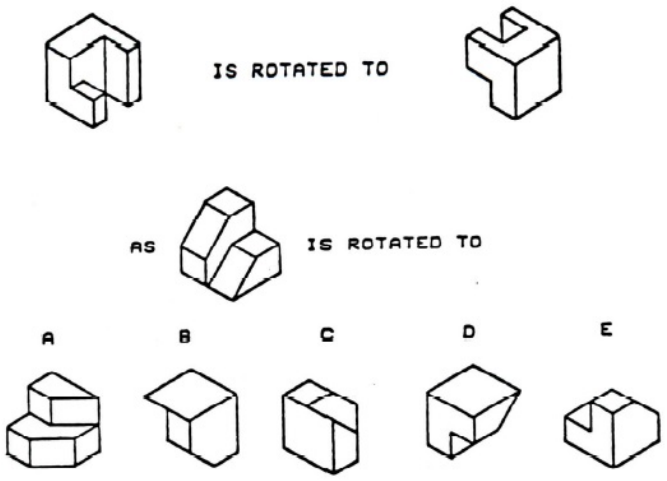

Figure 1. PSVT-R example question

3.2 Data Analysis

SPSS 22.0 statistical program was used for the quantitative data obtained from the implementation of AAT, AAS and PSVT-R. Before the statistical analysis, descriptive analyses were calculated for the scores taken from each test. After this, the following criteria were analyzed to find out which parametric/non-parametric technique to use for data analysis.

– Are the data normally distributed or no?

– Is the study group more/less than 30 people?

While determining the analysis technique of quantitative data, the data should be tested for having normal distribution. If the data have a normal distribution, parametric tests are used in analysis. The second point to take into consideration is the number of people to compare in groups. If the number of participants in groups is more than 30, it is possible to use parametric tests assuming that the results obtained from the data will be distributed normally (Can, 2014).

The number of pre-service teachers in this study is more than 30. Thus, the criterion that having a number of participants more than 30 was fulfilled. Normality tests were conducted to test whether the data were normally distributed, which is another criterion. Normality test results of AAT are given in Table 2.

Table 2. The results of normality tests

	Kolmogorov-Smirnov		
	Statistic	**df**	**p**
AAT	,097	280	,093*
AAS	,081	280	,200*
PSVT-R	,082	280	,200*

*p>,05

When Table 2 is analyzed, it can be seen that all tests for both groups have normal distribution. Thus, parametric analysis techniques were decided to be used in the analysis of AAT.

Before the analysis of non-parametric data, it was examined whether the assumptions of ANOVA technique to be used during the analysis process were met. These assumptions are as follows (Büyüköztürk, 2010).

– The scores (measurements) of dependent variables are within the least interval.

– The scores of the dependent variable have normal distribution in each sub-group.

– The variances of group scores are equal.

– Group covariance for paired combinations of measurement sets are equal.

– Difference score calculated for any subject is independent from the difference score calculated for other subjects.

Since AAT, AAS and PSVT-R are all tests/scales with equal intervals, the first assumption was met. For the second assumption, normality test scores were examined to find out whether the scores of the dependent variable were normally distributed (See Table 2). For the third assumption which included scored of pre-service teachers having equal variance, variance homogeneity Levene test was used for AAT, AAS and PSVT-R ($F_{(1,278)}$=,127; p>,05) scores. In line with the results, no significant difference was found between the variances of AAT ($F_{(1,278)}$=,258; p>,05), AAS ($F_{(1,278)}$=,534; p>,05) and PSVT-R ($F_{(1,278)}$=,127; p>,05) scores of pre-service teachers (See Table 3).

Table 3. AAT Levene test results

	F	df_1	df_2	p
AAT	,258	1	278	,060
AAS	,534	1	278	,465
PSVT-R	,127	1	278	,720

*p>,05

For the fourth assumption, covariance equality of tests was analyzed with Box's M test and the results are given in Table 4.

Table 4. Covariance matrix equality of AAT scores

	Box's M	F	df_1	df_2	p
AAT	885,643	1,103	528	30122,596	0,52
AAS	2095,588	1,400	1134	81965,099	0,66
PSVT-R	1422,178	1,075	930	54337,065	,058

*p>,05

In order to find out the suitability of the variance analysis to find out the significance of the difference in AAT, AAS and PSVT-R total scores, covariance equality of groups was tested and covariances were found to be homogenous. The fourth assumption which included covariance equality of groups for the combinations of measurement tests was also met. After this, the fifth assumption was also met since the difference score calculated for any subject was independent from the difference score calculated for other subjects.

