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RESEARCH ON THE PSEUDO-SCIENTIFIC BELIEFS OF PRE-SERVICE SCIENCE TEACHERS: A SAMPLE FROM ASTRONOMY-ASTROLOGY

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Abstract. *The purpose of this study was to determine perceptions embraced by pre-service science teachers on astrology, which is defined as a pseudo-science. It also aimed to reflect their abilities to distinguish between science and pseudo-science through the examples of astronomy – astrology. Twenty-nine grade 4 preservice teachers studying Science Education participated in the study. Among the qualitative research patterns, the phenomenological approach was used for the study. Data were collected through an open-ended question form, group discussion records, and research assignments, while individual interviews were conducted where necessary. Open coding was used for the evaluation of the data, and the validity of the study was obtained through verifications of preservice teachers on themes and theories during the interviews. The findings of the study showed that a vast majority of preservice teachers perceived astrology as a field of science or a subfield of astronomy. Quite a few preservice teachers expressed that astrology was a nonscientific field and that knowledge obtained through astrology could not be considered as scientific knowledge.*

Key words: *astrology, astronomy, pre-service science teachers, pseudo-science, science.*

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Introduction

In addition to being an intellectual activity, science has also become a socially accepted means of attaining knowledge integrated into our lives. With the increasing attention on science, "extraordinary scientific theories", which have serious implications for society, have been on the agenda, although scientists do not appreciate it (Gardner, 1957; cited in Turgut, 2009). These beliefs, which are defined as pseudo-scientific, have a long history, where they emerged in various patterns. There have been many pseudo-scientific doctrines supported with the claims to be scientific or legitimized by the public (Grove, 1985).

Pseudo-science is defined by Martin (1994) as "It is a systematic combination of proposals, applications, and attitudes that resemble science, but are in fact, not". The concept of pseudo-science has been discussed in social sciences through proving magical and mystical phenomena through data that resemble scientific data (Goode, 2000; Lucadou, 2000; cited in Arslan, 2010). Some of the pseudo-scientific and paranormal beliefs as phenomenon that are not in fact sciences but claim to have scientific authorities (Allchin, 2004) are beliefs such as ESP (Extrasensory perception), astrology, healing through mind power, communicating with the dead, psychic powers, mental telepathy, UFOs, the Bermuda Triangle, reincarnation, ghosts, and parapsychology (Allchin, 2004; Crow, 2006; Farha, Stewart, 2006; Grove, 1985; Happs, 1991; Krips, 1979; Lewis, 2002; Lilienfeld, Lohr, Morier, 2001; Martin, 1994; Matthews, 2009; Priest, 1995; Roig, Bridges, Hackett Renner, Jackson, 1998; Science & Engineering Indicators, 2002, 2004; Williams, Francis, Robbins, 2007).

Arslan (2010) emphasized the effect of mass communication tools and the Internet on spreading of these modern cults, referred to as pseudo-scientific, and mentioned the increase in paranormal themed elements such as astrology, palm reading, psychic reading, sorcery, and telepathy. Research studies have shown that 52% of western people recognize astrology as a science, that there are more than three million astrology websites visited by 120

million people per year, and that the tendency in Turkey towards astrology has increased daily (Kose, Ayten, 2009). Public opinion surveys present similar results about astrology along with findings that they believe in extrasensory perception (ESP) and UFOs (Science & Engineering Indicators, 2002). Since the beginning of the 1990s, research studies conducted in nationally and culturally different countries (United Kingdom, Check Republic, Canada, Sweden, Australia, and the United States of America) have indicated that supernatural and paranormal beliefs such as horoscopes and communication with souls and ghosts have become common among adolescents (Francis, Williams, 2009). In various fields of professional psychology, such as clinical applications and school psychology, it has been mentioned that challenges with problems related to distinguishing between science and pseudo-science still continue (Lilienfeld, Ammirati, David, 2012), that pseudo-scientific applications in medicine create a great risk, and could potentially harm the patients (Giuffre, 1997). In this case, it is important to draw a line between science and pseudo-science and distinguish between the two of them.

The problem of the border separating science and pseudo-science has been discussed by science philosophers such as Popper, Kuhn, Lakatos, and Laudan. While Popper suggested falsification, Kuhn built his theories on the existence or absence of a paradigm. Lakatos presented an expanding knowledge criterion while Laudan discussed the issue through the difference between strongly and weakly proven types of knowledge. In conclusion, there is not a clear-cut line between science and pseudo-science; however, the discussion has continuity. Science expands its exploration capacity within its non-rigid borders and is negotiated. On the other hand, despite the continuity of the border issue between science and pseudo-science, it is possible to establish a prototype and display the characteristics of pseudo-scientific knowledge accordingly (Afonso, Gilbert, 2009).

