

Research Article

Preservice Science Teachers' Views about Scientific Inquiry: The Case of Turkey and Taiwan^{1,2}

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Abstract

In recent years, the importance of examining the opinions of preservice science teachers who will educate future science literate individuals towards scientific research has been frequently mentioned. In this research, in order to contribute to the field, 88 preservice science teachers in Turkey and 80 preservice science teachers in Taiwan participated in the study. The data was collected via Views about Scientific Inquiry - VASI Questionnaires. Also, semi-structured interviews with volunteered preservice science teachers. Results showed that there is a significant difference on behalf of preservice science teachers in Taiwan in terms of “the way that the scientific inquiries are done”, “the place of experiment and observation in scientific inquiries” as for the first dimension, and “there is no single set or sequence of steps followed in all inquiries” as for the second dimension. Besides, the preservice science teachers from both countries stated their views in “scientific” level on the dimension of “The result of an inquiry should be in accordance with the collected data”. Moreover, it was revealed that preservice science teachers in Turkey have difficulty in defining that scientific research always starts with a question; and preservice science teachers in Taiwan have difficulty in defining the scientific data and scientific evidence. Considering all the findings, preservice science teachers' views of scientific inquiry in Taiwan are better than them in Turkey.

Keywords: *Scientific literacy, views about scientific inquiry, pre-service science teachers, science teacher education program*

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Fen Öğretmen Adaylarının Bilimsel Araştırmaya Yönelik Görüşleri: Türkiye ve Tayvan Örneği

Öz

Son yıllarda, geleceğin bilim okuryazarı bireylerini yetiştirecek olan öğretmen adaylarının bilimsel araştırmaya yönelik sahip oldukları görüşlerin incelenmesinin öneminden sıklıkla bahsedilmektedir. Bu doğrultuda alana katkı sağlamak amacıyla bu araştırmada, Türkiye ve Tayvan'daki fen öğretmen adaylarının bilimsel araştırmaya yönelik görüşleri incelenmiştir. Bu amaçla Türkiye'den 88 öğretmen adayı ve Tayvan'dan 80 öğretmen adayından bilimsel araştırmaya yönelik veriler toplanmıştır. Fen öğretmen adaylarının bilimsel araştırmaya yönelik görüşlerinin araştırılması için Lederman ve Lederman, Lederman, Bartos, Bartel, Meyer ve Schwartz (2014) tarafından geliştirilen Views About Scientific Inquiry Qustionnaire- VASI kullanılmıştır. Tarama modelinde olan bu araştırmada nitel ve nicel veri analizi yapılmıştır. Ayrıca ölçekte yer alan açık uçlu sorular sorularak, seçilen öğretmen adaylarıyla görüşmeler gerçekleştirilmiştir. Çalışmadan elde edilen bulgular doğrultusunda fen öğretmen adaylarının, bilimsel araştırmaların yapılışına ve deney-gözlemin bilimsel araştırmalardaki yerine ilişkin olan bilimsel araştırmanın birinci boyutuna ve bilimsel araştırmaların belli bir yöntemi ve basamağının olmadığına ilişkin olan ikinci boyutuna yönelik verdikleri cevaplarda ülke değişkenine göre Tayvan'daki fen öğretmen adayları lehine anlamlı bir farklılığın olduğu ortaya konmuştur. Ayrıca her iki ülkedeki fen öğretmen adaylarının bilimsel araştırmaya yönelik görüşlerinin “Çalışmanın sonucu, toplanan verilerle tutarlı olmalıdır” boyutunda “bilimsel” görüş düzeyinde toplandığı görülmüştür. Bunun yanında Türkiye'deki öğretmen adaylarının “Bilimsel araştırmalar her zaman bir problemle başlar” boyutunda; Tayvan'daki öğretmen adaylarının ise “veriler, kanıtlarla aynı değildir” boyutlarında çoğunlukla “yetersiz” görüş düzeyinde görüşe sahip oldukları belirlenmiştir. Sonuç olarak bilimsel araştırma düzeyleri göz önünde bulundurulduğunda Tayvan'daki öğretmen adaylarının Türkiye'deki öğretmen adaylarına göre daha iyi oldukları söylenebilir.

Anahtar Kelimeler: Bilimsel okuryazarlık, bilimsel araştırmaya yönelik görüş, fen öğretmen adayları, fen öğretmen yetiştirme programı

Introduction

The most important effects of the education system on society are that science affects a society positively, scientific thinking is spread among the masses of the public and science becomes a part of common thinking. Giving scientific quality to the cultural structure should be among the primary objectives of education at all levels, starting from primary school level. Students trained by the education system prepared for this purpose will be scientific literate individuals who can combine science with art and moral values, use scientific research skills, and find effective solutions to the problems they face today and in the future (MEB, 2005, 2018; Lederman ve Lederman, 2012). Scientific literacy in American National Science Education Standards (NSTA, 2003) is defined as knowing and applying scientific concepts and processes for making personal decisions, participating in social and cultural events and economic productivity (NRC, 1996). Briefly, scientific literacy requires being familiar with scientific issues, understanding scientific initiative, relationships between science and society (AAAS, 1993). For this reason, it is of great importance to teach students the nature of science and the nature of scientific inquiry, which are the most basic components of science literacy (Solomon, 1991; Reif & Larkin, 1991; Driver, Leach, Millar & Scott, 1996). Scientific inquiry is an important factor for students to think like scientists, develop positive opinions about science, and develop critical thinking skills in structuring knowledge and increase students' academic success (Anderson, 2002; Schneider, Krajcik, Marx & Soloway, 2002).

