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http://web.deu.edu.tr/baed
Dokuz Eylül Üniversitesi Eğitim Bilimleri Enstitüsü

ISSN 1308 – 8971

Cilt: 06, Sayı: 11, 2015, 1 – 36

PRE-SERVICE SCIENCE TEACHERS' PEDAGOGICAL ORIENTATIONS OF SCIENCE INQUIRY CONTINUUM

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Abstract

The purpose of this study is to determine the pedagogical orientation of a group of Turkish pre-service teachers towards inquiry. The participants in the study were 587 pre-service science teachers enrolled in five state universities in Turkey. The researcher developed a Pedagogy of Science Inquiry Continuum Test (PoSICT). The PoSICT consists of six items designated as the six inquiry characteristics of problem/question, procedures/design, results analysis, conclusions, alternative conclusions, results communication. Each item of the test requires choosing one out of four choices that correspond to changing levels of inquiry, starting from confirmation inquiry and ending with open inquiry. The results of the research showed that the pre-service teachers' orientations were at the structured inquiry level. Even though this orientation of the pre-service teachers did not correspond to a lower level of inquiry such as the confirmation level, the study found that the characteristics that would require the student to think independently were given to the student by the teacher. The reasons the pre-service teachers gave for choosing their inquiry levels were students' prior knowledge, the student's role and the teacher's role. These results indicate that when it is considered that the pre-service teachers were more oriented in a teacher-centered pedagogy; changes must be made in their inquiry experience.

Keywords: science inquiry, inquiry teaching, levels of inquiry, pre service science teacher.

INTRODUCTION

Inquiry is emphasized in the teaching of science concepts in order to facilitate students' understanding of science and provide them with the ability to think scientifically when trying to explain the events they encounter in their everyday lives. Although the definition of inquiry has been substantially established in the National Science Education Standards (NRC 2000), it is reported that teachers have inaccurate beliefs about inquiry and inquiry-based instruction (Tatar, 2012). While teachers believe they are implementing inquiry-based strategies, they are actually making use of a prescription-like inquiry model that is based on well-constructed step-by-step teaching (McLaughlin & MacFadden, 2014). Teachers understand the concept of inquiry as a way of discovering something and it can be seen that the concept of inquiry in schools involves an emphasis on having the teacher is in control, with pre-prepared instructions being given to the student (Morrison, 2013). Considered from the point of view of pre-service teachers, it has been found that prospective teachers do not possess an integrated understanding of inquiry and define it more as collecting evidence and providing explanations (Kang, Orgill & Crippen, 2008).

Domain general tools such as observation protocols (Morrison, 2013; Bodzin & Beerer, 2003; Marshall, Horton, & White, 2009; Sawada, Piburn, Falconer, Turley, Benford & Bloom, 2002) or survey instruments (Kang, Orgill & Crippen, 2008; Marshall, Horton, Igo & Switzer, 2009) have been used to understand teachers' beliefs and knowledge about inquiry. The results of these studies have provided teachers with a general understanding of inquiry but have failed to integrate teachers' beliefs or knowledge into specific content. Observational studies have various limitations in that they are generally restricted to almost one-time-only observations in a limited number of class hours, they do not include enough participating teachers to enable a generalization, and because content is not included when ascertaining the quality of the instruction (Marshall & Horton, 2009; Marshall, Horton, Igo & Switzer, 2009; Leonard, Barnes-Johnson, Dantley & Kimber, 2011). At the same time, there are few examples in the literature about inquiry-based science teaching that takes into consideration teachers' knowledge of content. For instance, Cobern et al. (2014) developed the "Pedagogy of Science Teaching Tests" to measure teachers' science teaching orientations. The assessment includes

16 vignettes that represent the use of inquiry-related methods in a science class. Direct didactic, direct active, guided inquiry, and open discovery are the teaching approaches which are reflected by the items' four-answer choices (Lakin & Wallace, 2015). It is only when the content of the test is associated with the content of the science program that the test becomes operable for the researcher. For instance, the curriculum appropriateness of the items for the South African curriculum was established by a panel of three science education researchers (Ramnarain & Schuster, 2014). The appropriateness of existing instruments for pre-service teachers should be explored since these instruments are usually used to determine the quality of the on-the-job applications that teachers employ. There is thus a need to study the subject of how the courses pre-service teachers take during their teacher training affect their pedagogical approach (Biggers & Forbes, 2012). This will make it possible to inquire as to the degree to which pre-service teachers appreciate the value of the inquiry opportunities offered to them and how much they make use of these as strategies in the classroom (Melville, Bartley & Fazio, 2013). The purpose of this study is to determine the pedagogical orientation towards inquiry of a group of pre-service teachers in Turkey. The research question addressed in the study is, "What are the pedagogies of science inquiry of pre-service science teachers?"

THEORETICAL FRAMEWORK

In keeping students engaged with scientific inquiry in science education, the goal is to make learning concepts in science meaningful and permanent, teach students to adopt the scientific method by using their inquiry skills and develop positive attitudes toward inquiry. For this reason, for almost the past half-century, the main emphasis of curriculum reforms has been to focus on student-centered inquiry-based learning (American Association for the Advancement of Science, 1990; National Research Council [NRC], 1996). Scientific inquiry took its place in the Turkish science curriculum comprehensively in 2004 and later on in 2013, when small revisions were made. In this context, the Turkish Ministry of National Education (TMNE, 2013) defines "inquiry" as "a form of learning in which students feel the need to explore everything around them, form strong arguments to provide sound explanations for events in the natural and physical world, and become individuals who feel the excitement of learning and appreciate the value of science." At the same time, it is reported that inquiry is treated in different ways in classrooms and a single definition of the concept is not possible (Haug & Ødegaard, 2014). Referring to Anderson's (2007) compilation of three versions of inquiry--namely scientific inquiry, inquiry learning and inquiry teaching--is useful in understanding what inquiry is, how it is learned and how it is taught. NRC (1996:33) describes the first of these versions, scientific inquiry, as "students formulate questions and devise ways to answer them, they collect data and decide how to represent it, they organize data to generate knowledge, and they test the reliability of the knowledge they have generated." In this case then, when students are engaged with the inquiry process, they think and act like scientists, using the scientific method to understand science concepts. Inquiry learning refers to the student's experiencing the content of the subject as an active learner and having the student take on the responsibility and authority to determine the subject to be inquired into and interpreted (Gijlers & de Jong, 2005, Salter & Atkins, 2013). According to Minner, Levy and Century's (2010) synthesis of research conducted from 1984-2002, there is a clear and positive trend to consider the student an active learner and to teach on the basis of conclusions gathered from data.