Pseudo-scientific beliefs have certain superficial characteristics that resemble science, while they also have characteristics indicating their nonscientific aspects hiding in their depths. Some superficial characteristics of pseudo-scientific characteristics are as follows: they are expressed in a technical language involving effective theories; their applications are presented by their users with complex and claims skillfully supported with proofs; their applications involve training for their users administered by authorized private institutions. Some in-depth characteristics of pseudo-scientific beliefs are as follows: relative proposals could not be tested or they are already falsified; their theories have been subject to critical tests and evaluations, which have proven to be false or attempts have been made to prove their falsehood with negative proofs; these practices have isolated themselves from a critical interaction or scientific questioning as well as scientific societies; supporters of pseudo-science have dogmatic and quite paranoid attitudes; they also are intolerant towards all other theories (Martin, 1994). Lilienfeld (2010) stated certain criteria to distinguish between pseudo-scientific knowledge and scientific knowledge. Accordingly, pseudo-science could be interpreted through cretin key concepts such as extreme confidence in ad hoc assumptions added to theories to support its validity, avoiding falsification, emphasis on skewing rather than falsification, lack of self-verification, proofs on extreme anecdotes and references of others, developing a protection mechanism against failure, and extreme use of technical language lacking content.

Thagard analyzed pseudo-science over the existence of three components: "theory, society, and historical context". What lies behind Thagard's theory are the similar structures such as confirmation, verification, explanation, and problem solving. Thagard usually expresses that these would be inadequate in distinguishing between science and pseudo-science. It is particularly important to consider the supporters of a theory. The answers to the following questions are also essential: Do the users agree on the principles of the theory and are they able to solve the problems? Are they interested in predicting abnormalities and comparing records or achievements of other rival theories with theirs? According to Thagard, it is important to distinguish between science and pseudo-science. This represents the progress of a theory; its success is interpreted through its ability to solve problems and predict facts. Thomas Kuhn also expressed that a theory that has prevailed for a long time was replaced with another when faced with an abnormality. Considering the three components of Thagard's theory, pseudo-science is defined as follows: *Pseudo-science*, is a theory or discipline claiming to be scientific, which is a nonscientific attempt that is selective in evaluating, confirming, and verifying when compared to others; and it in fact only encounters unsolved problems progressing slower than alterative theories for a long time; and receives quite a small number of attempts to develop theories for solving problems (Martin, 1994). On the other hand, *science* is an activity defining and causatively predicting the phenomenon related to humans, nature, and the universe. To achieve this, science acts within a scientific method, which is built on a system that defines how the definition and prediction could be made and attaches the scientific knowledge its basic characteristic (Topdemir, Unat, 2008).

Yazici (1999) set forth the criteria to determine whether certain knowledge is scientific or not as follows; testability among subjects, reliability, being certain and clear, being systematic and consistent, and comprehen-

siveness. Therefore, scientific knowledge should be reviewed and controlled by everyone in principle. Reliability means that the scientific knowledge should be proven with tests and there should be adequate reasons to believe in it. Being certain and clear indicates that scientific knowledge should not be far from closed, unpredictable, and possess relativist evaluations. In the meantime, it should maintain distance from irrelevance and contradiction. The comprehensiveness of scientific knowledge emphasizes that it should have as much predictive power as possible. In this respect, pseudo-scientific knowledge could be distinguished from the scientific knowledge by reviewing their characteristics.

This study made use of astrology as a pseudo-science. Crow (2006) considers astrology within occultism such as theosophy, anthroposophy, alchemy, spiritualism, rhabdomancy, prophecy, and lycanthropy. The word occult means hidden and the aforementioned subjects are called occult, as they are not taught at schools and are hidden from the public. Astrology differs from other occult topics, as it had been a topic taught at universities until 1800. Astronomy remained relevant to astrology for years, which actually represents an interpretation of people's destinies through stars. The first astronomers were the priests, who worked at temples, predicted the future, and initiated this science (Tola, 2008). Allchin (2004) expresses that although important scientists followed astrology in the past – such as Kepler, who used it in his various discoveries to find the elliptic orbits – it is recognized as a pseudo-science today. With the separation of astronomy and religion during the reign of the Greeks, the history of astronomy as a science began (Tola, 2008).