Today, the information that societies produce and share increases with such a speed that the effect of information on the progress of societies is also revealed. In the information age we are in, one of the most important needs is not to reach information, but to be aware of where and how to get the right information. In order to create this awareness and increase the number of scientific literate people of the society, it is very important that the education system of that society aims to provide its students with the skills to reach information rather than transferring the existing information. However, no matter how well the goals are determined in education and training, no matter how functional the course subjects are, it is not possible to get the expected result unless there are teachers with those goals and insights. For this reason, the most important element of an education system is the teacher. Teachers responsible for educating and directing students for educational purposes are expected to develop their understanding of

scientific issues, develop their skills for the nature and use of scientific processes, and guide their students in practicing in their life what they have learned in science classes (Kilpatrick, Swafford & Findell, 2001; Hill, Rowan, & Ball, 2005). However, current research has also shown that science teachers reflect their understanding of science, their views on science and their attitudes towards science into classroom practices (Akerson, Abd-El-Khalick & Lederman, 2000; Morrison, Raab & Ingram, 2009). American National Science Education Standards [NSES] (NRC, 1996) have established standards for the characteristics that teachers should have and listed these standards as follows: "All science teachers will understand the nature of scientific research, state the importance and importance of scientific research in science, have enough scientific knowledge to use it." (p.59). However, it is also stated in the studies conducted that the opinions of teachers and students about scientific research are not sufficient (Abd-El-Khalick, Lederman, 2000; Lederman, 2009; Lederman, Lederman, Bartos, Bartles, Meyer, and Schwartz, 2013; Schwartz, Lederman and Lederman, 2008). In the light of these studies, the most important research to be done to improve the education system is to examine teacher training programs. In other words, the education of teachers who will work in the education system in teacher training programs is important in terms of the quality of education. Accordingly, teacher training programs should be shaped according to the changing conditions of today, the competencies of teacher training programs should be reviewed, and the policies followed for the current situation and the desired targets should be constantly evaluated through field research. Therefore, it is of utmost importance to determine the pre-service teachers' understanding of scientific inquiry in order to train teachers who can make scientific inquiry applications and offer their students opportunities in this direction (Ma, 2011; Wang, Lv, Jou, and Zhang, 2016).

Individuals who are aware of the interaction between science and society and can conduct a scientific research, in order to raise science literate individuals, many countries organize their education programs for this purpose and take part in international educational performance comparison practices to evaluate their results. Among these applications, "Trends in International Mathematics and Science Study (TIMSS)" and "Program for International Student Assessment (PISA)" are the most commonly used. These international comparison exams play an important role in assessing changes in the education system and identifying deficiencies. In other words, in the light of the data obtained from such studies, issues such as strengths and weaknesses of the current education system, education policies, curriculum, teaching methods

and techniques, and competencies of teachers are reviewed (Keser, 2005; Brown & Brown, 2007).

One of the most important elements of the education system is teachers and teachers are shaped by the current education system (Kilpatrick, Swafford & Findell, 2001; Hill, Rowan & Ball, 2005). Therefore, studying teacher training should be one of the first steps to be taken to improve the education system in general. At the ranking of PISA and TIMSS exams, while Taiwan occupies on top position; unfortunately, Turkey is situated below the average. The literature review shows that they have a similar system of science education in Taiwan and Turkey. However, it is also seen that they have different science teacher training and selection policies (MEB, 2016).

Constructivism is the basis of science teacher training programs in both countries, and programs are based on practice-based education. The programs included the nature of science courses in order to develop pre-service teachers' understanding of science, elements of science and scientific inquiry. In addition, preservice teachers in both countries take scientific research and laboratory courses and perform various applications. Educational sciences courses in both countries' science teacher training programs are similar (MOE-Taiwan, 2001& HEI, 2007). However, there are also some differences between the two countries in terms of understanding of raising science teachers. The first of these, science teacher training programs are four-year programs in Turkey. Preservice science teachers must complete these programs. Those who succeed at the end of the process can graduate. Prospective teachers who graduate take the central exam and those who enter a certain percentage are appointed as teachers. This situation differs in science teacher training institutions in Taiwan. In order to become a science teacher in Taiwan, preservice science teachers must complete the teacher education certificate programs of the college or universities. Individuals who have graduated from different undergraduate programs or are still studying can also continue these programs. Preservice science teachers who graduated from this certificate program, enters a central exam similar to that of Turkey. Then they have to pass the local exam of the region they want to work as a teacher. Although Turkey and Taiwan have different science teacher training policies, the science teaching programs of these two countries aim to raise individuals who understand the nature of scientific inquiry, which is one of the most fundamental components of scientific literacy. Scientific research, which has been researched for a long time in science education, includes scientific process skills used in the structuring of scientific knowledge, and field knowledge, creativity

and critical thinking skills (Lederman, 2009; Lederman, Lederman, Lederman & Antink, 2013). While many resources available in this field (AAAS, 1993; NRC, 2011) focus on the importance of these skills to conduct research; in the American National Science Education Standards (National Science Education Standards- NSES), the difference between the skills required to conduct research and the basic understanding of the character of scientific research has been highlighted. For this reason, today, the focus of science education has been the applications that will bring the skills and understanding towards doing scientific research.

The nature of scientific inquiry includes processes involving the work of scientists, the processes of creating and accepting scientific knowledge (Schwartz, Lederman & Lederman, 2008; Lederman, Lederman, Bartos, Bartles, Meyer & Schwartz, 2014). Eight different dimensions have been defined for understanding of scientific research, which is beyond the basic research skills (NRC, 2000, 2011). These dimensions and their explanations are as follows (Lederman et al., 2014);

1. Scientific investigations all begin with a question, but do not necessarily test a hypothesis:

In scientific research questions may arise in various ways, sometimes from curiosity and sometimes from a theory-oriented prediction. Scientific inquiry begins with questions, but does not necessarily test a hypothesis.

2. There is no single set and sequence of steps followed in all investigations (i.e., there is no single scientific method): It has also been emphasized in the standards that students should gain awareness that scientists do not follow a single scientific method to conduct their research and produce valid knowledge (NRC, 2011).

3. Inquiry procedures are guided by the question asked: Scientific research mainly consists of the questions asked by the scientist, what they already know about the world and their answers. For this reason, scientists can follow different methods and processes for the same questions. Students need to understand that the research questions determine the approaches to be followed.

4. All scientists performing the same procedures may not get the same results: Students should realize that scientific data alone does not mean anything, scientists interpret scientific data and conclude (Osborne, Collins, Ratcliffe, Miller & Duschl, 2003).

5. *Inquiry procedures can influence the results:* Determining and organizing variables, data collection methods, measuring and analyzing variables affect the results obtained by the researcher. Students need to understand that there is a logical connection between the research method, the data collection method and the conclusion reached.

6. *Research conclusions must be consistent with the data collected:* Each research result will be supported by evidence from the data collected. Students understand that the strongness of scientists' claims depends on supporting these claims with evidence.

7. *Scientific data are not the same as scientific evidence:* In scientific research, data are observations collected by the scientist during the research and these observations can take various forms (eg numbers, descriptions, photographs, sound, physical examples, etc.). Evidence is the product of the data analysis process and subsequent comments. In order for students to interpret the data, they must first understand the difference between data and evidence.