Teaching scientific inquiry signifies finding appropriate ways to engage a student with an inquiry activity and instruction in scientific thinking (Flick & Lederman, 2006). When considered as a pedagogical tool, scientific inquiry can be used to teach science content and have students experience that content for themselves (Jianga & McComas, 2015). To answer the question of at what level this inquiry can be implemented, Schwab (1962), Herron (1971) and Shulman & Tamir (1973) offer a "level of openness of inquiry teaching" framework. According to this framework, as the level of responsibility given to the student increases, the openness of the inquiry also increases. In other words, while the teacher handles everything at the lowest zero level, as the level of openness increases, students begin to take on more control of the inquiry (Jianga & McComas, 2015). In a more detailed review, according to Bell, Smetana and Binns (2005), zero level inquiry is a type of confirmation inquiry because the problem, procedure, method and result are given to the student. The student confirms a principle by performing an experiment to produce previously known results. In the next level of openness, structured inquiry, the student is given clear instructions about how to conduct an experiment that is based on a previously determined problem (Bunterm et al., 2014). In Level 3, guided inquiry, the student is asked to inquire into a teacher-presented problem and design and then to collect data, analyze it and reach a conclusion (Sadeh & Zion, 2012). At the level of open inquiry, the student defines all of the stages of the experiment, in other words, the problem, the procedures and design, the analysis, the communication and the conclusions (Buck, Bretz & Towns, 2008).

The role of the teacher is important in planning, implementing and evaluating the inquiry. While pre-service teachers learn about the different characteristics of inquiry in their training, when they enter a classroom, they may have to cope with having to question themselves on how adequate their knowledge and skills are with respect to inquiry teaching. In this case, the pre-service teacher needs to adjust the inquiry teaching scheme to the classroom and the students and decide on what changes can be made in the scheme to ensure effective teaching. Or, if it is thought that the conditions in the scheme are inadequate, a lower level of inquiry will have to be pursued. For example, the results of the study by Biggers & Forbes (2012) showed that pre-service teachers defined inquiry as student-centered at the beginning of the semester but that after working with inquiry-based teaching, started to make plans for more teacher-centered instruction and implementation due to the difficulties they encountered. It can be seen then that in the face of the difficulties pre-service teachers experience in the classroom, instead of revising their inquiry schemes, the pre service teachers will tend toward a more teacher-centered pedagogy. Because of this, the pedagogical orientation of pre-service teachers with respect to inquiry should be determined and according to their orientation, either their inquiry schemes should be enriched or they should participate in learning environments where they will see the inadequacy of their schemes. Since this study strove to determine the pedagogical orientation of pre-service teachers, its aim is to try to determine what they were able to contribute to their experiences with inquiry and also how instrumental the courses they took were in this respect.

METHOD

In order to explore the relationships among pre-service science teachers' understandings of inquiry, a survey was conducted among pre-service science teachers in Turkey.

Participants

The study was conducted with 587 pre-service science teachers. The participants were enrolled in five state universities in Turkey. These universities were selected as a convenience sample. There were 469 male and 118 female students. Five students did not indicate their gender. Included in the 587 students surveyed were 139 first-year students, 159 second-year students, 145 third-year students, and 144 fourth-year students. All the students were fourth-year undergraduate students seeking a bachelor's degree in elementary education. At all of the universities, the students are required to complete courses in field knowledge, field teaching, general culture and professional knowledge. The content of these courses and credits offered have been set down by the Council of Higher Education. While in the first and second years of their program, the pre-service teachers take a more concentrated load of courses offering knowledge in their field, teaching courses make up most of the content of the third and fourth years. Courses on gathering experience in school are given in the last year of the program. Out of all of the courses, it is the third year courses, "Science Teaching Laboratory Applications", "Scientific Inquiry Methods", "The Nature of Science and the History of Science" that explore science, scientific method skills, history of science, scientific epistemology and ontology.

Instruments

Pedagogy of Science Inquiry Continuum Test (PoSICT): The PoSICT was developed by the researcher for pre-service science teachers. The objective of the test is to determine at what level of inquiry the pre-service teachers think of applying inquiry. In developing PoSICT, an adaptation was made of the plan developed by Smolleck, Zembal-Saul and Yoder (2006) as the "Teaching Science as Inquiry" instrument.

Item Preparation for PoSICT: For the item preparation, the researcher utilized a continuum for essential features of classroom inquiry and their variations as described in the NRC (2000) and Science Teacher Inquiry Rubric (Bodzin & Beerer, 2003). In addition, a correlation was made between the characteristics of inquiry defined by Buck, Bretz and Towns (2008) and the essential features of classroom inquiry to find out which characteristic of inquiry each feature represented. The content learned in the science program was taken into consideration as the questions were being prepared. Among the topics recommended by the TMNE (2013) for the science program are "Living Beings and Life," "Matter and Change," "Physical Phenomena," and "The World and the Universe." All of the topics in the program were included in the test since pre-service teachers in Turkey receive teachers education in the topics in the Science program in their field courses as well as in their field teaching courses. The middle school science program is implemented in Turkey as from the fifth grade onwards, ending in the eighth grade. Because of this, topics from the fifth to the eighth grades were included in the test.