One way variance analysis (One-Way Anova) technique was used to find out whether there was significant difference between the AAT, AAS and PSVT-R scores of pre-service teachers in terms of their years of study. One way variance analysis is used to find out whether the difference between the averages of two or more unrelated samples is different from zero significantly (Büyüköztürk, 2005; Can, 2014).

The level of significance was taken as 0,05 while interpreting the statistical analyses results. In order to test the influence of independent variables on each dependent variable *Cohen's f* values which show the dimension of the effect were calculated. 0,10 eta square value shows a small effect, 0,25 shows a medium effect and 0,40 shows a large effect (Cohen, 1988).

Correlation analysis was conducted to find out whether there was significant relationship between pre-service teachers' astronomy achievement and their attitudes towards astronomy and spatial thinking abilities. To do this, Pearson Moment Correlation Coefficient between the data sets was found. This can also be called "simple linear correlation". Pearson Moment Correlation Coefficient (r) is used to explain the linear correlation between two continuous variables measured within the interval or rate scale. Such an analysis tries to explain how consistently each Y value is matched with each X value in a linear way (Arney, 1990). Correlation Coefficient can vary between -1 and +1. A correlation coefficient of +1 shows perfect positive correlation while a correlation coefficient of -1 shows perfect negative correlation. A coefficient of 0 shows that there is no correlation. If r is between 0,30 and 0,70, there is moderate correlation between two variables, if it is lower than 0,30, there is a low correlation and if it is higher than 0,70 there is a high correlation. This comment which is thought for the positive side of the correlation is similar for the negative side of the correlation (Büyüköztürk, Çokluk, & Köklü, 2015).

4. Findings

The findings of AAT, AAS and PSVT-R are presented in subtitles. While presenting the findings of each measurement, first One-Way Anova results about whether there is difference between total scores in terms of years of study, then post hoc results for paired comparisons about whether there is significant difference between years of study were given. Lastly, correlation findings which showed the correlation between AAT, AAS and PSVT-R results were presented.

4.1 Findings of AAT

The achievement mean and standard deviations by year for pre-service science teachers' AAT scores are shown in Table 5.

Table 5. Descriptive statistics of AAT

Year	N	Mean	SD
1st	70	14,5571	2,89745
2nd	70	14,6714	3,43352
3rd	70	14,8143	4,90576
4th	70	18,7857	4,33353

When Table 5 is examined, it can be seen that the pre-service teachers in their first, second and third years of study have average AAT results which are very close to each other, while the pre-service teachers in their fourth year have higher average scores than the others.

One way variance analysis results to find out whether AAT scores of pre-service teachers differed significantly in terms of years of study are given in Table 6.

Table 6. One way variance analysis of AAT scores

Source of variance	Sum of squares	df	Mean square	F	p	Cohen's f
Between Groups (Year of study)	886,900	3	295,633	18,761	**,000***	,172
Within Groups	4349,086	276	15,758			
Total	5234,986	279				

*p<,05

According to Table 6, a significant difference was found between the average AAT scores of pre-service teachers in terms of years of study ($F_{3\text{-}276}$=18,761, p<,05). This finding can be interpreted as pre-service teachers' astronomy achievement differs significantly in terms of their years of study. In addition, according to *Cohen's f*, it can be stated that the effects of education faculty undergraduate students had a small effect (,172) on their astronomy achievement.

Table 7 gives the results about whether there is significant difference between years of study as a result of the paired comparisons of average AAT scores of pre-service teachers. For this result, ANOVA was conducted, then post hoc (Tukey) was conducted after one way analysis.