8. *Explanations are developed from a combination of collected data and what is already known:* To statements made by scientists; the data they collect for their research, the results they obtain from these data and the information that has been revealed in previous research and accepted as scientific information are guided. In addition, students should understand that scientists have to define the difference of well-supported results from accepted scientific knowledge or must define the superiority of well-explained phenomena over previous theories (NRC, 2011).

Teachers shaped by the current education system are among the most important factors affecting student success. Therefore, examining teacher training should be one of the first steps to be taken to improve the education system in general. Thus, it is believed that investigation of preservice science teachers' views on scientific inquiry, who have continued science teacher education program in Turkey and Taiwan, and making the comparison between the two countries' views on scientific inquiry will bring a different perspective to teacher training programs in our country. For this purpose, in this study, both in Turkey submissions on the scientific research of science teachers in Taiwan were investigated.

Method

The study is a descriptive study in order to determine the pre-service science teachers' opinions about scientific inquiry and survey method, which is one of the descriptive research methods, was used. Survey are research approaches aiming to describe a situation that exists in the past or still as it exists (Büyüköztürk, Çakmak, Akgün, Karadeniz & Demirel, 2014). The simple descriptive survey approach is one-shot survey for the purpose of describing the characteristics of a sample at one point in time apart (Mertens, 1998).

In this study, 88 preservice science teachers, who continued to the senior class of Science Education department of one university in Turkey; and, 80 preservice science teachers, who continued to the senior class of the National Taiwan Normal University in Taiwan, was participated. In addition, after the application scale, semi-structured interviews were conducted with 10 preservice science teachers from Turkey, and 8 preservice science teachers from Taiwan and the questions in the instrument were asked in the interviews.

Instrument

In this research, “Views on Scientific Inquiry Questionnaire” consisting of seven open-ended questions, which is a qualitative measurement tool, was used to determine the views of preservice science teachers about scientific inquiry. It was developed by Lederman, Lederman, Bartos, Bartel, Meyer and Schwartz in 2014 with the aim of determining views on scientific inquiry. The translation of VASI into Turkish was made by the researcher and the translation into Chinese was made by experts in the field. In order to ensure the language validity of the instrument, it was converted back to English by academicians who are experts in language fields, and it was used in the study after the necessary corrections were made and pilot application was made. The items of VASI have been prepared to determine eight aspects for scientific research. These aspects are; (1) Scientific investigations all begin with a question, but do not necessarily test a hypothesis. (2) There is no single set and sequence of steps followed in all investigations (i.e., there is no single scientific method). (3) Inquiry procedures are guided by the question asked. (4) All scientists performing the same procedures may not get the same results. (5) Inquiry procedures can influence the results. (6) Research conclusions must be consistent with the data collected. (7) Scientific data are not the same as scientific evidence. (8) Explanations are developed from a combination of collected data and what is already known.

Data Analysis

The data obtained in the study were analyzed using content analysis, which is one of the qualitative data analysis methods. In order to examine the responses of the participants to the forms, the rubric developed by Lederman (2014) was used, the pre-service teachers' answers were evaluated, and their views on scientific inquiry were classified as informed, mixed and naive. If preservice science teachers could justify their answers regarding the questions correctly, they were categorized as an “informed” view. Preservice science teachers provided sufficient explanation, but if the reasons for their answers are not clear or incomplete, they are categorized as a “mixed” view. If preservice science teachers did not provide sufficient opinions or their explanations were wrong, their opinions were categorized as “naive” view; and, if the preservice science teachers gave irrelevant or incomprehensible answers to the question, his answers were categorized as “not clear” view. Also, using rubrics, qualitative data collected by VASI was converted into quantitative data. Statistical Package for the Social Sciences-21 (SPSS-21) program was used to analyze the quantitative data obtained. In this study, the Chi-Square Test (Crosstabs) was applied to determine the possible differences between the pre-service teachers' answers to the VASI. Because of the fact that this nonparametric statistical analysis method is used to determine whether there are significant differences for events or objects, in this study, it was used to determine the difference between the views on the scientific inquiry of preservice science teachers in Taiwan and Turkey. In addition, frequency and percentage analyzes of the data were performed and interpretations were made by looking at these distributions.

Findings

In this study, the answers given by preservice science teachers in Turkey and Taiwan who participated in the research were analyzed under the eight aspects of the scientific inquiry and classified as informed, mixed and naive. The views of Turkish and Taiwanese preservice science teachers about the scientific inquiry aspects for these categories are presented in Figure 1 and Figure 2 respectively.

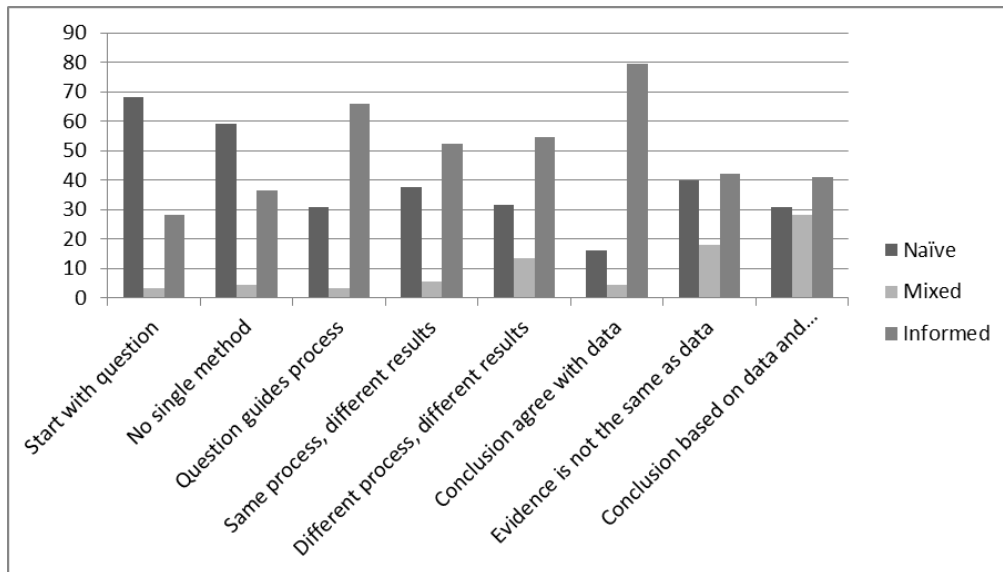


Figure 1. Views on Scientific Inquiry of Preservice Science Teachers in Turkey (n = 88)

Considering the graph in Figure 1, the preservice science teachers in Turkey have "informed" view in the four dimensions of scientific research more than naive view.

