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Development of Attitudes towards Serendipitous Science: A Validity and Reliability Study

Research Article

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ABSTRACT

This study aimed to develop a valid and reliable attitude scale to determine the attitudes of university students towards serendipitous science. The study sample consisted of 435 university students, 65 of whom were pilot application and 370 were the main application, selected from a universe whose educational language was English and located in the city centers of 4 metropolises situated at different geographical regions of Turkey by using convenience sampling. Whereas the scale was made of 35 items including one control item in the first stage, its final form consisted of 20 items, excluding the control item, as a result of the pilot application and performed analyses. The control item aimed to find out the students who answered the items of the scale randomly or wrongly. It was proven that the scale had a three-factor structure by using the exploratory factor analysis. It was seen that its factor structure was maintained as a result of CFA. The scale's reliability was checked for the entire scale and its factors by using internal consistency coefficient. The estimated Cronbach Alpha coefficient was 0.897 for the entire scale. This case was an indication that the scale was highly reliable. Considering the reliability analysis results of the scale factors, the internal consistency coefficient estimated for the disregard factor was 0.85, the internal consistency coefficient for the value factor was 0.73, and the consistency factor for the affective factor was 0.77. Based on these results, a valid and reliable scale of attitude towards serendipitous science was developed.

Keywords:
Serendipity, Serendipitous Science, Attitudes, Validity, Reliability

Introduction

Scientists have achieved great discoveries throughout history owing to their curiosity, observation skills, and inquiring characteristics. During this process, unpredictable, unforeseen incidences that turn their profound insights and hypotheses into scientific activities can develop (Buchem, 2011; Campanario, 1996). In case of discovery is achieved during the process of conducting such research by chance or accident, this

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circumstance is defined by the concept of serendipity (Buchem, 2011; Fine and Deegan, 1996). Despite most of the scientific researchers are conducted in a planned manner and in stages, scientific information can sometimes be found by chance, mistake or accident as a result of unforeseen instant chances or because of incidents that develop unpredictably (Bell, Lewenstein, Shouse, and Feder, 2009). There are many examples of scientific discoveries achieved without making a plan and unexpectedly as a result of auspicious comparisons. The fundaments of many discoveries are based on incidental coincidences including discovery of ascending force by Archimedes, coming up with universal gravity law by Newton, finding of penicillin by Fleming, exploring of atmospheric pressure by Torricelli, finding of DNA, X rays, Teflon, plastic, photograph, nonexplosive glass, paints, matches, shock therapy, cardiac pacemaker, and antidepressants (Cihaner, 2009; e Cunha, Clegg and Mendonça, 2010; Ellialtıoğlu, 2006; Roberts, 1989; Sönmez, 2009). In literature, the concept of serendipity is used to define the skill to discover valuable things by chance, serendipity and fortuitously based on a curious coincidence, a fortunate encounter, and without a search (Dew, 2009; Foster and Ford, 2003; Gritton, 2007; McBirnie, 2008; Merton and Barber, 2011). Since serendipity and scientific researches and discoveries are interrelated considerably, the relation of science and coincidence can conceptually be expressed as serendipitous science (Foster and Ford, 2003; Merton and Barber, 2011; McCay-Peet, Toms and Kelloway, 2015; Vedder-Weiss, 2017). It can be stated that coincidental discoveries not only lead to scientifically fundamental findings but they are also considered as critical components of learning environments. In this context, the term of *serendipitous learning*, accepted as a sub-dimension of casual learning, describes learning environments developed for coming up with novel ideas and contriving interesting aspects of an issue (Fine and Deegan, 1996; Gritton, 2007).