Krips (1979) states that astrology is used as a nonscientific example by philosophers or non-philosophers and highlights a declaration signed by 192 prominent scientists in a book called "Objections to Astrology" (Bok, B. and Jerome) in 1975. The explanation is as follows: *"whoever wishes to believe in astrology should be aware that it has no scientific basis for its own principles. It is simply a mistake to imagine that the forces exerted by stars and planets at the moment of birth can in a way shape our futures. The dissemination of astrological maps, predictions, and horoscopes by the media without criticism would only lead to an increase in irrationalism and obscurantism"*[1]. Hence, today, astrology is defined as *"a system of magic functioning by establishing relationships between the characteristics of celestial bodies, human beings, and events"* (Jerome, 2007:6). Astrology emerged from the thought that planets symbolized signs of the future by Gods, and depends on certain sign readings based on equivalence principles, various linguistic sleights, false theories, or some statistical studies (Jerome, 2007). Relevant research has shown that astrology does not experience any challenges for its existence. Studies on various age and occupation groups (Francis, Williams, 2009; Happs, 1991; Kallery, 2001; Kose, Ayten, 2009; Losh, Nzekwe, 2011; Martin, 1994; Morier, Keeports, 1994; Roig *et al.*, 1998; Science and Indicators, 2002, 2004, 2012;Sugarman, Impey, Buxner, Antonellis, 2011; Williams, Francis, Robbins, 2007; Yates, Chandler, 2000) involve findings supporting that astrology today is a pseudo-scientific belief of public interest. Very few studies in Turkey (Aglarci, Kabapinar, 2012; Turgut, 2009; Turgut, Akcay, Irez, 2010) focused on the distinction between science and pseudo-science. This fact is an indicator that it is very important for the preservice science teachers to distinguish between science and pseudo-science and distance themselves from occult studies, which are pseudo-scientific. Sugarman and his colleagues (2011), analyzed whether beliefs about astrology could be accurate barometers for scientific literacy concluded that teachers of astronomy often experienced confusion between astronomy and astrology, that they had to make introductory teaching sessions on astrology being not science, and that despite the general awareness on astrology being a common pseudo-science, there were very few studies where student characteristics on pseudo-scientific beliefs were studied and related to scientific literacy. In light of this view, the main problem of this study is the following question: "What kind of pseudo-scientific beliefs do preservice science teachers have in terms of astrology?"

Methodology of Research

General Background of Research

A phenomenological approach among the qualitative research patterns was used in this study. This pattern was selected due to the purpose of the study, which is to reveal the awareness levels of preservice teachers on a pseudo-scientific field. The purpose of phenomenological research is to define the differences in the way individuals understand, predict, and conceptualize a certain phenomenon (Ashworth and Lucas, 1998; cited in Cepni, 2009).

1 Bok, B. and Jerome, L. *Objections to Astrology* (Prometheus Books, Buffalo, NY, 1975), reprinted from *The Humanist* 35 (1975).

It is targeted to reveal thoughts of individuals on a phenomenon, of which they are aware but they lack a detailed understanding of (Holstein and Gubrium, 1996, Yildirim and Simsek, 2006).

Sample of Research

A total of 29 preservice teachers (20 females and 9 males) studying at a State University, Faculty of Education, Department of Primary School Science Education within the 2011-2012 academic year, participated in the study. Sample consisted of preservice science teachers taking the Astronomy course. 30 preservice science teachers had taken the course but one of them didn't participate in activities regularly. So research was carried on with 29 attendants. Since researcher was a teacher on Astronomy course, collected the data during this course. So sample can be perceived as an easily accessible sampling. Since this study is the qualitative research, sample does not represent any universe. Only analytical generalizations have been obtained at the end of the research.

Instrument and Procedures

The primary data collection tool of the study was an open-ended question form consisting of 10 questions. While determining the questions, information on astrology that resembled scientific information was obtained from the social media. The form aimed to determine the perceptions on astrology in terms of the existing knowledge about astrology and the place of astrology in experiences. Data collected through the form were used in a group discussion in the classroom. The discussion was carried out without providing any information on the topic.

Pre-service teachers were then assigned to prepare a research assignment on "What is astronomy? What is astrology? What is their relationship/ What are their differences?" After the submission of the assignments, the researcher analyzed them, and another group discussion was conducted in the classroom. During this process, students were invited to individual and semi-structured interviews based on their responses to the questions on the form or points that were misunderstood in their assignments.

Data Analysis

After all records were recorded, data were resolved holistically through content analysis and "open coding" among the data resolution techniques (Punch, 2005: 199; Yildirim, Simsek, 1999: 163). Themes or arguments were created from codes where necessary. The researcher made use of the "golden sample" (Mayring, 2000:104) as a phase of the content resolution technique to clarify the coding. A golden sample is the sample script that acts as a prototype in predicting a category. In this study, to clarify the situations indicated by the researcher, certain expressions of preservice teachers were used in their original forms.

Due to the fact that more than one single code could be obtained from one preservice teacher's discourse, the sum of frequencies of the codes is not equal to the number of participants. While samples were taken from participants' statements, numbers indicating the sequences were placed under the letters "F" and "M" indicating their genders.

Validity and Reliability

More than one data source was used to predict the phenomena to ensure data diversity, and participation confirmation was made to ensure the accurate representation of truth. Therefore, the internal validity in quantitative research or persuasiveness in qualitative research was obtained. Through different data collection tools, the coherence in opinions of preservice teachers was analyzed to ensure the internal reliability of the study. Detailed descriptions were used in the presentation of the findings. For external reliability, an expert in physics was requested to make confirmatory analysis on coding and findings.