A general look at the structure of the test reveals that the pre-service teacher had to answer the multiple-test items in Table 1 related to the various topics and units. The inspiration for the items derived from the Pedagogy of Science Teaching Test (POSST) that had been developed by Cobern et al. (2014). The pre-service teacher was first asked questions about the features of classroom inquiry (problem/question, procedures/design, results analysis, conclusions, and alternative conclusions results). There were 4 choices for each question. These choices were prepared in the light of Bodzin & Beerer's (2003) inquiry continuum. At this point, the hierarchies presented by the different researchers were reviewed to determine the level of inquiry of the choices. According to these hierarchies, inquiry levels changed according to the level of the features of classroom inquiry presented to the student. However, in this study, each feature was not determined according to the level at which it was presented to the student and instead, the inquiry level of the choice for the question was altered from a teacher-centered orientation to a student-centered hierarchy. In other words,

Table 1. Item numbers, essential features of inquiry and inquiry characteristics for PoSICT

Essential Features of classroom inquiry	Item Number	Inquiry Characteristics	Class Level	Topic
• Learners are engaged by scientifically oriented questions.	1	Problem/Question	Seventh	Matter and Change
• Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.	2-3	Procedures/Design Results analysis	Fifth Sixth	The World and the Universe Physical Phenomena
• Learners formulate explanations from evidence to address scientifically oriented questions.	4	Conclusions	Eighth	Matter and Change
• Learners evaluate their explanations in the light of alternative explanations, particularly those reflecting scientific understanding	5	Alternative Conclusions	Fifth	Physical Phenomena
• Learners communicate and justify their proposed explanations.	6	Results communication	Seventh	Living Beings and Life

each subsequent choice represented a different inquiry level. The inquiry level hierarchies were inspired by Bodzin & Beerer (2003) while content was developed based on the works by Fay, Grove, Towns & Bretz (2007), Buck, Bretz & Towns (2008), Staer, Goodrum & Hackling, (1988). After the choices were made, the pre-service teachers were asked to explain in writing why they selected this particular choice. This was done so that the pre-service teachers could provide responses related to their chosen preferences.

Content Validity for PoSICT: After the pilot test was completed, both the inquiry continuum rubric prepared for the test and the test itself were sent to specialist faculty members at four different universities. The specialists were asked to review the rubric and the test, come to a consensus and make their recommendations. The specialists' feedback revealed grammatical errors and 17 inconsistencies between the rubric and the test items. The researcher took the faculty members' feedback into consideration and made changes in the test, sending the final version to the specialists once again. Since the specialists did not advise any new revisions, the pilot test was given its final form.

Implementation of the pilot test: The pilot test was administered to pre-service teachers at the researcher's university enrolled in a different program and who had taken two semesters of the science-teaching course. A total of 133 students replied to the test. In measuring the reliability of the scale, Cronbach α reliability coefficient was calculated as .66. Furthermore, the t test performed to determine the significance of the difference between the item scores of the upper 27% and lower 27% groups, ascertained according to the total scores received by the pre-service teachers, revealed that the differences were significant for all the items. This indicated that all of the items on the scale were distinctive. The test comprises a total of 6 items. Scores received on the test are a minimum of 6, a maximum of 24 points. The test takes approximately a half-hour to complete. PoSICT is presented in Appendix-1.

Data Analysis

Data analysis was performed in two parts. Descriptive statistics were used for PoSICT. An arithmetic mean is found when each item response is scored on the test. Firstly, each choice from level 1 to level 4 was scored as 1, 2, 3 and 4 respectively. Then it was determined which level the pre-service teacher marked for each question. Accordingly, an arithmetic mean and the standard deviation were found for each item and for the test as a whole. In addition, the pre-service teachers' pedagogical orientations were determined according to the means found for each item and for the entire test. To find out which orientation corresponded to which inquiry level, the interval width of each level was calculated. The lowest score on an item is 1; the highest is 4, meaning a range of 3. When the range is divided by the interval figure 4, the interval width for each item is 0.75. Thus, the score interval for each level is as shown in Table 2.

Table 2. Inquiry level score intervals for PoSICT

Interval Width	**Inquiry Level**
1.00 < x <1.74	Level 0: Confirmation
1.75 < x < 2.49	Level ½: Structured inquiry
2.50 < x < 3.24	Level: Guided inquiry
3.25 < x < 4.00	Level 4: Open inquiry

Furthermore, after each item, the pre-services teachers were asked to explain why they marked that particular choice. The outline of Cohen, Manion and Morrison (2007) was used in the analysis and presentation of the explanations. First, the explanations were reviewed by the researcher and explanations that were similar were grouped under a single set of reasons. Then the frequencies of these groups were calculated and the percentages were marked in a table. Reasons that consisted of only one word or were incomprehensible or were difficult for the researcher to group were eliminated from the analysis. Because of these, the number of respondents and percentages varied for each item. The reasons were not individually treated at each inquiry level but the pre-service teachers marking the confirmation or structured inquiry levels were marked as Teacher Centered (TC) and those that marked the guided and open inquiry levels were labeled as Student Centered (SC). In the presentation of the analysis, each item was considered in terms of which inquiry level corresponded to its pedagogical orientation and at the first, the explanations given by the pre-service teachers were provided at this level. Later, the other explanations were presented and the different reasons were compared with each other or presented as a correlation.

RESULTS

In this section, an analysis is provided about the orientation of each inquiry characteristic following a general review of the pre-service teachers' general orientations according to PoSICT. The reasons for the pre-service teachers' choices have also been presented.

Overall findings about pre-service science teachers' pedagogical orientations of inquiry

Table 3 shows the results of the descriptive analysis performed for the pre-service teachers' characteristics and the overall PoSICT. In general, the pedagogies of the pre-service science teachers displayed a mean of 2.48, showing that their orientations were at the structured inquiry level.