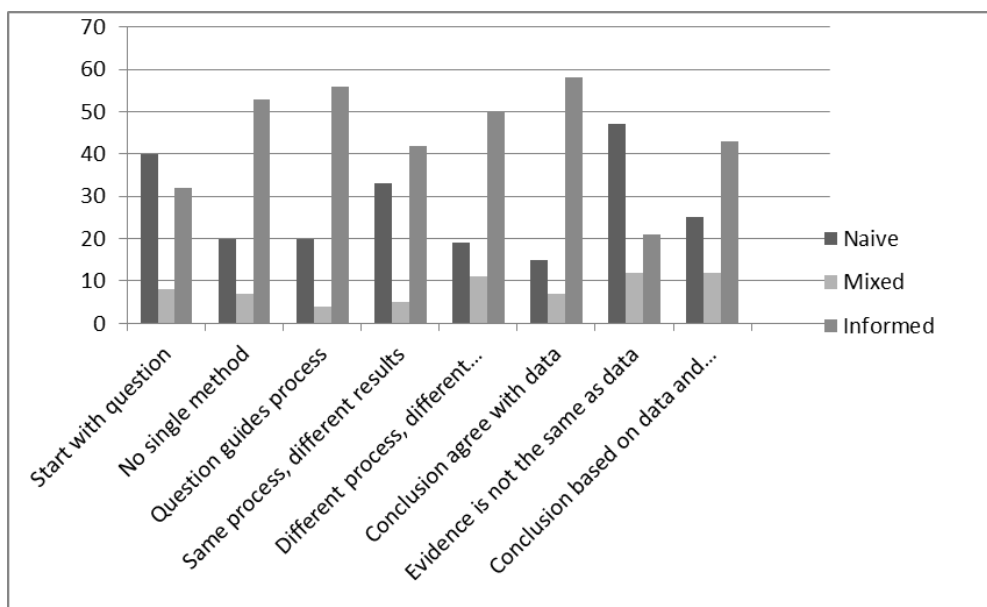


Figure 2. Views on Scientific Inquiry of Preservice Science Teachers in Taiwan (n=80)

To consider the graph in Figure 2, the preservice science teachers in Taiwan have "informed" view in the six dimensions of scientific research more than naive view.

1. Aspect: Scientific investigations all begin with a question, but do not necessarily test a hypothesis

In Turkey and in Taiwan, some examples of preservice science teachers' responses to the first aspect of scientific inquiry are presented in Table 1.

Table 1.

Examples of Preservice Science Teachers' Responses Representing their Informed, Mixed and Naive Views on the First Aspect of Scientific Inquiry

1. Aspect of Scientific Inquiry	Informed	Mixed	Naive
Scientific investigations all begin with a question, but do not necessarily test a hypothesis	It is scientific. This person may have started with the question. Why are the beaks of these birds different? It started with a question and continued with research on it, made examinations, observed, and made classification. So it is scientific. (PST _{TURKEY} 2)	An idea that may not start with scientific questions. But to get absolutely reliable information, that person puts his curiosity and question into a scientific way and starts his research. In fact, the research begins with a scientific question, with curiosity. (PST _{TURKEY} 5)	Scientific research sometimes begins with curiosity, not always with scientific questions. (PST _{TURKEY} 66)
	Scientific inquiry includes observation, revealing the problem, presenting and proving the hypothesis. If the data is handled carefully and systematically when it is collected and concluded, the research that this person has done is scientific. (PST _{TAIWAN} 9)	Yes, but we need to define scientific questions, I think we can hardly define things like religion and emotion, for example. (PST _{TAIWAN} 33)	Sometimes scientific research can be from direct observation and experiments without questions. Sometimes, a theory is suddenly created only after something has been observed for a long time and then designs and proves the experiment. (PST _{TAIWAN} 16)

*PST – Preservice Science Teacher

In this aspect of the VASI, the a and b part of the first question and the second question targets understanding that scientific inquiry always starts with a problem, that problems that inspire research actually arise from observations and that this is a part of science. The results obtained for this aspect, only 28.4% of preservice science teachers in Turkey and 40% of preservice science teachers in Taiwan have "informed" view. When the answers given to the questions in this aspect are examined in detail, in the case of the part a of the first question, opinions of

whether the birdwatching research given in the question is scientific or not were taken. When the results were examined, it was determined that approximately half of the preservice science teachers in both countries did not have sufficient views about this aspect and that they could not accept the research mentioned in the first question of VASI scientifically, because they stated that only observation was made. In addition, 46.6% of teachers in Turkey, while 37.5% of teachers in Taiwan stated that scientific research always starts with a problem, and it is determined that they have "informed" view on this subject.

Also, when the answers to the questions of the first aspects are examined in detail; When the answers given by the Turkish preservice science teachers to the part a of the first question (1a) of the first aspect "Would you scientifically accept the examination of this person?", it was determined that only 19.3% of their answers were at the level of "informed" view. In addition, 32.5% of Taiwanese preservice science teachers were found to be at the "informed" view. It has been determined that pre-service teachers at this level are able to provide sufficient answers regarding how scientific research should be together with their reasons, and they use definitions such as "observation were made for research" and "systematic data collection were made". In another question of this dimension, the opinions of the preservice teachers on whether the examination of the bird watcher should be accepted as an experiment or not were received. The findings stated that 76.1% of preservice science teachers in Turkey and 42.5% of preservice science teachers in Taiwan was found to have a "naive" view. It was determined that these preservice science teachers could not determine the difference between experiment and observation, and they experienced a confusion about this issue. Moreover, quite a few of the teachers in Turkey, while close to half of the teachers in Taiwan has "informed" view. It was determined that these pre-service teachers could explain the reason for this research sample that it was not an experiment, and could distinguish between experiment and observation. When the findings for the other question of this aspect, for scientific research always start with a problem, in Turkey (50%) and in Taiwan (61.2%), most of the preservice science teachers have "naive" view unfortunately. It was found that these preservice science teachers often stated that scientific research could always start with curiosity or by chance, not with questions.

2. Aspect: There is no single set and sequence of steps followed in all investigations

In Turkey and in Taiwan, some examples of preservice science teachers' responses to the second aspect of scientific inquiry are presented in Table 2.

Table 2.