Bases formed by coincidences for explorations, studies, learning environments and the process of scientific information development lead them to gain more value in this field. Coincidences can sometimes be instructive for initiating scientific research and sometimes, can cause achieving novel and valued explorations as different from the purpose of an ongoing study (Andel, 1994; Campanario, 1996). Though the process of development and actualization of serendipitous science progresses unexpectedly, instantly and without a plan, the presence of specific elements supporting this progress can be mentioned. Primarily, it is said that the experiences and skills, creativity, imagination and readiness of a researcher in a particular filed support serendipitous science (Buchem, 2011; e Cunha et al, 2010). It can be emphasized that the skills noted here are the skills to observe encountered opportunities, comprehend and recognize irrelevant connections and to turn coincidences to a valued exploration (Fine and Deegan, 1996). Serendipitous science is connected with many disciplines through both its examples and different applications and aspects. The literature consists of numerous examples of the relation of serendipitous science with other disciplines and fields. Applications of serendipitous science exist in many fields including science (Ramakrishnan and Grama, 1999), the characteristics of science (Clough, 1997; Moss, 2001), science management (Murayamaa, Nireib and Shimizub, 2015), science sociology (e Cunha et al, 2010), humanities (Foster and Ford, 2003), and medicine (Popescu and Faussone-Pellegrini, 2010).

The interest and faith in serendipitous science, which goes back to the old times in terms of its effects on the field and the results it leads to yet can be considered new in terms of its conceptual use, is fundamental to understand science and the scientific process. Attitude studies, predicting the decisions, tendencies, and behaviors of individuals since the 19th Century, can be viewed in this context (Tavşancıl, 2014). Attitude can be defined as the emotive dispositions of an individual towards objects, people, places, incidents, and ideas positively and negatively (Papanastasiou, 2002). Attitude is the affinity to constantly react to a particular object positively or negatively (Fishbein and Ajzen, 1975). Attitude expresses what an individual feels about a certain thing (Robbins, 1994). Attitudes are considered critical for providing preliminary information about the future behaviors of persons. Hence, attitudes that are developed in school and family are permanent and are difficult to be changed. Negative attitudes can lead to some personal, social and national-size problems (McGuire, 1985). The cognitive component of attitude is the knowledge, believes and thoughts of an individual about the attitude object. For a person to develop an attitude towards an attitude object, that person must go through experience about that object. Thus, a knowledge, belief and thought organization develops about that object (Tavşancıl, 2014). The emotive component of attitude is the negative or positive emotions of an individual about an attitude object (Köklü, 1995). In order to understand that a person has an attitude, that person is expected to exhibit observable behaviors as an indicator of that attitude (Baysal, 1981). The behavioral component of attitude shows the proposition of an individual towards an attitude phenomenon (Tavşancıl, 2014). Various methods are used to measure attitudes including behavior observations, measuring physiological reactions, and scale techniques. The most widely used method for measuring attitudes is scaled. Scales are made of a series of adjectives and statements that individuals can use to react and scales are used to put forward attitudes exhibited toward an incident, object or idea. Scales are preferred due to their simple use and repeating and application simplicity and for enabling measurement of abstract concepts (Edwards, 1987).

This study aimed to develop a valid and reliable scale to determine attitudes of university students, who are intermingled with science, science history, and the scientific process. It was thought that this study would aid a different perspective to serendipitous science, which is a novel concept in literature, and the characteristic of science.

Method

The research consisted of a scale development study and its applications to determine attitudes of university students towards serendipitous science in the scope of the qualitative research method. Table 1 shows that various attitude scales have been developed to assess attitudes in literature. The fundamental function of measurement tools is to determine the psychological aspect of an individual in terms of the measured characteristic based on his/her answers to specific test items. Likert type scales are the most commonly used scale development techniques to measure attitudes. Likert type scales are more economical, easy and practical in terms of preparation procedures. Their preparation requires less effort in comparison to the scales of Thurstone and Guttman. Moreover, Likert type scales are based on instincts substantially in comparison to the other scales (Babbie, 2014; Tavşancıl, 2014; Tezbaşaran, 1997). Therefore, the scale type to be developed in this study towards serendipitous science was designated as a Likert type scale.