Table 3. Descriptive analysis according to each characteristic and the overall PoSICT

	Inquiry Level (%)				**Mean**	**Standard Deviation**
Inquiry Characteristic	Level 0 Confirmation	Level ½ Structured inquiry	Level 1 Guided inquiry	Level 2 Open inquiry		
Problem/Question	33	46	12	10	2.00	.91
Procedures/Design	21	41	15	23	2.41	1.05
Results analysis	11	20	47	22	2.81	.90
Conclusions	12	28	47	14	2.63	.86
Alternative Concl.	18	19	11	51	2.96	1.19
Results comm.	41	27	8	23	2.13	1.18
Overall					2.48	.55

It was found that the pre-service teachers' orientations according to their inquiry characteristics were on a level of between structured inquiry and open inquiry (Table 4). Outside of results communications, it was found that the pre-service teachers' pedagogical orientations changed from being teacher-centered to student-centered. While the pre-service teachers tended to display an orientation toward considering teacher's preferences or prompts in their inquiry planning, the analysis of the data showed that the students tended to be active in their conclusion characteristics. What was interesting was that although the expectation was that the pre-service teachers would be student-centered in communicating their conclusions, they tended to defer to the teacher's decision about the content and form of their presentations.

Table 4. Pre-service teachers' pedagogical orientations of inquiry according to inquiry characteristics

	Inquiry Level (%)			
Inquiry Characteristic	Level 0 Confirmation	Level ½ Structured inquiry	Level 1 Guided inquiry	Level 2 Open inquiry
Problem/Question		✓		
Procedures/Design		✓		
Results analysis			✓	
Conclusions			✓	
Alternative Concl.				✓
Results comm.		✓		

Pre-service Science Teachers' Pedagogical Orientations of Inquiry Characteristics

Problem/Question Characteristic

The pre-service teachers were at the structured inquiry level according to their problem/question characteristic scores. The pre-service teachers expected to have students make a choice from a teacher-offered list instead of directly posing the problem or question to be studied. This displayed an orientation for inquiry using teacher-offered problems; in other words, at the point where students were to determine the problems to be explored, instead of having students devise their own problem, the pre-service teachers thought that students would have a better learning experience if they started the investigation knowing the problem in advance. The pre-service teachers' reasons are shown in Table 5.

According to the reasons set forth by both the Teacher-Centered (TC) and the Student-Centered (SC) teachers, before starting the experiment, the teacher should complete the deficiencies in the student's pre-knowledge since these will be a barrier to the student's continuing with the exploration of the subject. On the other hand, a lower percentage of the SC teachers said that if the student was given the opportunity to determine the problem on his/her own, this would facilitate determining the student's pre-knowledge and preparedness. The TC teachers stressed that the clues provided by the teacher helped to

Table 5. Pre-service science teachers' reasons regarding the problem/question characteristics.

Themes	**Sample response**	**TTC PST (%)**	SC PST (%)**)**
Completing pre-knowledge	Since students do not have any knowledge of this subject beforehand, they will be better able to understand what to do with the problem and the sample together.	9.8	2.7
Determining pre-knowledge	Being able to determine what their pre-knowledge or estimates are about the subject.	-	1.2
Shared problem	It would seem as if I were giving the students a clue since they would then understand what they have to learn; this way, their research capacities will develop.	16.3	-
Student role	I make the introduction to the topic and then leave the rest to the student. The student researches the subject, defines and determines it independently.		20.5
Real life connection	For knowledge to be retained, it is important that an association is made with daily life.	4.7	35.3
Hands-on learning	I want my students to learn by performing and experiencing. I'm their guide; I help them through guidance.	1.2	1.2

emphasize the problem shared with the teacher in the planning stage. But none of the SC teachers spoke of this kind of sharing. At the same time, the SC teachers explained that it was not the teacher who needed to find what should be explored but the students themselves and that it was only in this way that the student could take an active part in the class. In the TC group, there was only one pre-service teacher who explained this in this way. When the other explanations were reviewed, it was found that more TC teachers rather than SC teachers believed that the examples from daily life would interest the students and that this would make the problem more comprehensible. The pre-service teachers asserted that providing a ready-made problem or having the student determine it would cause the student to take more interest in the class and the student would pay more attention to the lesson. Furthermore, because the experiment would be carried out after the planning, the student would learn by doing and experiencing.

Procedures/Design Characteristic

It was seen that the pre-service teachers assumed a teacher-centered orientation for the procedure/design characteristic. In other words, students are unable to design an experiment independently of the teacher. The pre-service teachers first perform the experiment and demonstrate it to the students and then expect the student to execute it. Under the circumstances, the teacher both plans the exploration and also performs the implementation but thanks to the question and answer technique, the teacher is able to have the student participate in the inquiry process. Table 6 shows the reasons the pre-service teachers offered regarding this characteristic.

Table 6. The pre-service science teachers' reasons regarding the procedures/design characteristic

Themes	**Sample response**	TC PST (%)	SC PST (%)
Teacher's Role			
Teacher-provided Procedures/ Design	Setting up the experiment and following a path on the basis of the answers to the questions ensures the students' participation in the class and by demonstrating by performing and experiencing, this also facilitates the students' understanding and retention of the subject matter.	23.8	-
Teacher-encouraged Procedures/ Design	The opportunity for better understanding is presented because the teacher directs the students into exploring the subject without explaining it first.	-	7.1
Visualizing the subject	I would set up the experiment so that the students would learn by observing.	13.5	-
Student's role	Because the students designed and implemented the experiment themselves. In other words, when the lesson is taught from a student-centered orientation, the subject matter learning is retained longer.	-	27.6
Hands-on learning	Among the applications, the experiment is one of the methods that is the most instructive and the most likely to remain in the memory. The best choice is for the teacher to perform the experiment at this point.	12.9	4.2
Drawing interest to the lesson	The important thing is to draw the student's attention. Because of this, I ask them for their original thoughts and help them until they get it right.	3.3	2.9