Results of Research

Results Obtained from the Open-Ended Question Form

Findings obtained from the open-ended question form were listed under three titles displaying how preservice teachers perceived astrology as a pseudo-science, how astrology is defined, and preservice teachers' beliefs

and opinions about information presented under the title of "astrology". The first portion involved definitions constructed by preservice teachers on astrology and relevant concepts, while the second portion indicated the relationship between astronomy and astrology; the third portion contained beliefs and opinions on their knowledge related to astrology.

Definition of astrology: This portion is an analysis of the responses by preservice teachers to the questions on definition of astrology and certain related concepts. The question on the definition of astrology was not responded to by 7 out of 29 preservice teachers. The answers to the rest of the sampling were listed under three categories:

Category 1: Definitions emphasizing that astrology is a field of science *(Frequency: 10)*

Category 2: Definitions emphasizing the relationship between astronomy and astrology *(Frequency: 9)*

Category 3: Definitions emphasizing that astrology is a source of knowledge *(Frequency: 5)* [2*]

All definitions emphasizing that astrology is a field of science contained the term "field of science". Five preservice teachers mentioned that astrology was a field of science and the research field of astrology was horoscopes. These definitions could be exemplified as follows: "It is the science that provides information about horoscopes" by F_{15}; "It is the science related to horoscopes" by F_{20} and F_{3}. The remaining five definitions indicated that astrology is confused with astronomy or it was seen as a subfield of astronomy. Here are some examples by preservice teachers:

> "It is the field of science that does research on space." [F_{8}]
> "It is the field of science related to astronomy." [F_{13}]
> "It is the field of science studying the effects of astronomy on the Earth and living things." [F_{1}]

As the definitions indicate, the definitions by F_{8} and F_{13} indicate that the terms astronomy and astrology were confused. These preservice teachers have misconceptions. The other sees astrology as a field of science that emerged from astronomy. As a result, 10 out of 29 preservice teachers believe that astrology is a field of science. There were also preservice teachers with misconceptions confusing astrology with astronomy.

Definitions in the second category defined astrology in relation with astronomy as follows:

> "It could be analysis on the effects of astronomical knowledge on daily life." [F_{18}]
> "It analyzes the changes in human behaviors as a result of the movement of the moon, sun, and stars." [F_{11}]
> "It is a field related to characteristics, relationships, and behaviors of planets or particles within the context of astronomy." [F_{14}]

As statements of pre-service teachers indicate, astrology was explained in relation to astronomy. Some definitions mentioned the relationship between astronomy and astrology directly, while in some other definitions were made using celestial bodies and their movements as a topic of astronomy.

Definitions in the final category mentioned astrology as a hobby and there were statements on how astrology attained knowledge. The sources of knowledge or the means of attaining knowledge in astrology were mentioned in statements such as: "It determines people's horoscopes according to planets. It analyzes how it affects people." by F_{6}; "It is the field of science that analyzes horoscopes according to stars" by F_{4}; and "A personal hobby predicting people's characteristics and future according to the positions of the stars." by M_{2}.

To determine pre-service teachers' perceptions on the context of astrology, they were asked the question: "Who is an astrologist? Could you give examples of famous astrologists?" The responses by pre-service teachers were analyzed and it was observed that 11 pre-service teachers either left the question blank or indicated that they did not know the answer. Seventeen out of the remaining 18 pre-service teachers defined astrologists as follows: "They analyze horoscopes. They make predictions." [F_{20}], "An astrologist predicts the future." [F_{19}]; "He is a person who gives information on horoscopes and deals with horoscopes." [F_{15}]; and "Astrologists predict horoscopes on a daily basis." [M_{7}]. Nine pre-service teachers gave the names of five astrologists with a frequency level of 15. The names are not mentioned here; however, the researcher searched the names and discovered that all of them introduced themselves as astrologists. Approximately one-third of the pre-service teachers knew those who

2 * Due to the fact that more than one single code could be obtained from one preservice teacher's discourse, the sum of frequencies of the codes is not equal to the number of participants.

introduced themselves as astrologists. One response by a pre-service teacher was rather interesting; F_{13} defined astrologists as: "They deal with astronomy--planets and stars." The pre-service teacher confuses astronomer and astrologist, indicating his/her misconception. The same pre-service teacher also defined astrology as astronomy. This pre-service teacher could not give any names as astrologists.

In this phase, pre-service teachers were asked what a "horoscope" was as an important tool for astrology. Here, the purpose was not to determine whether they could define this concept accurately. Therefore, the responses were not analyzed and categorized in detail, but they were examined for potential misconceptions. Three pre-service teachers were observed to confuse telescope with horoscope as follows: "It is a type of telescope." [F_{13}]; "It is a tool for analyzing celestial bodies." [F_{11}]; and "It is a telescope that is used for analyzing celestial bodies [F_{10}]."