Table 1. A Comparison of the Four Standart Attitude Scale (Fishbein & Ajzen, 1975, p. 79)

	Guttman	**Thurstone**	**Likert**	**Semantic Differential**
Properties of Items				
Quantification	ordinal	interval	qualitative	-
Neutral items retained	yes	Yes	no	no
Trace lines	monotonic (step-shaped)	nonmonotonic (intervened U)	monotonic (linear)	monotonic (linear)
Cumulative scale	yes	No	no	no
Item selection	response-inferred	response-inferred and judgmental	response-inferred	response-inferred

The universe of this research consisted of students, who were at the city centers of 4 different metropolises situated at various geographical regions of Turkey during the spring semester of the academic year of 2017-2018 and whose educational language was English. The study sample consisted of 435 university students, out of whom 65 were pilot and 370 were the main applications and selected from the universe by using the convenience sampling. The convenience sampling ensures the researcher to reach the appropriate sampling in a shorter time (Patton, 1990). In the research, cities located at different geographical regions were preferred from among the metropolises that the researchers could access conveniently.

Data Collection

First, explanatory factor analysis and item analysis were made when the reliability and validity analyses of the scale were made and subsequently, confirmatory factor analysis was made. Evidence-based systematic methods are considered as more valuable in place of approaches towards the heuristic results to interpret the validity and reliability analyses data of a scale (Cheung, 2009; Munby, 1997). It is seen that confirmatory factor analysis is used to scrutinize the concealed structure of a scale during the scale development process generally (Brown, 2006). When a calculation is made to find out a factor in explanatory factor analysis, it is said that critical aspects of attitudes are studied and the specific typical characteristics and interesting connections are attempted to be revealed (Jöreskog and Sörbom, 1993; Tapia and Marsh, 2004). In confirmatory factor analysis, on the other hand, a procedure that was performed previously about the relationship between variables is tested. It is said that it is based on a classification pattern to prove and verify the structures of factors that are obtained as a result of explanatory factor analysis and the testing cases (Çokluk, Şekercioğlu, and Büyüköztürk, 2012; Jöreskog and Sörbom, 1993). The explanatory factor analysis and item analysis of the research were made by using SPSS 24.0 packet program. Confirmatory factor analysis studies were conducted by using Lisrel 8.80 (Linear Structural Relation Statistics Package Program) software. The significance level was accepted as .05 for all statistical procedures used in the research process.

Scale Development

Primarily, the national and international literature was reviewed in the scale development stage and a literature scope was generated for the scale of attitude towards serendipitous science. Case statements representing the characteristics of attitudes towards serendipitous science (ATSS) were determined by benefiting the opinions of experts in this field. Item statements were written and a wide item pool was generated to allow testing of the scope of serendipitous science and each of its dimensions. Following the preparation of item pool, the scale type and answer choices to be used were designated. It was decided that Likert type scale was to be used in the study due to its preparation, application and assessment convenience. Since Likert type scales are more practicable in the development process in comparison to the other ranking scales, they are used most frequently and commonly in comparison to other scales to measure attitudes (Tezbaşaran, 2004). Likert scale is organized with five scores to be suitable to the group of study. The answer choices are set as scores from 1 to 5 progressing among the choices of "I don't agree at all" and "I completely agree". Therefore, it is thought that clearer and more explicit outcomes will be received without causing confusion for the participants when they give intermediate answers.

Expert opinions were resorted to when the scale was prepared during the organization of the items. In this stage, two persons specialized in the education field, and three Turkish and English experts and two teachers reviewed the items and provided their opinions. The items were organized under the light of these opinions. The organized attitude items were assessed as negative, positive and neutral by a group of 40 students representing the universe for which the scale was to be applied. Following all of the assessments, two items which were difficult to understand were removed from the scale and it was decided that a total of 34 items, 17 positive and 17negative, were to be used in the scale.

One control item was added to the 34 items used in the scale and hence the scale consisted of 35 items. Control item aimed to determine the students who answered the scale items randomly or erroneously. Control item was included in the scale as ''this item is checking whether or not you are reading the other items. If so, please choose "4 (four)" for this item". The scale was ready for pilot application following the required spelling and formal organizations.

Pilot application of the scale was carried out by a sampling of 65 education faculty students. Following the pilot application, the scales which did not contain the asked choice in the control item were not evaluated. The data collected as a result of pilot application were transferred to SPSS 24 package program and analyzed. Reliability and validity analyses were assessed by using SPSS program item analysis. Following the factor analysis of obtained data, it was seen that there were items, of which factor-load was under .30 and which were in relation with other factors. These 12 items, not successfully reflecting the property that was intended to be measured, were removed from the scale for improving the validity and reliability (Tabachnick and Fidell, 2001). As a result of the item analysis assessment, it was decided that the determined items were to be removed from the scale in order to improve the reliability and validity of the scale.