Examples of Preservice Science Teachers' Responses Representing their Informed, Mixed and Naive Views on the Second Aspect of Scientific Inquiry

2. Aspect of Scientific Inquiry	Informed	Mixed	Naive
There is no single set and sequence of steps followed in all investigations	Scientific research can have more than one method. If we go through the same research, the observation method was used in this study. Instead, it can also use the test method by intervening. There are two different methods here, both scientific. (PST _{TURKEY} 55)	It can be done in many ways, for example, a researcher can prove the boiling point of water with one experiment, while another researcher can prove it with another experiment. (PST _{TURKEY} 5)	All scientists follow the same path. Identifying the problem, setting up hypotheses, designing the experiment, determining the variables, etc. (PST _{TURKEY} 6).
	There are different methods. For example, the first one is the experiment. Hypotheses simply follow the experimental processes and prove their hypothesis. It creates hypothesis with deductive method, tests it by experiment and supports its hypothesis. Another method is survey. By collecting many data and classifying (books, bibliography etc.), analysis is made and the literature is collected. Unlike the experiment, after editing the data, there is evidence to fit the hypothesis. The two methods are different, but the purpose of the two is to link the cause and effect in each study. Both can be considered scientific method. (PST _{TAIWAN} 10)	Yes. There are various methods for testing surface tension, for example. You try it with experiment or.. (PST _{TAIWAN} 76)	It should be the only method because science can be analyzed by the logical method and it has general stages. (PST _{TAIWAN} 4)

*PST- Preservice Science Teacher

The b and c of the first question in the second dimension of the VASI scale and the preservice science teachers' views about the method and steps of scientific inquiry were tried to be determined. One of the most common beliefs about science is the idea that there is only one standard method in scientific research. When the findings regarding this dimension were examined, most of the preservice science teacher in Taiwan (66.2%) had a scientific view and

were able to justify their answers with various examples. But, unfortunately, more than half of the science teachers in Turkey (59.1%) is determined to have a "naive" view towards this aspect. These preservice science teachers emphasized that scientists should follow a single way to reach scientific information, otherwise their studies will not have a scientific quality. Based on the findings of this study, it is possible to say that the preservice science teachers in Turkey have an important misconception about this aspect.

3. Aspect: *Inquiry procedures are guided by the question asked*

In Turkey and in Taiwan, some examples of preservice science teachers' responses to the third aspect of scientific inquiry are presented in Table 3.

Table 3.
Examples of Preservice Science Teachers' Responses Representing their Informed, Mixed and Naive Views on the Third Aspect of Scientific Inquiry

3. Aspect of Scientific Inquiry	Informed	Mixed	Naive
Inquiry procedures are guided by the question asked	Team A is better, because it is necessary to keep something under control. The effect of other factors on what we keep constant is being investigated. There may also be two tires or more. So team A is more accurate because it tries multiple brand tires. (PST _{TURKEY} 4)	Those who try a brand in different ways have done the proper experiment, tried three tires, but I'm not sure.... I think this is more accurate because the other group is a controlled experiment that has tried different brands. (PST _{TURKEY} 5)	I think it would be better to try a tire in three different ways, because we can understand why. But if we try different tires with different processes, it would not be more convincing. (PST _{TURKEY} 3)
	Team A is trying different brand tires in different ways. Team B is trying only one brand on the road. Since different brand tires are asked in the question, team B cannot answer the question of which brand tires are better. But team A can answer. (PST _{TAIWAN} 66)	Since the brand is asked, one time is not enough. He needs to try more than one. (PST _{TAIWAN} 11)	There is only one control variable. Thus, the link between the brand of the wheel and its easy explosion can be found. (PST _{TAIWAN} 10)

*PST- Preservice Science Teacher

Data for the this aspect of scientific inquiry, which is "The research process is guided by the questions", collected by the fifth question of VASI and the findings of the study stated that majority of the preservice science teachers in both countries Turkey (65.9%) and Taiwan (70%) have "informed" view. Based on this result, it can be said that science teacher candidates are

aware that the scientific research process varies depending on the research question. In the “informed” view responses to this question, expressions such as “different brands of tires should be tried in the experimental design because the possibility of explosion of different brand tires is asked” is frequently encountered.

4. Aspect: *All scientists performing the same procedures may not get the same results.*

In Turkey and in Taiwan, some examples of preservice science teachers' responses to the fourth aspect of scientific inquiry are presented in Table 4.

Table 4.

Examples of Preservice Science Teachers’ Responses Representing their Informed, Mixed and Naive Views on the Fourth Aspect of Scientific Inquiry

4.Aspect of Scientific Inquiry	Informed	Mixed	Naive
All scientists performing the same procedures may not get the same results.	I think there will be a difference. Because we are all different, we think differently. Even if we look at the same thing, we will find different things. (PST _{TURKEY} 3)	The same question, the same way. they may have different results or they may have the same result! But it is better that they achieve the same result, their scientificity increases. (PST _{TURKEY} 15)	They all come to the same conclusion. Because asking the same questions and doing the same process means doing the same scientific research. If we consider the situation of getting different results, maybe there will be error situations. I think they come to the same conclusions of all kinds. (PST _{TURKEY} 2)
	They may not reach the same conclusion. Everyone thinks differently. Even if we look at the same thing, we create different thoughts, findings, explanations. Even with the same data, different researchers can draw different conclusions. Different interests and different infrastructures also affect this. (PST _{TAIWAN} 29)	They come to different conclusions because there are many different factors in the process. Researchers' thoughts are important. But it must be repeatable for its science. That is one. (PST _{TAIWAN} 38)	Science is universal, whoever does it, they reach the same method, the same question, the same result. (PST _{TAIWAN} 34)

*PST- Preservice Science Teacher

The findings of this aspect of scientific inquiry; that the scientific data alone does not mean anything, the importance of reaching the result by the interpretation of the scientific data by the scientist; stated that more than half of the preservice science teachers in both countries, Turkey

(52.2%) and Taiwan (56.8%), has been determined to have "informed" views. Besides, 37.5% of preservice science teachers in Turkey and 41.3% of preservice science teachers in Taiwan for this aspect of scientific inquiry, as quite a high percentage, have "naive" view. Generally, in the statements of prospective teachers with insufficient opinions, it is determined that science is universal and scientists will reach the same result even if they use different methods.

5. Aspect: *Inquiry procedures can influence the results*

In Turkey and in Taiwan, some examples of preservice science teachers' responses to the fifth aspect of scientific inquiry are presented in Table 5.

Table 5.