TC and SC teachers have different views about the teacher's role. TC teachers prefer to have the teacher present the procedure and the experiment's design to the students. At the same time, the pre-service teachers do not want the students to be completely passive and rather take care to draw the students into the experiment by asking them questions. SC teachers however believe that instead of explaining the topic directly, the teacher should encourage students to design their own experiments. According to the TC teacher reasons for preferring visualization, students should perform experiments so that they can fully visualize the topic first-hand. On the other hand, the SC teachers did not refer to any contribution made by visualization; instead emphasizing that student should use their own ideas and assume an active role in their participation in the learning process. Another reason set forth by both the TC and SC teachers was the notion of learning through doing, although the preference of the TC teachers was that the teacher should perform the experiments while the SC teachers said that the students should perform them. This alters the answer to the question of who is learning by doing and experiencing the experiment. Again, both groups believed that having the experiment performed would increase the interest of the student in the subject.

Results Analysis Characteristic

A student-centered orientation was seen in terms of the results analysis characteristic. The pre-service teachers believe that rather than planning the experiment, students should take on a more active role in the collection of data and its analysis. In this, the student collects the data independently during the investigation and then performs the data analysis. The teacher however may explain the needed skills in part in advance, not specifically for the particular subject but as general skills. The reasons set forth by the pre-service teachers for the results characteristic are given in Table 7.

According to the reasons shown by both the SC and TC teachers, the student's playing an active role is important; in other words, the student will learn more by performing the experiment him/herself, and learning will be enhanced because the student will be learning through experience. The reasons set forth by the pre service teachers indicate that they perceived the teacher's role in different ways. It was seen that the reason given that the

Table 7. The pre-service science teachers' reasons regarding the results analysis characteristic

Themes	**Sample response**	**TC PST (%)**	**SC PST (%)**
Student's role	Because what the students learn by experimenting on their own will be more permanent in their minds.	1.1	28.3
Hands-on learning	Because I think the topic will be better understood by learning through experience	.3	21.1
Teacher's Role			
Performance through Demonstration	Because the subject is a challenging one for students, the teacher should first perform a demonstration. This method may be consistent with the technique of execution following a demonstration. Later, the students should carry out activities about the subject in groups.		
Teacher-provided results	There can't be an activity in every class session; the seriousness of the class would be disrupted. I would have explained this subject to the students through discussion and brainstorming with them, learning their ideas.	5.4	2.9
Skill-learning	This way they will achieve both a quantitative and a qualitative observation.	5.4	1.7
Drawing interest in the course	Because this will seem like a game to the children, their participation will increase and they will be more interested and better understand.	.3	1.7

teacher should explain the data collection and data analysis first represented the highest percentage of reasons given by the SC teachers. Inasmuch as the pre-service teachers stated that the student's role should be active, the message sent to the student was "perform an experiment that looks like the teachers' and is within certain limits." Similarly, according to the TC teachers, the teacher should use the available data set to perform the data analysis him/herself since the student's level of knowledge may not be appropriate or because performing guided or open inquiry is more time-consuming. Besides these reasons, both the TC and the SC teachers believed that as the student collects and analyzes the data, manual skills will be developed in terms of creating tables, graphs and taking quantitative measurements. Drawing attention to the lessons is a reason that was set forth by both groups.

Conclusions Characteristic

The students reached their own conclusions at the end of the study; in other words, instead of verifying the previously ascertained result, the students thought over the prompts given to them by the teacher and were able to add more meaning to the data. Since both the SC and the TC teachers are able to analyze the data and reach their own conclusions, they play active roles. The SC teachers, however, emphasized the importance of the ideas they came up with themselves while the TC teachers stressed that students should produce ideas by answering the questions that the teacher asks. The pre-service teachers believe that their students' skills in interpretation and reaching a conclusion will improve, but the percentage of SC teachers emphasizing learning these skills was higher compared to the TC teachers. According to the pre-service teachers, in reaching conclusions, students can assess what they have learned by comparing the aim of the experiment with the knowledge actually gained from the experiment. This is because when the student is deciding upon the accuracy of the collected data, the entire process of the experiment is reviewed. The student can thus determine the errors made in the experiment; decide on how much he/she has learned from it, thus checking to see whether something has been learned. This reason was emphasized more by SC teachers compared to the TC teachers. According to the SC teachers, having the student perform the experiment independently allows access to knowledge as the student learns both through experience and by using cognitive skills. On the other hand, the TC teachers stressed that the student must determine the inquiry process according to the boundaries delineated by the teacher. In other words, instead of having the student make an interpretation and use critical thinking skills to reach a conclusion on his/her own, the student should consider the result provided by the teacher and use classification and comparison skills to answer the questions asked by the teacher in order to reach a conclusion. Also, the TC teachers said that if students knew the results of the experiment beforehand, they would make no mistakes and would be better able to associate theoretical knowledge with the results of the experiment. This indicates that the teacher candidates perceive the aim of the experiment to be a verification of the theoretical knowledge provided by the teacher (Table 8).