The final scale consisted of 22 items as a result of the data obtained in the pilot application. A control item was included in the scale in order to determine whether the scale was read and answered in this way. The final application form was generated as a result of the required spelling and formal organizations. In the data set collected as a result of its application to the study group, 48 scales where number 4 (four) answer choice was not checked in the control item were removed from the sample. The data obtained from the remaining 322 scales were transferred to SPSS 24.0 and Lisrel 8.80 packet program and the necessary analyses were made. 2 items with the extreme values were removed from the scale as a result of the analysis. The appendix 1 contains the last version of the scale.

Data Analysis

The data were analyzed by Explanatory Factor Analysis (EFA) to determine the factor structure of the scale of attitude towards serendipitous science according to the Likert type scale. In this context, it was aimed to ensure the structure validity of the scale. Expert opinions were benefited to ensure the appearance and scope validity of the scale. In this stage, two persons specialized in science education, one person specialized in Turkish language and literature and two science teachers reviewed the items. The data of the attitude scale were analyzed by confirmatory factor analysis (CFA) to support the accuracy of the factor structure established based on the results of explanatory factor analysis. The reliability analysis of the scale was achieved by estimating Cronbach alpha internal consistency coefficient according to Likert type scale.

Results

Results Obtained as a Result of EFA Scale of Attitudes towards Serendipitous Science

The descriptive statistics on the items making up the scale of attitude towards serendipitous science are shown in Table 2.

Table 2. Descriptive statistics for serendipitous science

Item	Min.	Max.	$\bar{X}$	SS	SS^2
1	2,00	5,00	3,9500	,78625	,618
2	1,00	5,00	3,5563	,92507	,856
3	1,00	5,00	3,9719	,86148	,742
4	1,00	5,00	3,8063	1,02015	1,041
5	1,00	5,00	3,7938	,82741	,685
6	1,00	5,00	3,6031	,85756	,735
7	1,00	5,00	3,9438	,89755	,806
8	1,00	5,00	3,7969	,94983	,902
9	1,00	5,00	3,5813	,93669	,877
10	1,00	5,00	3,9875	,99521	,990
11	1,00	5,00	3,7031	,96132	,924
12	1,00	5,00	3,8844	,87229	,761
13	1,00	5,00	3,5031	1,05936	1,122

14	1,00	5,00	3,8781	,88570	,784
15	1,00	5,00	3,7438	,92846	,862
16	1,00	5,00	4,0531	,89249	,797
17	1,00	5,00	3,9719	,80894	,654
18	1,00	5,00	3,9688	,92626	,858
19	1,00	5,00	4,0438	,90174	,813
20	1,00	5,00	4,0375	,80272	,644

Table 3. Descriptive statistics on total scores obtained by ATSS.

$\overline{X}$	SS	Variance	Min.	Max.	Kurtosis	Skewness
76,7781	10,5413	111,120	36,00	100,00	,879	-,484

Considering Table 3, it is seen that the average of the total scores obtained by the scale of attitudes towards serendipitous science was 76.77, its standard deviation was 0.54, its variance was 111.120, and minimum and maximum values were 36.00 and 100.00. The kurtosis and skewness values were evaluated to see whether the scale data showed normal distribution or not. Since the kurtosis and skewness values of the scale situated in the interval of -1 and +1, it can be said that the data showed a normal distribution (Tabachnick and Fidell, 2001).

Kaiser-Meyer-Olkin (KMO) coefficient and Barlett test estimation results were studied to determine whether the scale data were adaptable to factor analysis. In order to do a factor analysis of the scale, KMO coefficient must be larger than 0.60 and Barlett test significance must be smaller than 0.05 (Büyüköztürk, 2014). KMO coefficient of the scale items was found significant as .901 and Barlett test result was found significant as .000 (x^2=2255,774, sd=190, p<.000). In this context, the serendipitous science attitude scale was appropriate for factor analysis.