As a result, at this phase some of the pre-service teachers were observed to perceive astrology as a field of science and they were confused about concepts of astrology – astronomy, astronomer-astrologist, and telescope-horoscope.

***Questioning the relationship between astronomy and astrology*:** At this stage, pre-service teachers were asked whether there was a relationship between astronomy and astrology, and were asked about the type relationship the two fields have. Data were evaluated and five pre-service teachers were observed to leave the answer blank. The remaining 24 pre-service teachers gave answers, which were listed under two categories according to their emphasis on the existence or absence of a relationship. Table 1 displays the coding and frequencies of the answers.

Table 1. Relationships emphasized by pre-service teachers between astronomy and astrology.

Coding	Theme	N	%
Subfield Common phenomena Knowledge production- interpretation Not specified	Emphasis on the existence of a relationship	21	72.40
Superstition Science/non-science distinction Independent science	Emphasis on the absence of a relationship	3	10.34
	No answer	5	17.25
	Total	29	100

Answers by the majority that expressed a relationship between astronomy and astrology (72.40%) were analyzed and it was observed that six pre-service teachers perceived astrology as a subfield of astronomy. The response by F_3 could be given as an example:

> "Yes, there is a relationship. However, I cannot define this relationship fully. But I believe that astronomy is a more general science while astrology is its subfield."

Pre-service teachers, whose responses were listed under the "common phenomena" as the second code, indicated that they both analyzed the same phenomena. The common code for F_5 stated, "With the movement of planets, the changes in the characteristics of horoscopes are determined. They are related but their meanings are different" was the planets and stars were the common code for the response by M_2 as: "As it predicts according to the positions of the starts, it is related to astronomy." F_{12}'s response was: "Astronomy deals with space and celestial bodies. Astrology deals with horoscopes and does this according to the stars. The relationship is about the celestial bodies." and indicated celestial bodies as the common phenomena.

Pre-service teachers who believed that there was a relationship between astronomy and astrology explaining this relationship through "knowledge production-interpretation", mentioned that astronomy produced knowledge,

while astrology interpreted this knowledge. For instance; F_{11} stated that, "While astronomy tries to explain the structure and function of celestial bodies, astrology deals with the changes occurring due to the movements of these bodies." F_{16} said, "Astronomy analyzes the structure, movement, and events of celestial bodies. Astrology examines how this affects the daily life." According to this approach, while astronomy produced knowledge, astrology made use of and interpreted the produced knowledge.

Finally, the following answers exemplify statements where the existence of a relationship between astrology and astronomy was mentioned; however it was not explained:

> "I think there is." [F_{13}]
> "Yes, there is. I don't know the relationship." [M_4]

There were three (10.34%) preservice teachers who claimed that there was no relationship between astronomy and astrology and their statements were as follows:

> "Astronomy is field of science, while astrology is a superstitious expression derived from the outcomes of this field of science." [M_8]
> "Astrology is not a field of science. Astronomy is a field of science." [F_4]
> "Astrology is a field of science dealing with horoscopes. Astronomy is a field of science, which attempts to explain what occurs in space." [F_2]

As the expressions of pre-service teachers indicate, there was no relationship found between astronomy and astrology. M_8 and F_4 interpreted astrology as non-scientific and distinguished it from astronomy accordingly; however, F_2 considered astrology as a separate science unrelated to astronomy. As a result, in these expressions claiming no relationship, astrology was defined not as a science, was found to be a superstition, or it was perceived as a field of science separate from astronomy. It is a striking but unfortunate finding to discover that only 2 out of 29 preservice teachers emphasized that astrology was not a science and that it was a superstition unrelated to astronomy.

During the group discussion in the classroom, pre-service teachers expressed coherent opinions to the answers they had provided to the questions. The following section of discussion supports this view.

> …
> **M-2:** Astrology looks at the positions of the stars. Astronomy looks at the closer appearance of them. There is a small relevance here.
> **M-5:** Astrology is a subfield of astronomy, I guess. Astrology analyzes the effects of the positions of stars and planets on human beings, and this type of characteristics according to the position of the planets.
> **F-4:** As far as I know astrology is not a science.
> Some students agreed and say, "Yes".
> **F-11:** (It is) not a science but it makes sense of scientific data.
> **M-9:** Teacher, I find astrology so stupid. That star moved there. It got closer to this one. Am I going to be rich because they made a 45-degree angle? That is nonsense. Both Leo and Virgo said you will get huge amount of money. They both said the same thing but I never found that money though.
> Students start to discuss among themselves.
> …

In the discussion, pre-service teachers mentioned that astrology is a subfield of astronomy, that they analyze the same phenomena, that there is a relationship in the form of knowledge production and interpretation, and that it was assumed to be nonscientific.