Table 7. Paired comparison of AAT scores

		Mean difference	SD	p
1st Year	2nd Year	-,11429	,67098	,998
	3rd Year	-,25714	,67098	,981
	4th Year	-4,22857	,67098	**,000***
2nd Year	1st Year	,11429	,67098	,998
	3rd Year	-,14286	,67098	,997
	4th Year	-4,11429	,67098	**,000***

	1st Year	,25714	,67098	,981
3rd Year	2nd Year	,14286	,67098	,997
	4th Year	-3,97143	,67098	**,000***
	1st Year	4,22857	,67098	**,000***
4th Year	2nd Year	4,11429	,67098	**,000***
	3rd Year	3,97143	,67098	**,000***

*p<,05

When Table 7 is examined, significant difference can be seen between pre-service teachers in their fourth year and the others (p<,05). When the averages are taken into consideration, this result was found to be in favor of pre-service teachers in their fourth year. In addition, no significant difference was found between pre-service teachers in their second, third and fourth years in terms of astronomy achievement. The average AAT scores of pre-service teachers in these groups had very close average AAT scores in these classes.

4.2 Findings of AAS

The mean and standard deviations by year for pre-service science teachers' AAS scores are shown in Table 8.

Table 8. Descriptive statistics of AAS

Year	N	Mean	SD
1st	70	96,3857	15,64302
2nd	70	97,5429	12,79910
3rd	70	98,4143	10,79653
4th	70	110,5286	10,53045

When Table 8 is examined, it can be seen that AAS scores of pre-service teachers in their first, second and third years increased, though little, while the average scores of pre-service teachers in their fourth year increased more when compared with the others.

One way variance analysis results to find out whether AAS scores of pre-service teachers differed significantly in terms of years of study are given in Table 9.

Table 9. One way variance analysis of AAS scores

Source of variance	Sum of squares	df	Mean square	F	p	Cohen's f
Between Groups (Year of study)	9128,325	3	3042,775	19,138	**,000***	,175
Within Groups	43882,386	276	158,994			
Total	53010,711	279				

*p<,05

According to Table 9, significant difference was found between the average AAS scores of pre-service teachers in terms of their years of study ($F_{3\text{-}276}$=19,138, p<,05). This result can be interpreted as the attitudes of pre-service teachers towards astronomy differed significantly in terms of their years of study. In addition, according to *Cohen's f*, it can be stated that the effects of education faculty undergraduate students had a small effect (,175) on their astronomy attitude.

Table 10 gives the results about whether there is significant difference between years of study as a result of the paired comparisons of average AAS scores of pre-service teachers.

Table 10. Paired comparison of AAS scores

		Mean difference	SD	p
1st Year	2nd Year	-1,15714	2,13136	,948
	3rd Year	-2,02857	2,13136	,777
	4th Year	-14,14286	2,13136	**,000***
2nd Year	1st Year	1,15714	2,13136	,948
	3rd Year	-,87143	2,13136	,977
	4th Year	-12,98571	2,13136	**,000***
3rd Year	1st Year	2,02857	2,13136	,777
	2nd Year	,87143	2,13136	,977
	4th Year	-12,11429	2,13136	**,000***
4th Year	1st Year	14,14286	2,13136	**,000***
	2nd Year	12,98571	2,13136	**,000***
	3rd Year	12,11429	2,13136	**,000***

*p<,05

When Table 10 is examined, it can be seen that there is significant difference between the attitudes of senior pre-service teachers towards astronomy and the attitudes of other pre-service teachers (p<,05). When the averages are taken into consideration, this difference can be seen to be in favor of senior pre-service teachers. In addition, no difference was found between pre-service teachers in their first, second and third years in terms of their orientation to astronomy. The average AAS scores of pre-service teachers in these groups were found to be very close to each other.

4.3 Findings of PSVT-R

The mean and standard deviations by year for pre-service science teachers' PSVT-R scores are shown in Table 11.

Table 11. Descriptive statistics of PSVT-R

Year	N	Mean	SD
1st	70	12,3714	4,44017
2nd	70	12,2857	3,97872
3rd	70	13,2286	3,35862
4th	70	14,2571	4,20381

When Table 11 is examined, it can be seen that freshmen and sophomore pre-service teachers had very close average PSVT-R scores; juniors had higher scores while the highest scores belonged to seniors.

One way variance analysis results to find out whether PSVT-R scores of pre-service teachers differed significantly in terms of years of study are given in Table 12.