Examples of Preservice Science Teachers' Responses Representing their Informed, Mixed and Naive Views on the Fifth Aspect of Scientific Inquiry

5. Aspect of Scientific Inquiry	Informed	Mixed	Naive
Inquiry procedures can influence the results	They can come to the same conclusion, or to different conclusions. Here, the individual differences of scientists are important. For example, two different scientists who deal with a question with different methods can draw the same conclusion because of differences of thought, or they can reach different conclusions too. (PST _{TURKEY} 40)	If they ask the same questions and follow the same procedures, they will definitely come to the same conclusion. If they asks the same questions and follows different processes, they may reach the same conclusion, or may not reach the same conclusion too. There may be differences. (PST _{TURKEY} 26)	Scientists ask the same questions. Regardless of the way, the same result is obtained. (PST _{TURKEY} 61)
	... if the same data cannot reach the same result even if it is the same method, they can reach different results with more possibilities here. Because the processes followed are different. (PST _{TAIWAN} 29)for example, the same substance may come out of different chemical reactions, even if it is the same chemical reaction (for reasons such as degrees, pressure), different substances can come out. We cannot know this. (PST _{TAIWAN} 51) minor errors in the accuracy of the processes applied and the process they follow may affect the result. (PST _{TAIWAN} 60)

*PST- Preservice Science Teacher

According to findings for this aspect that the research process can affect result, many preservice science teachers in both countries in Turkey (54.5%) and in Taiwan (62.5%) have "informed" view. Based on this result, it is possible to say that preservice science teachers who have

“informed” view are aware that scientists who ask the same questions and follow different procedures can reach the same result or different result depending on the procedures performed. But the research findings shows that 31.8% of preservice science teachers in Turkey and 23.7% of preservice science teachers in Taiwan have "naive" view for this aspect of scientific inquiry. To this result, it is possible to say that these preservice science teachers have a lack of knowledge that the results of the research may differ depending on the difference of the research process.

6. Aspect: *Research conclusions must be consistent with the data collected*

In Turkey and in Taiwan, some examples of preservice science teachers' responses to the sixth aspect of scientific inquiry are presented in Table 6.

Table 6.

Examples of Preservice Science Teachers’ Responses Representing their Informed, Mixed and Naive Views on the Sixth Aspect of Scientific Inquiry

6.Aspect of Scientific Inquiry	Informed	Mixed	Naive
Research conclusions must be consistent with the data collected	With growth, the light is inversely proportional. The table says this. This plant may not be a light-loving plant. (PST _{TURKEY} 30)	B is more accurate. When there is light, plants grow. There must be an inverse proportion. (PST _{TURKEY} 17)	A is true. Light and plant growth are directly proportional because plants do photosynthesis, that is, they need light. (PST _{TURKEY} 87)
	B choice is correct. I made a direct inference. The numbers in the table are inversely proportional to each other. Although there may be another factor, we only have this data at the moment. (PST _{TAIWAN} 63)	A and C cannot be. No inverse proportion. But wrong. (PST _{TAIWAN} 76)	In this experiment, no other effective factor was designed for plant growth. Therefore, it can be determined that such a result has occurred due to the reaction of the plant only against sunlight. (PST _{TAIWAN} 9)

*PST- Preservice Science Teacher

When examined the findings of this aspect that each research result should be supported by evidence from the data collected, the majority of preservice science teachers in both countries, in Turkey (79.5%) and in Taiwan(72.5%), have "informed" view. Based on this result, it can be said that most of the science teacher candidates who have scientific views towards this dimension are successful in reading data and have the knowledge that the results of the research depend on the data collected. In addition, 15.9% of preservice science teachers in Turkey and 18.7%of preservice science teachers in Taiwan were found to be missing in reading data; and it was determined that there was a lack of knowledge of these preservice science teachers that

the results of any research depend on the data collected. These preservice science teachers ignored the data given in the question and selected the "plants grow longer in much light" option based on their knowledge.

7. Aspect: *Scientific data are not the same as scientific evidence*

In Turkey and in Taiwan, some examples of preservice science teachers' responses to the seventh aspect of scientific inquiry are presented in Table 7.

Table 7.
Examples of Preservice Science Teachers' Responses Representing their Informed, Mixed and Naive Views on the Seventh Aspect of Scientific Inquiry

7.Aspect of Scientific Inquiry	Informed	Mixed	Naive
Scientific data are not the same as scientific evidence	Data is the information collected, and evidence is the implications presented depending on this situation. (PST _{TURKEY} 30)	Data and evidence are not the same. Data are the values we obtain, and evidence is the result of the data. (PST _{TURKEY} 6)	Data and evidence are the same. Data is the result of an experiment, and evidence is to prove that experiment. (PST _{TURKEY} 13)
	Data is the information collected, it is meaningless by itself. If the data fits the question after collection and analysis, it is used as evidence and makes sense. (PST _{TAIWAN} 27)	It is not exactly the same. There is a difference between data and evidence. One of them just has the result. The other is evidence that can support the hypothesis after it is organized and classified. The data (numbers) do not represent evidence, but the evidence comes from the data (number). (PST _{TAIWAN} 10)	The data is also included in the evidence. The data may be correct; it may also be wrong. But the evidence has already been proven in general. (PST _{TAIWAN} 8)

*PST- Preservice Science Teacher

The findings for this aspect of scientific inquiry that the data and evidence serve different purposes in the scientific research showed that the 39.7% of preservice science teachers in Turkey examining and 26.2% of preservice science teachers in Taiwan have "informed" view. These preservice science teachers could identified the difference between data and evidence, and they stated that “The data is research-related information collected in the research. The proof is the researcher's explanation by supporting this data with various sources”. On the other

hand, findings of the research showed that nearly half of the preservice science teachers in Turkey (42%) and over half of preservice science teachers in Taiwan (58.7%) had "naive" view for this aspect. Because of this result it is possible to say that these preservice science teachers could not differentiate the evidence and the data.

8. Aspect: Explanations are developed from a combination of collected data and what is already known

In Turkey and in Taiwan, some examples of preservice science teachers' responses to the eighth aspect of scientific inquiry are presented in Table 8.

Table 8.