Table 8. Pre-service science teachers' reasons regarding the conclusions characteristic

Themes	Sample response	TC PST (%)	SC PST (%)
Student's role	I think the most important part of this experiment is the stage at which the data is reviewed and conclusions are reached. Because what you understand from an experiment and what it will teach you in the long-run have to do with how well you accomplish this stage. That's why it's logical to expect students to go through this stage by themselves. The teacher may however support the student with questions.	3.4	45.3
Skill-learning	To have the students apply their scientific method skills (making observations, formulation hypotheses)	2.8	8.1
Self-assessment	Because when students interpret their data results after performing the experiment, this shows that they understood the topic and were able to reach a conclusion on their own.	1.6	7.2
Hands-on learning	Learning by experiencing is more reinforcing.	.3	6.8
Directing the learner	I would want the students to reach a conclusion by themselves under my direction	15.0	-
Confirmation	After the data collection stage, the teacher should reveal the correct conclusion.	5.9	-
Student's role	I think the most important part of this experiment is the stage at which the data is reviewed and conclusions are reached. Because what you understand from an experiment and what it will teach you in the long-run have to do with how well you accomplish this stage. That's why it's logical to expect students to go through this stage by themselves. The teacher may however support the student with questions.	3.4	45.3

Alternative Conclusions Characteristic

While the student assesses the conclusions derived from the experiment, he/she reviews the sources suggested by the teacher so as to be aware of alternative explanations. In other words, an experiment does not signify a conclusion; to the contrary, an experiment may result in more than one conclusion. The pre-service teachers, however, believe that the teacher's role is to provide the student with resources so that differences between conclusions can be made more meaningful.

In the reasons indicated by the SC teachers, emphasis is given to having the student make his/her own assessment (Table 9). The student is thus able to compare the different results

Table 9. Pre-service science teachers' reasons regarding the alternative conclusions Characteristic

Themes	**Sample response**	**TC PST (%)**	**SC PST (%)**
Self-assessment	I chose this statement because students will form their thoughts not only with their own experiments but also on the basis of experiments performed in other groups and students need to be aware of the various differences.	-	33.8
Communication	Students work in committees, reach different conclusions and share these conclusions with each other. By sharing, they become aware of wrong and right answers. In other words, sometimes students can be more effective than teachers; carrying out an activity may remain in the student's mind for a longer time.	.3	6.9
Student's role	The students should become aware of the differences by themselves at the end of the experiment; they should then question the differences and find a solution	-	28.6
Directing the learner	It is already impossible for students to reach conclusions about a subject they know nothing about; that's why I explain it to them at first and give them homework on it so that what I explain to them is reinforced	26.9	-

and notice the mistakes he/she has made. The student will then explore further to understand the reason for the mistakes and achieve a learning experience in this way. In addition, the SC- teachers believe that all of these cognitive processes, the opportunity students have to share their ideas with their friends and to present and discuss them will result in improved communication skills. This again makes it necessary for the student to assume an active role in learning. The TC teachers, on the other hand, did not speak of any of these factors. As a matter of fact, according to the TC teachers, students have no other choice but to submit to the direction of their teachers since they are not capable of interpreting the results of the different experiments. Because of this, the teacher must first bring forth alternative explanations; in other words, decide on behalf of the student what it is that must be learned. This means that in order to reach definitive knowledge, students listen to the teacher's explanations and to the teacher's interpretation of what the differences are in the data, instead of becoming aware of these on their own. Thus, for the student to understand the reasons for mistakes, instead of exploring, the teacher's explanations are considered and the student is unable to make his/her own assessment.

Results Communication Characteristic

According to the pre-service teachers, while the students communicate the results obtained, it is the teacher who must decide on the content and method of the presentation. Instead of explaining the processes step by step, however, the teacher tells the student which topics should be included in the presentation and how it can be made more effective. In this case, the students remain within the boundaries drawn by the teacher instead of exploring and presenting the topics at his/her own initiative.

According to the reasons given by the pre-service teachers, as the student uses communication skills, the teacher's role changes (Table 10). The TC teachers believe that if the teacher decides on the content of the presentation and how it is to be carried out, the student will not have researched erroneous or deficient knowledge. Also, a higher percentage of TC teachers compared to SC teachers assert that having students work with visual materials will make learning more permanent. When these two reasons are considered together, the idea emerges that the teacher should first make a presentation on the topic and then supports this with visual materials to facilitate understanding. In this case, the teacher is the provider of the content and the student is in the role of follower. At the same time, both TC and SC teachers state that students play an active role in learning. The difference is that the two groups of pre service teachers assign different responsibilities and cognitive tasks to the students. According to the SC teachers, because the students will choose differing methods of presentation, they will discuss the different methods among themselves and gain different knowledge. Thus, their communication skills will improve and through their discussions, an exchange of knowledge will have been achieved among the students.

DISCUSSION

In this study, pre-service science teachers' pedagogical orientations of science inquiry were examined through PoSICT. The study took as its theoretical foundation the essential features

Table 10. The pre-service science teachers' reasons regarding the results communication Characteristic

Themes	**Sample response**	**TC PST (%)**	**SC PST (%)**
Teacher's Role			
Teacher-guided communication	When teachers tell students how to prepare to receive the knowledge, they are preparing them for more effective learning in getting ready for the lesson.	27.3	.3
Teacher-provided communication	The students will be more easily able to understand the subject when I classify it and support it with videos, images and other materials.	26.5	2.1
Student's role	When they make their own decisions and put these to practice, their interest in the lesson not only increases but their desire to learn the subject is also enhanced.	9.8	20.4
Communication	...they share the information with their friends in the classroom after doing research in the relevant resources. In the others, the teacher may be more active than the student.	.3	10.7

of inquiry determined by NSES (2000). PoSICT contributes to the literature because it measures the pedagogical orientations of pre-service teachers from the perspective of content knowledge. At the same time, the results of the research may be an indicator of the level of guidance that is provided to pre-service teachers in their engagement with research According to the results of the study, the pedagogical orientation of the pre-service teachers is at the structured inquiry level. As they move from the problem/question characteristic to the results communication characteristic, however, the inquiry level of the pre-service teachers never reaches the open inquiry level. While the pre-service teachers exhibit a teacher-centered orientation in the problem/question, procedures/design and results communication characteristics, they are student-centered in their orientation in the results analysis, conclusions and alternative conclusions characteristics. In other words, inquiry starts and ends at the initiative of the teacher. Even though this orientation of the pre-service teachers does not correspond to a lower level of inquiry such as the confirmation level, the study found that the characteristics that would require the student to think for him/herself were followed up by the teacher. This may be related to the past experiences with inquiry of the pre-service teachers themselves. The fact that the pre-service teachers did not have the knowledge and skills to put inquiry into practice in the classroom may be the reason behind this teacher-centered orientation (Mugaloglu & Saribas, 2010). For example, the teacher candidates it should be used candidates may have had the learning experience of being expected to repeat an experiment after the instructor demonstrated it only once (Dickson & Kadbey, 2014). The laboratory experience that the candidates had had ever since elementary school may have led to their harboring mistaken ideas about inquiry (Tatar, 2012). If it is considered that many studies report that the experiments included in textbooks are only at the structured inquiry level, it becomes easier to understand why the pre-service teachers' orientation is at the structured inquiry level (Cheung, 2011; Yıldız-Feyzioğlu & Tatar, 2012). This is why pre-service teachers may have the tendency to apply the inquiry level to which they have been accustomed in their own experience.