Table 12. One way variance analysis of PSVT-R scores

Source of variance	Sum of squares	df	Mean square	F	p	Cohen's f
Between Groups (Year Level)	177,300	3	59,100	3,665	**,013***	,200
Within Groups	4450,343	276	16,124			
Total	4627,643	279				

*p<,05

According to Table 12, significant difference was found between the average PSVT-R scores of pre-service teachers ($F_{3\text{-}276}$=3,665, p<,05). This result can be interpreted as significant difference between the three dimensional thinking skills of pre-service teachers in terms of their years of study. In addition, according to

Cohen's f, it can be stated that the effects of education faculty undergraduate students had a small effect (,200) on their ability of thinking three dimensional

Table 13 gives the results about whether there is significant difference between years of study as a result of the paired comparisons of average PSVT-R scores of pre-service teachers.

Table 13. Paired comparison of PSVT-R scores

		Mean difference	SD	p
1st Year	2nd Year	,08571	,67875	,999
	3rd Year	-,85714	,67875	,587
	4th Year	-1,88571	,67875	**,030***
2nd Year	1st Year	-,08571	,67875	,999
	3rd Year	-,94286	,67875	,507
	4th Year	-1,97143	,67875	**,021***
3rd Year	1st Year	,85714	,67875	,587
	2nd Year	,94286	,67875	,507
	4th Year	-1,02857	,67875	,430
4th Year	1st Year	1,88571	,67875	**,030***
	2nd Year	1,97143	,67875	**,021***
	3rd Year	1,02857	,67875	,430

*p<,05

When Table 13 is examined, it can be seen that there is significant difference between spatial thinking ability of senior pre-service teachers and spatial thinking abilities of freshmen and sophomores (p<,05). Averages showed that there was no significant difference between pre-service teachers with other years of study in terms of the ability of thinking three dimensional.

4.4 Findings of the Correlation between AAT, AAS and PSVT-R

Simple linear correlation was made to find out whether there was correlation between pre-service teachers' astronomy achievement and their attitudes towards astronomy and spatial thinking skills. The results of this analysis are given in Table 14.

Table 14. The correlation between AAT, AAS and PSVT-R

		AAT	AAS	PSVT-R
AAT	Pearson Correlation	1	,165	,727
	Sig. (2-tailed)		**,006***	**,000***
	N	280	280	280
AAS	Pearson Correlation	,165	1	,102
	Sig. (2-tailed)	**,006***		,088
	N	280	280	280
PSVT-R	Pearson Correlation	,727	,102	1
	Sig. (2-tailed)	**,000***	,088	
	N	280	280	280

*p<,05

When Table 14 is examined, a positive and significant correlation can be found between pre-service teachers' astronomy achievement, attitudes towards astronomy and spatial thinking skills. When the correlation between the astronomy achievement and their attitudes towards astronomy was examined, positive and significant correlation was found between these two groups (r =,165, p<0,05). However, the correlation was low since "r" was lower than

0,30. In general, it can be said that as pre-service teachers' attitudes towards astronomy increased, their astronomy achievement also increased.

When the correlation between pre-service teachers' astronomy achievement and their D thinking skills were examined, positive and significant correlation was found between these two (r =,727, p<0,05). In addition, a "r" value higher than 0,70 shows that the correlation is high. Based on these, it can be said that as pre-service teachers' spatial thinking skills increased, their astronomy achievement also increased greatly.

5. Discussion and Conclusion

It was concluded that there was significant difference between the astronomy achievements of pre-service teachers in terms of their years of study. However, this difference was seen not in the first third years of the university education, but in the last year (4^{th} year of study). It was found that freshman, sophomore and junior students studying science teaching had very close astronomy achievement and no significant difference was found between them. This situation changed with the seniors. Astronomy achievement of seniors was higher than the astronomy achievements of freshman, sophomore and junior students. The reason for this may be the fact that the two hour astronomy class in the curriculum of science teaching undergraduate program is taught during the last year. Another result of our study is that the astronomy achievement of students who did not get any astronomy classes until the last year did not change as ages and years of study advanced. These results are in line with the results of some studies in literature (Türk, Şener, & Kalkan, 2015; Bisard, Emrahoğlu, & Öztürk, 2009; Kalkan & Kıroğlu, 2007; Trumper, 2001c; Zeilik et al., 1998). As a result of their study on the concepts of pre-service science teachers, Emrahoğlu and Öztürk (2009) found that pre-service teachers had misconceptions all the time from the first year of study to the last one and also their success was found not to change much. Similar results were also found in the studies of Kalkan and Kıroğlu (2007) and Zeilik et al. (1998).