Examples of Preservice Science Teachers' Responses Representing their Informed, Mixed and Naive Views on the Eighth Aspect of Scientific Inquiry

8.Aspect of Scientific Inquiry	Informed	Mixed	Naive
Explanations are developed from a combination of collected data and what is already known	I think they may have set off from their anatomy. From the anatomy of present-day creatures over extinct creatures that lived in past ages. The hind limb bones are thicker. Since the center of gravity is probably on the back and for walking ... They may have thought that the second is the best possibility. Scientists use the results of previous studies when explaining scientific results. They need to base scientific knowledge on the source to explain its results. It is necessary to explain with evidence. They use this kind of information by publicizing the results of the experiment. (PST _{TURKEY} 5)	Support is needed to stand up. The hind legs in the second picture are smaller. They look at creatures and compare. They use information. (PST _{TURKEY} 22)	His hind legs should be stronger because his balance is on him. If he is weak, he cannot benefit from many things. The second reason is that we can think in terms of moving faster. It can catch its prey better. As I said, there may be a nutritional structure, movement. Where the weight is more or less. While scientists are explaining their results, they set out by examining the environment. (PST _{TURKEY} 6)
	Scientists thought that dinosaurs were moving with two legs. The second reason would be difficult to walk with small feet, so there should be big feet on	In order to be able to walk physiologically, it must be this way. They looked at the previous fossils. They ask other researchers. (PST _{TAIWAN} 9)	So hard. Need more information. For example, physiology, front legs, hind legs and muscle. (PST _{TAIWAN} 73)

the back so that he can carry the body. Scientists may have studied and compared different types here. For example, they might have looked at the monkeys, saw the strong feet on the back and thought about it. While scientists explain their results on this issue, they ask other researchers and check their studies.
(PST_{TAIWAN} 44)

*PST- Preservice Science Teacher

According to findings for this aspect of scientific inquiry that the results of the researches are created by research data and interpretation of the available information, 40.9% of preservice science teachers in Turkey and 53.7% of preservice science teachers in Taiwan have "informed" view. It shows that preservice teachers who have this view are aware that the explanations made in scientific research are formed by comparing and combining the data collected in the study with the results of previous studies. But in addition, of the 30.7% of preservice science teachers in Turkey and 31.2% of preservice science teachers in Taiwan was determined to have "naive" view. The frequency values of preservice science teachers' answers regarding the aspect of VASI are presented in Table 9.

Table 9.
Frequency Values of Preservice Science Teachers' Views on the Dimensions of Scientific Research According to Country Variable

	f	<i>Informed</i>		<i>Mixed</i>		<i>Naive</i>	
		PST in Turkey	PST in Taiwan	PST in Turkey	PST in Taiwan	PST in Turkey	PST in Taiwan
Research Question	25	32	3	8	60	40	
Scientific Method	32	53	4	7	52	20	
Research Process	61	56	3	4	24	20	
Social Effect on Science	50	44	5	7	33	29	
Process-Result Relationship in Research	48	50	12	11	28	19	
Research Result	70	58	4	7	14	15	
Data-Evidence Difference	37	21	16	12	35	47	

Scientific Explanation	f	36	43	25	12	27	25
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*PST- Preservice Science Teacher

The findings of the research, more than half of preservice science teachers in Turkey at the four aspects of scientific inquiry, and more than half of preservice science teachers in Taiwan at the six aspects of scientific inquiry shows that they have "informed" view. In addition, findings showed that in five aspects of scientific inquiry, preservice science teachers in Taiwan have more "informed" view than preservice science teachers in Turkey. The chi-square test was conducted to compare the views of preservice science teachers in the two countries regarding the aspect of scientific inquiry and the results are presented in Table 10.

Table 10.

Chi-Square Test Results of Preservice Science Teachers for VASI

Aspects of Scientific Inquiry	χ^2	p
Research Question	6.76	0.03*
Scientific Method	19.89	0.00*
Research Process	3.26	0.19
Social Effect on Science	1.12	0.56
Process-Result Relationship in Research	1.43	0.48
Research Result	1.60	0.44
Data-Evidence Difference	4.89	0.08
Scientific Explanation	4.89	0.08

*(χ^2 , $p < 0.05$)

When Table 10 is examined, it has been shown that there is a significant difference in the answers given by preservice science teachers to the first and second dimensions of scientific inquiry, according to the country variable. These differences for both of aspects of scientific inquiry is positive in terms of preservice science teachers in Taiwan [$\chi^2(1) = 6.76$, $p = 0.03$; $\chi^2(1) = 19.89$, $p = 0.00$]. It was determined that there was no significant difference in the answers given by the preservice science teachers for the other six aspects of scientific inquiry, according to the country variable.

Discussion and Conclusion

This study has been planned to analyze views of preservice science teachers on scientific inquiry in Turkey and Taiwan and to make comparisons for finding out the differences. According to the conclusions of the analysis, it is found that there are some differences between the views of preservice science teachers on scientific inquiry in both countries. The conclusions of the study can be summarized as following:

One of the most significant conclusions of this study is that most preservice science teachers in Turkey and Taiwan have “inadequate” views about scientific inquiries always starting with a problem and not necessarily having to test a hypothesis. The research findings obtained from both countries indicate that most of the preservice science teachers state that scientific inquiries can start out of curiosity or by chance and do not always need to start with a problem. In addition, it is found that many of the preservice science teachers cannot distinguish scientific questions from daily ones. Therefore, as the answers of the preservice science teachers in both countries are not satisfying, science teacher education programs in both countries can be considered to have deficiencies. Similar results have also been obtained from the researches about teachers and preservice science teachers conducted by Karaman and Apaydın (2014), Şenler (2015), Bologna Soares de Andrade and Cola Levoratob (2017), Leblebicioğlu et al. (2017), Aydemir, Uğraş, Cambay and Kılıç (2017). These studies show that teachers and preservice science teachers have inadequate information about that scientific inquiries have to start with scientific questions. As the questions of scientific inquiries determine purpose of the research, data collection method, analysis and evaluation methods (Lewis, 2014; NRC, 2000), the conclusion actually indicates that preservice science teachers know scientific research only as a concept, but do not deeply comprehend the meaning.

There is not only one scientific method and science does not fully depend on experiments. McComas (2000) states that doing experiment is the most useful method in science but it is not the only one. Therefore, it will be incorrect and misleading to call physical science as “experimental science”. Physical sciences contribute hugely to science by means of theoretical thinking methods and theoretical structures. The conclusion of the study indicates that although preservice science teachers in Taiwan has a better level of knowledge about probability of various methods in scientific inquiry, preservice science teachers in Turkey have a lack of knowledge on this issue. Furthermore, many preservice science teachers participated in the