***Personal beliefs about astrology*:** At this phase, personal beliefs of pre-service teachers about astrology were attempted to be determined. Pre-service teachers were asked questions on what they knew about signs, how they followed the interpretations of their signs, and how they were affected by the interpretations of their signs. What they knew about signs did not have scientific significance; therefore, they were not coded. However, all pre-service teachers, except for three, made certain statements about signs. The statements involved the names, numbers, groups, and characteristics of signs as well as stars, star maps, and celestial bodies. All 29 pre-service teachers knew their signs and 17 out of them knew the group their sign belonged to. Twenty-two pre-service teachers described the characteristics of their sign in detail, 9 of which mentioned that they had the same characteristics, another 9

explained with examples that they partly had the characteristics of their signs and 2 of them mentioned that they did not have the characteristics of their signs. Pre-service teachers' responses to questions on whether they followed their daily horoscope or whether they were affected by the interpretations were quite diverse. Six pre-service teachers mentioned that they did not read their sign interpretations, while the remaining 23 said they read about them at different frequencies (everyday, usually, sometimes, rarely). On the other hand, none of the pre-service teachers indicated that they believed in what they read about their signs, nor did they act accordingly. Only three pre-service teachers expressed tendencies as follows:

> "Yes. I read them. I read because I am curious. But I also think that they are correct. I don't live my life according to sign interpretations. But I keep them in mind." [F_6]
>
> "I read them every day. But they do not affect me. I believe sometimes they are correct." [F_7]
>
> "I sometimes read them. They affect me but I don't act according to the interpretations there." [M_6]

Results Obtained From the Research Assignment

This phase involved the analysis of the research assignments that the pre-service teachers were given on "What is astronomy? What is astrology? What is their relationship? / What are their differences?" They were asked to reflect on the classroom discussions on their assignments along with what they thought before and after the discussions. Table 2 displays the findings related to how teachers expressed their perceptions of astrology before and after the discussion. Related codes were listed under themes as "epistemological emphasis, cognitive awareness, social effect, and indifference/curiosity"; the determined themes were indicated in terms of their frequencies of appearance before and after the study.

Table 2. Findings obtained from the research assignments.

Theme	Codes		N (Before)	N (After)
Epistemological emphasizes	Science		5	7
	Scientific criteria	- Repeatability	-	1
		- Testability	-	1
		- Objectivity	-	2
		- Proving	-	1
	Sub field		5	-
	Common phenomena		-	1
	Knowledge production-interpretation/usage		2	4
	Non-science		10	18
	System of thought		-	2
	Belief system		-	2
	Fortune telling		-	2
	Religious data		-	1
	Difference in purposes		-	1

Theme	Codes	N (Before)	N (After)
Cognitive awareness	Emphasis on lack of knowledge	12	4
	Awareness in distinguishing between science and pseudo-science	-	4
	Defining	4	-
Social effect	Popular culture	-	1
	Media	-	1
	Indifference/curiosity	3	1

According to Table 2, five pre-service teachers assumed astrology to be a field of science before questioning and research, while 10 pre-service teachers indicated that it was not a field of science. Later on, the numbers increased for both opinions. The number of pre-service teachers claiming that it is a science increased to 7, while the number of pre-service teachers indicating that it is not a science reached 18. Four pre-service teachers did not mention astrology being a science; however, they mentioned that astronomy produced knowledge while astrology made use of that knowledge. Eighteen (62.07%) out of 29 pre-service teachers emphasized that astrology was not a field of science after the research and discussions, while 7 (24.14%) of them still perceived astrology as a science. The perception of seeing astrology as a science increased and rose to 7 from 5 pre-service teachers. The remaining four did not mention this issue directly, but stated that astrology made use of astronomy. The following paragraphs illustrate expressions of pre-service teachers after the study. Samples were chosen among those who claimed that it is a science, those who claimed that it is not a science, and those who changed their mind after the study.

Sample indicating the participant still believes that it is not a science:

"There is no doubt that I had certain beliefs about astronomy and astrology, but I never thought that astrology was a field of science. It was the same before I enrolled in this faculty and learned about scientific thinking. I found what people wrote in newspapers so empty and I still think the same. I don't believe that human beings and their behaviors are that simple. " [M_9]

Sample indicating the participant still believes that it is a science:

"... in some opinions, they mention that astrology is fortune telling. I think astrology is not related to that. Meteorology tells you what is the weather going to be like tomorrow, and you take precautions. Similarly astrology informs you of potential effects that could be felt in the future. We are made of energy, therefore I believe that the rotation speeds of planets could affect us..." [F_6]

Sample indicating the change from science to non-science:

"...I learned. What surprised me is that astronomy and astrology are totally different from each other. I used to think that they were affected by each other. I even believed that astrology was a subfield of astronomy." [F_{20}]
"I used to believe that astrology was consistent in terms of celestial bodies affecting human behaviors and characters. In my further research, I don't think astrology is valid, as such an effect cannot be scientifically proven, nor does our holy book, the Quran, mention anything about such a relationship." [M_6]

Sample indicating the change from non-science to science:

> "Astrology always seemed to me to be a subfield of astronomy. In the end, it is illogical to analyze the effects of starts and planets on human beings without observing them; Bbt it was. Astrology is one of the first fields of science that was dealt in human history. It is a field of science, which led to the emerging of math and geometry." [F_8]

Pre-service teachers, who claimed that astrology is not a field of science, called it a "system of thought, belief, and fortune telling" with two frequencies each. The claim that astrology produced knowledge obtained by astronomy had two frequencies before the study, while after the study it increased to four. Again, after the study, one pre-service teacher indicated that their common point was their focus on the same phenomena. The thought that astrology is a subfield of astronomy was repeated five times before the study, while it disappeared after the study. One of the pre-service teachers mentioned that they both had different purposes, while another mentioned its invalidity due to religious facts (this statement by the pre-service teacher M_6 was mentioned in the samples section on changing between science and non-science). Pre-service teachers were expected to make an evaluation depending on scientific criteria and declare that astrology was not a science; however, the frequency of reasons relevant to scientific criteria was five, unfortunately. The statement in the research assignment by pre-service teacher F_2 could be an example as follows:

> "...but it cannot be repeated, tested like astronomy, nor does it fit the objectivity criteria,...it is a system of thoughts, which attempts to establish parallels between the prophecies and lives of individuals, does not have a scientific aspect in terms of criteria and emerges only with the interpretation of individuals..." [K_2]

Apart from the above statement, in assignments by two pre-service teachers, there was the emphasis on objectivity and proof. After the researcher analyzed the assignments, findings supportive of other data were obtained during the discussion in the classroom. The criteria, which were not often mentioned in the assignments as indicators of astrology being non-scientific, were frequently repeated during the discussions and different data were also mentioned. Pre-service teachers expressed three different opinions during the discussion, and the discussion continued around these opinions. The findings are summarized in Table 3.

Table 3. Findings related to opinions mentioned in the discussion at the end of the study.

	Opinion 1: Astrology is a field of science.	**Opinion 2: Astrology is not a field of science.**	**Opinion 3: There is a relationship between astronomy and astrology.**
Reasons	Follows a statistical method.	Does not follow scientific method.	Astronomy is derived from astrology.
	Does not make personal judgments, makes generalizations.	Many variables affect the predictions of human psychology.	Astrology makes use of knowledge attained by astronomy.
		Involves inconsistent knowledge.	
		Involves conflicting knowledge.	
		It is subjective.	
		There is no field of education.	
		There is no official professional field.	

According to Table 3, pre-service teachers who claim that astrology is a science in Opinion 1 state that it makes use of statistics and it could be generalized rather than being personal. (*For instance, pre-service teacher M_5: Astrology makes use of astronomy. I mean, it makes use of methods obtained through scientific methods… Looking at them, it observes what happened according to their movements. It follows a statistical method as a result of these movements. For example it says, those who were born in this month, those who were born between the first and tenth of January, for those the big dipper is at this position. That is how they use characteristic methods in a statistical way.*)

Pre-service teachers supporting Opinion 2 as astrology not being a science mentioned that it does not follow a scientific method, that there are many variables that affect human psychology, that it involves incoherent and conflicting knowledge, it is subjective, it has no educational fields, and there is no professional field. A section indicating its lack of scientific method utilization is as follows:

> **M_9:** Teacher, for something to be considered as science, it needs to follow the scientific method. Plain and simple. But in astronomy (student says astronomy by mistake and then corrects as astrology) there is no scientific method. It only interprets how movements of stars and planets and their attributed signs change certain behaviors of human beings. It does not have any scientific proof; that is they say if Mars moves like this, then it affects individuals in this way, but this doesn't have any proof. That is, there is no scientific method. There is no scientific method, so it is not a science.

Reasons for the last opinion demonstrate emphasis on the belief that astronomy is derived from astrology *(For instance, pre-service teacher F_{10}: ...Astrology is known to be the oldest written science of human beings. It says it gave life to math and geometry and it started historically in 30 thousand BC, it says it is the start of astrology when the movements of the Moon are carved on stones...)*, and that astrology made use of knowledge attained by astronomy (*For instance, pre-service teacher M_7: Teacher, I think astronomy is a field of science. Astrology is a system of thought that interprets the effects of knowledge obtained by astronomy on human beings and their lives*.).