When the results of pre-service teachers' attitudes towards astronomy were examined, it can be seen that pre-service teachers had parallel results to astronomy achievement. The attitudes of pre-service teachers in their first, second and third years of study towards astronomy were found to increase in a very small rate based on the year of study. A remarkable increase was seen in the attitudes of pre-service teachers in their fourth year of study towards astronomy. In line with these results, it was found that the attitudes of pre-service science teachers towards astronomy differed significantly. However, this change was not observed between first, second and third years of study while it was seen only between fourth year of study and other years of study.

Another sub-problem in the study was about the spatial thinking abilities of pre-service teachers. Significant differences were found between the PSVT-R scores of pre-service teachers in terms of their years of study. This difference was found only between seniors and freshmen and sophomores (in favor of seniors). However, when the difference between juniors and seniors was examined, no significant difference was found. In general, there were no big differences s between the PSVT-R scores of pre-service teachers. The fact that the average achievement in a test of 30 questions differed between 12,37 and 14,25 shows that pre-service teachers had difficulties.

One of purposes of the study was about the pre-service teachers' astronomy achievement, their attitudes towards astronomy and their spatial thinking skills. The first result obtained from this purpose was the positive and significant correlation between pre-service teachers' astronomy achievement and their attitudes towards astronomy. However, this correlation was not high. Thus, it can be said that as the attitudes of pre-service teachers towards astronomy increased, their achievements can be said to increase partially. Similarly, according to Kind, Jones and Barmby (2007), the positive attitudes of students towards a lesson and the achievement of the students are in parallel. This results shows that the results of our study support the literature. However, when an attitude is formed once, it does not change easily (Ajzen & Fishbern, 1980). Considering this, it can be said that the results of our study are very important because pre-service teachers began to develop positive attitude towards astronomy after they got astronomy lesson in their last years. Thus, when pre-service teachers start the profession of teaching, they can develop positive attitudes in their students towards astronomy.

A positive and significant correlation was found between astronomy achievement of pre-service teachers and their spatial thinking skills. That is, it can be said that as spatial thinking skills of pre-service teachers increased, their astronomy achievement also increased greatly. This result is in parallel with the results of ChanLin (2000) and Orde (1997). In ChanLin's (2000) study, students with high spatial ability could more easily imagine and visualize abstract concepts or objects. Students who had less of this ability needed more cognitive processes and extra knowledge while doing the same processes. It can be seen that spatial ability or activities to improve this ability is not much included in educational studies. In general, the education given in schools aim to develop oral skills; however, activities for spatial ability rarely exist. As a result of this, students have difficulties in areas which require high spatial ability such as astronomy, science and mathematics (Black, 2005; Hartman et al., 2006).

Studies conducted in different areas support this claim. Studies in astronomy education (Shen, 2006), educational sciences (Huk, Steinke, & Floto, 2003), chemistry (Bodner & Guay, 1997), and engineering (Potter & Merwe, 2001) are some examples. Thus, this factor should be taken into consideration in astronomy education and a method which appeals to students with high and low spatial skills should be implemented.

6. Research Limitations and Future Directions

– When it is considered that astronomy concepts are quite abstract, first of all in the education of teachers and pre-service teachers, concrete-physical-scaled models, hands-on models, 3D simulation modellings and planetariums should be used and how to use these in education should be clearly taught. Thus, astronomy concepts which are difficult for students in the period before abstract processes to gain in two dimension should be taught with methods suitable for constructivist approach.

– In line with the results of the study, the number of astronomy lessons in education faculties in Turkey should be increased and they should be taught not only in the fourth year but also in the first three years.

– This study was planned cross sectional. While this situation saves time, it has limitations such as not being able to take data from the same person with different intervals of time. Thus, developmental studies which will present the changes in pre-service teachers' astronomy achievement, attitudes towards astronomy and spatial thinking abilities by taking measurements at different years of study from the same sample can be conducted.

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Note

Note 1. Science teaching program in Turkey consists of 4 years. Therefore students from year of study levels 1st, 2nd, 3rd and 4th were incorporated for study.