The study also determined the pre-service teachers' pedagogical orientation with respect to each inquiry characteristic. The problem/question and procedure/design characteristics that emphasize the pre-service teachers' research planning indicated a teacher-centered orientation. In other words, the pre-service teachers' orientation was largely to have the students choose from among the choices given to them by the teacher in determining the aim of the investigation. In this orientation with respect to the problem/question characteristic, the pre-service teachers believe that the pre-knowledge of the student is not enough for him/her to plan the research. Because of this, instead of leaving the responsibility of handling the problem-determination characteristics up to the student, they prefer to share this responsibility. At the same time, only the SC- teachers believe that the student will play an active role in determining the problem and stress that this will permit them to make an association with real life. This leaves one to wonder about the actual level of skills the pre-service teachers have with respect to the problem characteristic. Other studies have shown that teachers are inadequate in terms of engaging in scientifically oriented questions

(Leonard, Barnes-Johnson, Dantley & Kimber, 2011; Kang, Orgill & Crippen, 2008). The pre-service teachers make the association between variables but have difficulty in formulating a comprehensible problem (Graves & Rutherford, 2012; Windschitl, 2004; Arslan, 2014). Also, it has also been reported that pre-service teachers do not help students in making use of their own ideas to formulate and test hypotheses and design experiments (Yoo, Joung & Kim, 2012). A similar situation is also true in the context of conducting experiments. TC teachers, based on their teacher-provided procedure/design justification, believe that the teacher should be one step ahead of the student. Again according to the TC teachers' reasoning, having students learn by observation is one step ahead of learning by thinking. Under the circumstances, instead of leaping over the difficulty that might be encountered during the research planning, the pre-service teachers adopt a teacher-centered orientation and prefer to remain on the easier level of inquiry (Roehrig & Luft, 2004). The pre-service teachers should however want to direct students into open inquiry, eventually abandoning the idea that only the teacher's recommended research questions can be used in investigation, allowing students to set forth new ideas and define their own research problems as well as design their own procedures and applications (Wilcox & Kruse, 2012; Cheung, 2007).

According to the pre-service teachers, the student should collect the data in the light of the clues provided by the teacher and carry out the analysis independently. When the instruction demonstrates how data are to be collected and allows the student to carry out the experiment independently, this brings the student into the role of becoming the observer first and then an implementer. As far as the results analysis characteristic is concerned, while the pre-service teachers spoke of the student's taking on an active role, they also said that the teacher's demonstrating from the start had a more positive effect on the student's learning process. Accordingly, it may be said that the pre-service teachers pedagogical orientation to inquiry did conform to their reasoning; their reasons were based on teacher-centered grounds. For example, while the pre-service teachers talked about how the manual skills of the students would improve, they did not stress that the student needed to go through an in-depth thinking process about the concept to be learned. Although the student should be playing an active role, it is yet the teacher who is the focus and the person that fulfills this characteristic is actually the teacher. In this case, to the extent that they are not student-driven, hands-on activities provided to the student are not inquiry-based (Rankin, 2000). ~~Whereas~~ Rather than having the student conduct the investigation only as much as the instructor allows, allowing the student to perceive the instructor as a "guide" or "facilitator," asking the instructor's help only when needed, may be a better approach (Saunders-Stewart, Gyles, Shore & Bracewell, 2015). At the same time, the student at this level plays a more active role than at the confirmation level, where the student follows the procedures independently step by step after watching the teacher perform the same steps.

According to the pre-service teachers, the students reached their own conclusions at the end of the investigation; in other words, instead of verifying the previously ascertained result, students think through the data, making it more meaningful, guided by the prompts provided to them by the teacher. Since students are active in reaching a conclusion independently, they can decide for themselves how much they have learned and in this way check their own learning process. This result is consistent with the observation that the pre-service teachers are strongest in the characteristic of inquiry-based practices in which learners formulate conclusions and/or explanations based on evidence to address scientifically oriented questions (Leonard, Barnes-Johnson, Dantley & Kimber, 2011). In their reasons, the pre-service teachers stated that the student was playing an active role, developing skills, practicing self-assessment and learning by experiencing. At the same time, the reasons of the TC pre-service teachers revealed their belief that students should be guided with prompts to draw the correct conclusion or to verify the theoretical knowledge that the teacher had provided to them. According to the pre-service teachers, when students are given specific steps to follow, they will not experience confusion about the results of the task and may even experience increased self-confidence (Mumba, Mejia, Chabalengula & Mbewe, 2010). According to Tsai (2003), however, when experimentation procedures are used at this level continuously, students may perceive that the aim of the experiment is only to verify scientific principles. Therefore, to achieve learning and retention, it is recommended that students carry out experiments that are complex enough so that they can use their high order cognitive skills but easy enough to give them the feeling of accomplishment (Colburn, 2000).