In the stage of calculating factor analysis of the scale, principal component analysis and Varimax rotation technique, one of the vertical rotation techniques, were used to find out factor structure of the items and factor distributions. As a result of Varimax rotation technique application, care was taken that the connection level of each item with any factor was 0.30 and higher (Tabachnick and Fidell, 2001). It was paid attention that there is a difference at the level of 0.10 between the relation levels of the factors and the items gathered under more than one factor. As a result of all of these statistical descriptions, the items which had the wished factor level and the scale were analyzed by factor analysis. It was seen that the scale items were distributed under three factors as a result of factor analysis. Disregard factor consisted of 8 items (3, 7, 10, 11, 14, 16, 18, 19), value factor had 6 items (1, 2, 4, 5, 6, 13), and affective factor contained 6 items (8, 9, 12, 15, 17, 20).

Table 4. EFA Results about the ATSS (n=320)

		Factor Loads			
	Items	1	2	3	rj
Factor 1 Disregard	T18	,713			,558
	T19	,679			,592
	T14	,659			,610
	T3	,657			,507
	T10	,656			,678
	T7	,608			,512
	T11	,579			,506

	T16	,544			,584
Factor 2 Value	T5		,724		,504
	T2		,653		,396
	T1		,649		,475
	T6		,622		,487
	T4		,536		,498
	T13		,417		,465
Factor 3 Affective	T12			,690	,474
	T20			,671	,564
	T17			,637	,590
	T15			,577	,390
	T9			,497	,547
	T8			,489	,498
Eigenvalue		6.878	1.743	1.438	
Variance %		34.390	8.716	7.190	
Cumulative Variance %		34.390	43.106	50.296	
Cronbach Alpha (α)		0.85	0.73	0.77	
Total α= .89					

Considering the factor analysis results of serendipitous science attitude scale (Table 4), it is seen that gathering of the twenty items analyzed according to the explained total variance values under three factors that had an eigenvalue of larger than 1 showed that the scale had three factors. The eigenvalues of the three factors found out as a result of explanatory factor analysis were 6.878, 1.743 and 1.438 in turn. The variance explained about the scale by these three factors was 50.296%. The estimated variance value of greater than 40% showed that the scale had good reliability (Büyüköztürk, 2014). The common variances of the three factors defined for the items change between 0.305 and 0.648 generally and this shows that the scale items are valid. In this context, it is clear that the three factors found in the analysis explained most of the total variance of the items and the variance of the scale. Considering the variance value explained by each factor separately, it is seen that they were 34.390%, 8.716%, and 7.190%. The item-total test correlation values were in the interval of .390 and .678. These values of greater than.30 shows that scale items ensured adequate distinguishing (Field, 2009).

Table 5. Descriptive Statistics of the Sub-dimensions of the ATSS

Factors	Min	Max	SS	SS²	Kurtosis	Skewness
Disregard	14,00	40,00	5,16899	26,718	,781	-,643
Value	10,00	30,00	3,61534	13,071	,523	-,555
Affective	9,00	30,00	3,62113	13,113	,912	-,528

Correlation values were estimated to determine the relations of the factors of the scale with each other and it was found that the correlation values between the factors remained between .559 and .887 (Table 6). Considering the correlation values, it can be said that the sub-dimensions making up the scale had a positive and high-level relation with each other (Büyüköztürk, 2014).

Table 6. The Correlation Value between the Sub-Dimensions of the ATSS

		Total	Disregard	Value	Affective
Total	r	1			
	P				
	N	320			
Disregard	r	,887**	1		
	P	,000			
	N	320	320		
Value	r	,813**	,559**	1	
	P	,000	,000		
	N	320	320	320	
Affective	r	,832**	,597**	,572**	1
	P	,000	,000	,000	
	N	320	320	320	320
** p<.01					