Looking at other themes obtained from the research assignments and especially the coding under the cognitive awareness theme, it was observed that the "lack of knowledge" code was frequently repeated, particularly before the study. Twelve pre-service teachers indicated that before this topic was discussed in the lesson and research was conducted, they had quite rough knowledge about it and that they were not even aware that they were confused about astrology and astronomy, or their establishment of an inaccurate relationship between them. Four pre-service teachers still indicated that their knowledge was shallow. They confirmed their inadequacy through classroom discussions. Finally, only one pre-service teacher mentioned the effect of popular culture and media on the presentation of astrology as a scientific claim. Pre-service teacher F_5 describes this as follows:

> "...in light of my observations, I can say that many people around me know more about astrology than astronomy including myself. I think that is because of popular culture. Curiosity should also be considered. As signs, star maps and such topics attract us more; astrologists are usually on the agenda. Media makes use of them for their own benefit.... " [F_2]

Discussion

In this study, perceptions of pre-service science teachers about astrology being classified as a pseudo-science and their abilities to distinguish between science and pseudo-science were determined. In light of the purpose of the study, the initial phase consisted of data collection through an open-ended question form. Following the evaluation of the forms, a classroom discussion was made on the topic. At this phase, the naive perceptions of pre-service teachers were determined. At the beginning of the study, data obtained indicated that astrology was found to be a field of science by pre-service teachers with a frequency of 10, it was related to astronomy with a frequency of 9, and it was indicated as a source of knowledge with a frequency of 5. The intensive expression of astrology as a science or its being a sub-field of astronomy demonstrates that pre-service teachers perceived a pseudo-scientific claim as a science. In research by NSF (National Science Foundation) in the United States, the perceptions of adults, women and men aged between 18 and 65 years, at different educational levels about astrology were scanned 14 times between 1979 and 2010. These 14 scans reached a minimum of 1434 and a maximum of 2041 individuals. The statistics obtained in the given period of time indicated that the perception of astrology as a science ranged between 0 - 46%. The perception that astrology was a type of science received values ranging between 12 and 55%. Indicators for individuals in the year 2010 showed that 11% of 1434 participants found

astrology quite scientific, while 43% saw it as a type of science (WEB1). This result is supportive of the findings of this study. Similar outcomes were obtained from pre-service homeroom teachers as the sampling of Happs (1991), college students as the sampling of Roig *et al.* (1998), pre-service homeroom teachers, and other subjects as the sampling of Yates and Chandler (2000) in Australia, kindergarten teachers as the sampling of Kallery (2001) in Greece, young adolescents as the sampling of Williams *et al.* (2007) aged between 13 and16, pre-service teachers as the sampling of Losh *et al.* (2011), college students as the sampling of Sugarman *et al.* (2011), and pre-service teachers of chemistry as the sampling of Aglarci and Kabapinar (2012).

The study did not involve any actions to chance pseudo-scientific beliefs of pre-service teachers about astrology; it only aimed to predict their perceptions. However, after the classroom discussion and research assignment, there were pre-service teachers who experienced changes in their opinions. Accordingly, 18 out of 29 pre-service teachers indicated that astrology was not a science following the research assignments. Nevertheless, the scientific criteria to draw lines between science and pseudo-science were rarely mentioned. Repeatability, testability, and proof were repeated with a single frequency, while objectivity was repeated with a frequency of two. In the study by Turgut (2009) on pre-service science teachers, it was found that pre-service teachers did not have a critical approach to distinguishing between science and pseudo-science, they displayed an approach with provability at one pole and the other pole with a scientific approach where everything was analyzed, and that they were inadequate in distinguishing between science and pseudo-science. This is supportive of the findings of this study as well.

Conclusions

The findings of the study showed that a vast majority of pre-service teachers perceived astrology as a field of science or a subfield of astronomy. Quite a few pre-service teachers expressed that astrology was a nonscientific field and that knowledge obtained through astrology could not be considered as scientific knowledge. However, according to their explanations on why astrology was not a science, they were observed to lack the adequate intellectual capacity in terms of their ability to distinguish between science and pseudo-science.

As a result, it was observed that a vast majority of the participating pre-service teachers embraced a pseudo-scientific belief about astrology. They were found to be inadequate in distinguishing between scientific and pseudo-scientific subjects. One reason for this intellectual failure could be the lack of education or incomplete acknowledgement on this distinction during any stage of the formal education level. During the discussions in the classroom, pre-service teachers mentioned their lack of education in the topic field as the reason for their lack of knowledge. Therefore, course contents should involve subjects where pre-service teachers could distinguish between science and pseudo-science, especially through discussing examples (example of astrology-astronomy as the topic of this study). Martin (1994) supports that pseudo-scientific and paranormal beliefs should be included in the science education targets, not to impose those beliefs on students, but with the purpose of encouraging them to think critically about these beliefs. In this respect, it is suggested that the science curriculum should contain objectives regarding the distinction between science and pseudo-science.

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