study in Turkey cannot discriminate between experiment and observation. The preservice science teachers have been noticed to usually consider that science will not be possible without experiment and experiment must certainly be conducted to prove accuracy of information. It has also been determined that these preservice science teachers have a false opinion about observation is not being adequately scientific. One of the reasons of this false opinion is that experimental approach is often explained as “scientific method” in textbooks and implementation classes as stated by Schwartz, Lederman and Lederman (2008) and thus, students have adopted the concept of “experiment” as scientific method. Similar conclusions have also been emphasized in other studies. (Palmquist & Finley, 1997; Doğan, 2010; Abd-El-Khalick & BouJaude, 1997; Dickinson, Abd-El-Khalick & Lederman, 2000; Abd-el-Khalick & Akerson, 2004; Aslan, Yalçın & Taşar, 2009; Arı, 2010; Doğan, 2010; Karaman & Apaydın, 2014; Dursun, 2015; Öztürk, 2015; Bayır 2015; Ogochukwu, 2016; Yenice & Atmaca 2017; Adisendjaja, Rustaman, Redjeki & Satori 2017). Another reason is that experimental researches are given as examples of scientific inquiry and taught in lessons and experimental studies are mostly conducted while the students learn steps of a scientific inquiry. In implementation classes, preservice science teachers have opportunity to experience practically that scientific observations are conducted in a way that an observer watches natural phenomena carefully without any intervention, which leads the phenomena to be comprehended as scientifically reliable. The other conclusion of the study is that research process is conducted with questions.

The research question asked in a scientific inquiry is the most important element for defining the methods and techniques to be applied. The way of asking questions may even cause to change the research method. In this respect, teachers and students should be aware of the importance of relation between question and research. In analysis of this study, it is inferred that a great majority of preservice science teachers both in Turkey (65.9%) and Taiwan (70%) has a “scientific” view about research question is directing research process. As based on this inference, we can conclude that most of preservice science teachers in both countries are aware of the fact that scientific inquiry process can change according to the research question. As emphasized in studies of Karışan, Şenler and Bilican (2017) who have received similar findings, lessons given to preservice science teachers are effective in helping them have a scientific view of the fact that scientific inquiry is guided by questions.

As scientists work in a social, cultural, historical and political environment, science is a social activity and is influenced by values. Personal attitudes, values, opinions, thoughts, judgement,

creativity and imagination of the scientists play a quite important role in their doing science. More than half of the preservice science teachers in Turkey (56.8%) and Taiwan (55%) have “informed” view about that the scientists who follow the same method in a scientific inquiry can reach different results. As similar to the conclusions of this study, Liang, Chen, Chen and Kaya conducted a study with Turkish, Chinese and American preservice teachers in 2006 and found that although these preservice teachers are from different countries, they have the scientific view of the fact that the scientists may reach different results even if they use the same methods. On the other hand, it is indicated in analysis of results of many researches (Çelikdemir, 2006; Arı, 2010; Bayır, 2016) that teachers and preservice teachers are not knowledgeable enough about explaining social and cultural factors in formation of scientific inquiry. For instance, unlike the findings of this study, Aydemir, Uğraş, Cambay and Kılıç (2017) have observed that preservice teachers have a false notion about that scientists who research the same questions must not reach different conclusions for reliability of the research. In the research conducted by Çavuş (2010), he has also found that preservice teachers think science is objective and scientists reach scientific information in the light of data and perceptible information and without including their subjective opinion.

In scientific inquiry, data is not the only distinctive factor of the research question. Interpretation of data and reaching different results indicate creative aspect of science (Osborne, Collins, Ratcliffe, Millar and Duschl, 2003). The scientists, who ask similar questions, follow similar methods and even use the same data, can reach different but acceptable results because the scientists can comprehend the same data diversely and focus mainly on one part of the data (Schwartz, Lederman & Lederman, 2008). The preservice teachers, who state that scientists work in a social community and are aware of this feature, are able to educate students who are open-minded about different ideas and can make original researches. According to conclusions of the research in this respect, more than half of preservice science teachers in Turkey (54.5%) and Taiwan (62.5%) have “informed” view. However, it is seen that more preservice science teachers have “informed” level-view in Taiwan when compared to the numbers in Turkey. The reason for the difference can be that implementation classes in the curriculum of science teacher education are more than the ones in Turkey within the context of number and duration.

The conclusion of the research based on that scientific inquiry results must be consistent with the collected data and be supported by evidences obtained by the collected data indicates that the majority of preservice science teachers in Turkey (79.5%) and Taiwan (72.5%) have

“informed” view. This conclusion of the research has similarity with the study conducted by Karışan, Bilican and Şenler (2017). It may have helped the preservice science teachers contribute to having informed level view as they have opportunity especially to compare the results of their own studies, which they have carried out during practices in laboratory classes, with the collected data and thanks to experiences they gain about science. However, 40.9% of preservice science teachers in Turkey and 53.7% of preservice science teachers in Taiwan have the informed view about the fact that the results of scientific inquiries are formed by interpretation of research data and current knowledge. In fact, the percentages in both countries are not very satisfying and it may be resulted from inefficient concentration of preservice science teachers on the process while they explain the results they obtain in laboratory practices, their inefficient questioning about cause and effect relation.

Another conclusion of the research indicates that most of preservice science teachers in Turkey (%42) and Taiwan (58.7%) cannot discriminate between data and evidence. In addition, a great majority of preservice science teachers (65%-75%) stated that data and evidence are different but it has been observed that they cannot define the concepts properly or have misconception. As based on the conclusion found in many researches ((Abd-El-Khalick; 2005; Tuncel, 2012; Karaman & Apaydın, 2014; Öztürk, 2015; Aydemir, Uğraş, Cambay & Kılıç, 2017), it is likely to underline that curriculums of science teacher education should mostly be based on case study or discussion and there should be more activities to identify the relation between data and evidence.

As all the conclusions are evaluated in general, it can be inferred that preservice science teachers in Taiwan have more informed view than those in Turkey among five of eight aspects of the scientific research. These preservice science teachers are more willing to use information, which they get in the lessons on scientific inquiry, and to take education approach they have adopted (Haefner & Zembal-Saul 2004, Kim & Chin 2011), which results from the difference between curriculums of science teacher education in Turkey and Taiwan and the classes in both program do not have the same effects.

It is obvious if teachers do not know about the concepts and views, they will not be able to convey them to their students. That preservice teachers have an adequate view on scientific inquiry plays a major role in development of professional experience in future (Gess-Newsome, 2002; Lederman, 1998, 2007). The conclusions of the research indicate that faculties of

education are incapable of having preservice teachers to adopt these views on scientific inquiry and cannot meet preservice science teachers' needs in this field. Therefore, it is a need to restructure teacher education system and to form a new theoretical frame in training of teachers for science education. Nevertheless, preservice science teachers' opinions on scientific inquiry should initially be identified for this new restructure and the foundation needs to be laid by considering these conclusions.

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