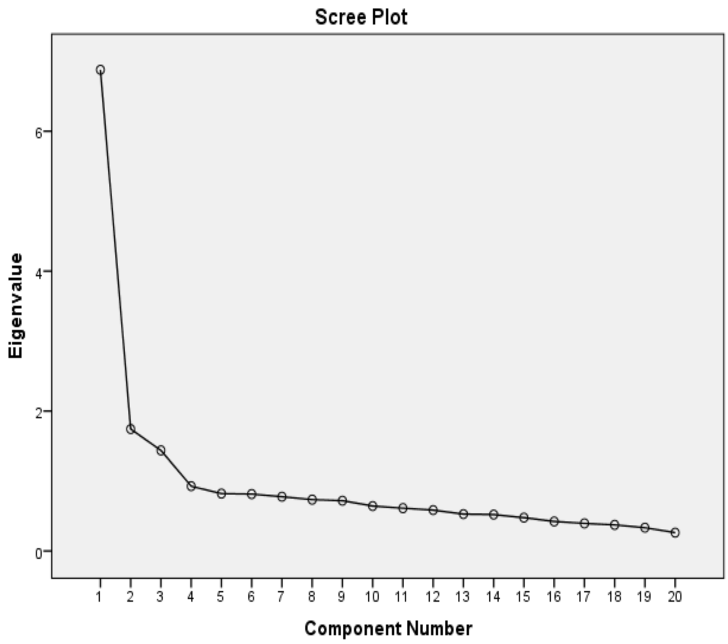

Figure 1: Eigenvalue graph of ATSS

The number of factors was found as three in the factor analysis of the attitude scale. In this context, considering the shown line graph (Figure 1), the presence of three break points in the graph supported that the scale had three factors. The graph progressed horizontally in general in the fourth and the following factors and it is seen that there is no significant break or dropping tendency. This situation explained that the contributions of the fourth and the following factors to variance were close to one another (Büyüköztürk, 2014, p.143).

Results Found as a Result of Serendipitous Science Attitude Scale CFA

Confirmatory Factor Analysis (CFA) is used for scale development and validity analysis in general and to verify and support a structure predetermined previously by EFA. CFA is used to test whether the factors were adequate to explain and represent the scale and assesses the structure behind the data. Development of CFA was achieved by Karl Jöreskog in 1960 (Aytaç and Öngen, 2012; Erkorkmaz, Etikan, Demir, Özdamar and Sanisoğlu, 2013). Confirmatory factor analysis was made on a 320-person data by using Lisrel 8.80 package program to assess and verify the three-factor structure received as a result of serendipitous science attitude scale EFA.

Table 7. Fit indices about the ATSS related CFA

Consistency indices	Obtained values	Accepted values
x^2/sd	2,2613	≤ 2.5= perfect fit (Kline, 2005).
RMSEA	0,063	≤ 0.07 good fit (Steiger, 2007)
NNFI	0,96	≥ 0.95= perfect fit (Hu ve Bentler, 1999; Sümer, 2000)
CFI	0,96	≥ 0.95= perfect fit (Hu ve Bentler, 1999; Sümer, 2000; Thompson, 2004)
IFI	0,96	≥ 0.95= perfect fit (Byrne, 1998)
RMR	0,05	≤ 0.05= perfect fit (Brown, 2006; Byrne, 1994)

Considering Table 7, the division of chi-square optimality consistency by the degree of freedom was 2.26, which is smaller than 2.5 and this showed that the scale was perfectly consistent (Kline, 2005). RMSEA value of 0.063, which is lower than 0.07, showed that the scale was well compatible (Steiger, 2007). NNFI, CFI and IFI values of 0.96 showed that the scale was perfectly compatible (Hu and Bentler,1999; Sümer, 2000; Thompson, 2004). RMR value of 0.05 showed that it had perfect compatibility (Brown, 2006; Bryne, 1994). As Figure 2 shows, the factor loads of the items ranged between .45 and .75 as a result of CFA and this was significant (p < .01).

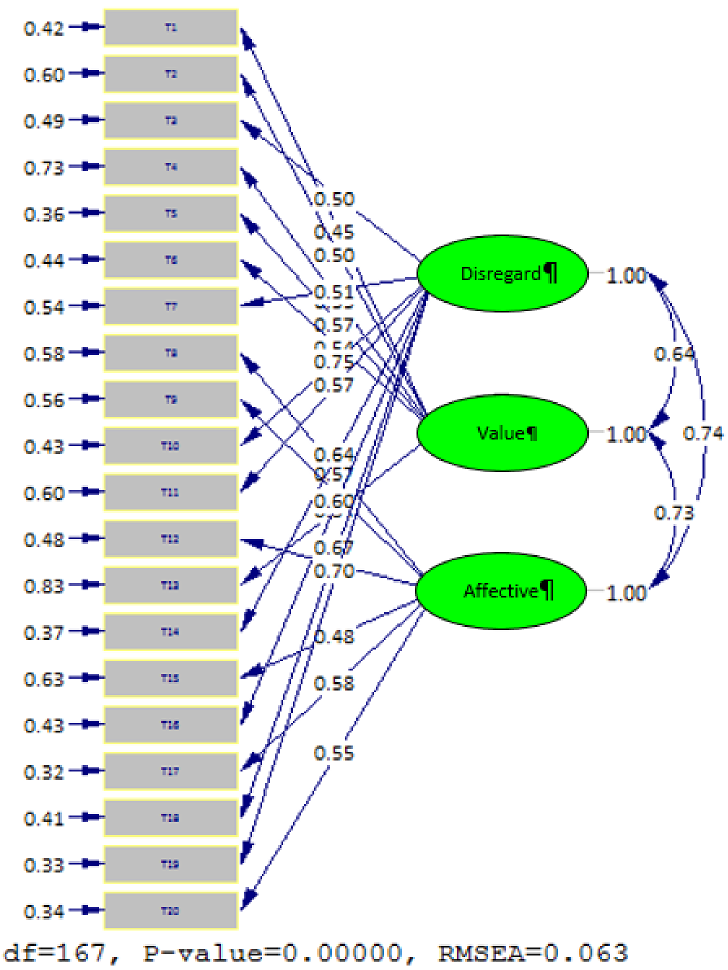

Figure 2: CFA for ATSS

Results about the Scale's Reliability

Measuring the reliability of a scale is an indicator showing how well it measures the asked characteristic. Since the serendipitous science attitude scale was prepared according to the Likert type, the scale's reliability analysis was made by estimating the Cronbach Alpha internal consistency coefficient. Considering the reliability analysis results of the serendipitous science attitude scale, Cronbach Alpha internal consistency coefficient of .897 was an indicator that the scale was well reliable. Considering the reliability analysis results of the scale factors, internal consistency coefficient estimated for disregard factor was 0.85, internal consistency coefficient estimated for value factor was 0.73 and internal consistency coefficient estimated for affective factor was 0.77 (Table 8). Since Cronbach Alpha coefficients were 0.70 and greater than .70 for all of the factors, it can be accepted that the scale was reliable (Büyüköztürk, 2014).

Table8. Reliability Coefficients for ATSS and its Factors

Factors	Item number	Reliability Coefficient (α)
Disregard	9	.85
Value	7	.73
Affective	4	.77
Total	20	.89

Discussion and Conclusion, Recommendations

As a result of the conducted scale development study, the serendipitous science attitude scale consisted of 20 items (excluding the control item) and was organized as 5 Likert type scale. Data analysis results showed that the scale had a three-factor structure. Considering these three sub-dimensions, disregard sub-dimension contained 8 items and the factor load values of the items ranged between .54 and .71 and moreover, it explained 4.390% of the total variance. Value sub-dimension consisted of 6 items and the factor load values of the items ranged between .41 and .72 and furthermore, it explained 8.716% of the total variance. The final sub-dimension of the scale, affective factor, included 6 items and the factor loads of the items ranged between .48 and .69. In addition, this dimension explained 7.190% of the total variance. Distribution of the items making up the scale was at a level as close to one another. Cronbach Alpha internal consistency coefficient found as a result of the made analyses to ensure the scale's reliability showed that the scale was reliable. Results of EFA and CFA conducted to achieve the reliability of the scale and to support the results showed that the scale achieved structure validity.

Considering serendipitous science in terms of learning, it can be said that it emphasizes that science education cannot be limited by a designed or planned environment and order (Vedder-Weiss, 2017). Sometimes information can be found serendipitously when conducting a scientific study. Considering that any scientific study already requires intellectual preparation, persons with a certain competency can reach information more readily than some others. Furthermore, the serendipitous science process can be triggered by the appropriate research or learning environments that are to be prepared (Foster and Ford, 2003). Another example of a situation that makes serendipitous science important is that the process has a perplexing and amazing aspect. The researcher does not know what he/she is looking for or what he/she will acquire at the beginning of the scientific study he/she is conducting. It can be accepted that this circumstance makes the discovery process even more valuable. It seems like it is not rather possible to control scientific information production and manage the scientific progress in general (Ramakrishnan and Grama, 1999). However, it can be stated that accepting scientific progress within still a specific progressivity, order and plan affects the acceptance and development of the existence of serendipitous science unfavorably. It is expressed that the significance of the unwanted and uncontrollable factors must be emphasized more extensively rather than focusing on controllable empirical science environments (Campanario, 1996). Serendipitous science can be regarded as encouraging for scientific studies since it has the liberty to deviate from the existing program and it enables reaching unsearched and valuable explorations.

EFA and CFA were carried out through a single sample in this study, instead of two different samples. It was thought to divide the sample into two on a random-basis, however, it was not preferred due to the reason that the sample to be used within one of two analysis methods would be less than 200. Additionally, the sample of the study comprises science preservice teachers, thus not involving physics, chemistry and biology preservice teachers. Therefore, the findings of this study are limited to the science preservice teachers.

Future studies to be conducted in this field gain importance because of the popularization of scientific studies and because the countries inevitably accept science and technology as a precondition to establishing a labor force which is to build the fundament of progress and growth in the 21st Century. It is thought that the scale developed in this study would both help raise awareness about coincidences which play a critical role for the generation and development of scientific information and would determine the attitudes and aid in developing teachings about it. Serendipitous science is related to the scientific process and the characteristics of science. There are only a scarce number of studies putting forward this connection (Clough, 1997; e Cunha et al, 2010; Moss, 2001; Murayamaa et al, 2015; Ramakrishnan and Grama, 1999). A literature review has shown that since there is no attitude scale prepared about serendipitous science, the developed scale will produce attitude elements that can be exhibited towards serendipitous science in the areas of interest, value, and sense and will complete a serious deficiency. Considering that the perspective towards science and scientific process changes and develops constantly, the prepared scale is at a level to exert the states of university students viewing this field through a different and new window. Furthermore, determining attitudes of primary school, secondary school and high school students towards serendipitous science can be achieved by conducting future studies, making reforms in education and by conducting validity and reliability studies by using this scale or new scales to be developed.

Appendix–1. The Attitudes Towards Serendipitous Science

Hello,

This scale was developed to determine your attitudes towards serendipitous science. After carefully reading each item, indicate the degree to which you agree or disagree with the marking (X) on the right side of the list. It is very important for you to be sincere in your answers and not to leave unanswered items.

You can score from 1 to 5 by placing an (X) in the relevant box.		Strongly Disagree		→		Strongly Agree
1	I believe that serendipity plays a role in the scientific process.					
2	I believe scientists attach importance to serendipity in the process of science..					
3	I think that serendipity is an obstacle to the process of science.					
4	I think that there is no serendipity in science.					
5	I think that serendipities affect scientific developments.					
6	I think that serendipity affects science in a positive manner.					
7	I think serendipity in scientific research should be ignored.					
8	Scientific inventions taking place through serendipity attract my attention.					
9	I think that serendipity increases the number of scientific discoveries.					
10	If I were a scientist, I would pay attention to serendipity.					
11	I do not find it realistic that serendipity can influence science.					
12	The serendipities that I encounter during a scientific research increase my willingness to work					
13	I can list some examples of scientific discovery resulting from serendipity.					
14	I believe it is a waste of time to pay attention to the role of serendipity in the scientific process.					
15	I see serendipities as lucky encounters.					
16	I do not enjoy reaching information through a serendipity.					
17	I think serendipity could result in new research.					
18	Serendipities do not interest me in scientific research.					
19	I do not think serendipity plays a role in scientific research.					
20	Coming across with serendipities while doing research makes me feel happy.					

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