The pre-service teachers believed in this context that while students assess the conclusions derived from the experiment, they review the sources suggested by the teacher and become aware of alternative explanations. In this case, it may be said that the pre-service teachers are far away from accepting the approach of transmitting a simplistic message of inquiry to the student where results that are not consistent with scientific knowledge are considered (Schwartz et. al., 2002). The tendency of the pre-service teachers towards this relatively more complex level requiring more effort allows students to improve their thinking skills (Chinn & Hmelo-Silver, 2002). The reasons given by the pre-service teachers for this were that the student can engage in self-assessment, develop communication skills and play an active role in the learning process. However, the pre-service teachers' reasons to the effect that the instructor needed to explain the alternative conclusions to the students indicates that they were not interested in creating an awareness in students about drawing alternative conclusions. In other words, the teacher presents the student with alternative explanations and does not allow the student to become aware of the alternative explanations provided by others.

According to the pre-service teachers, while the students communicate the results obtained, it is the teacher who must decide on the content and method of the presentation. While the pre-service teachers explained the importance of presentation in terms of the effect of visual input on learning, they also indicated that the student played an active role in the learning process. At the same time, while the student is making the presentation, communication skills will also record progress. The TC pre-service teachers, however, pointed to the teacher's role as being the direct or indirect decision-maker as regards the content or method of presentation. These pre-service teachers believe that the student cannot decide upon which knowledge is to be presented. In other words, the deficiencies in the student's presentation create anxiety in the teacher that there will also be deficiencies in the learning of the topic. In this case, the teacher is still the determiner of learning and content while at the same time using visual aids to make the presentation more comprehensible. Other studies too have reported that teachers' skills in communicating explanations during inquiry teaching are inadequate (Kang, Orgill & Crippen, 2008; Chabalengula & Mumba, 2012). This is because, according to the teachers, the students have trouble with work that requires written expression (Mumba, Banda, Chabalengula & Dolenc, 2015) and so the teacher must carry out these processes on the students' behalf.

RECOMMENDATIONS

This study, which examined the specific orientation of pre-service teachers with regard to inquiry in general and each inquiry characteristic, offers, albeit indirectly, information about their inquiry experience. Although the emphasis of the program of the TMNE is on research and inquiry courses are included in the program content, it can be seen that the pedagogical orientation of pre-service teachers are not in line with either the program's research focus or with the content of the courses. The pre-service teachers instead display more of a teacher-centered inquiry pedagogical orientation, which shows that their inquiry experience must be enhanced. Although the pre-service teachers emphasize that the student has an active role in learning, must learn through experiencing and developing skills, it is also important that teacher candidates understand that the student must become more mentally active as well. Under the circumstances, the pre-service teachers' experience with inquiry should offer them the opportunity to be active in the characteristics of inquiry, rather than make them work with ready-made problems, procedures and results.

The pre-service teachers' inquiry pedagogies may be associated with their self-efficacy perceptions in the context of teaching science. For example, if a pre-service teacher's inquiry pedagogy is at the confirmation level, how is that teacher's self-efficacy regarding teaching science? In other words, when pre-service teachers at their present inquiry level orientation are confronted with a problem, could their orientation have anything to do with their perception of their own self-efficacy? These questions need to be answered through new research. Despite the fact that the test developed by the researcher measures the pre-service teacher's inquiry pedagogy, the level of the teacher's inquiry pedagogy in the classroom is still unknown. Because of this, it may be useful to observe the candidate's inquiry practices in instances that the test is being implemented. In this way, the correlations between the statements made for each characteristic and the actual orientation displayed may be revealed. At the same time, it can be determined whether or there is any change in the pre-service teachers' inquiry pedagogies as they move up from one class to the next. This approach will make it possible to get a notion about whether inquiry courses make a contribution to their experience with inquiry.

The test used in the research was prepared based on the NRC inquiry characteristics. The researcher drew up a test item, a total of six, for each characteristic. These characteristics may be re-examined to devise a greater number of questions for each. The scope of the six-item test may thus be broadened.

REFERENCES

American Association for the Advancement of Science. (1990). The liberal art of science: agenda for action: Washington, DC.

Anderson, R. D. (2007). Inquiry as an organizing theme for science curricula. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 807-830). London: Routledge.

Arslan, A. (2014). Transition between open and guided inquiry instruction. *Procedia - Social and Behavioral Sciences*, 141, 407-412.

Bell, R. L., Smetana, L., & Binns, I. (2005). Simplifying inquiry instruction: assessing the inquiry level of classroom activities. *The Science Teacher*, 72(7). 30-33.

Biggers, M. & Forbes, C. T. (2012). Balancing teacher and student roles in elementary classrooms: Preservice elementary teachers' ideas about the inquiry continuum. *International Journal of Science Education*, 34(14), 2205-2229.

Bodzin, A. M. & Beerer, K. M. (2003). Promoting inquiry based science instruction: The validation of the Science Teacher Inquiry Rubric (STIR). Journal of Elementary Science Education, 15 (2), 39-49.

Buck, L. B., Bretz, S. L., & Towns, M. H. (2008). Characterizing the level of inquiry in the undergraduate laboratory. *Journal of College Science Teaching*, 38(1), 52-58.

Bunterm, T., Lee, K., Ng Lan Kong, J., Srikoon, S., Vangpoomyai, P., Rattanavongsa, J., & Rachahoon, G. (2014). Do different levels of inquiry lead to different learning outcomes? A comparison between guided and structured inquiry. *International Journal of Science Education*, 36(12), 1937-1959.

Chabalengula, V. M. & Mumba, F. (2012). Inquiry-based science education: A scenario on zambia's high school science curriculum. *Science Education International*, 23(4), 307-327.

Cheung, D. (2007). Facilitating chemistry teachers to implement inquiry-based laboratory work. *International Journal of Science and Mathematics Education*, 6(1), 107-130.

Cheung, D. (2011). Teacher beliefs about implementing guided-inquiry laboratory experiments for secondary school chemistry. *Journal of Chemical Education*, 88, 1462-1468.

Chinn, C. A. & Hmelo-Silver, C. E. (2002). Authentic inquiry: introduction to the special section. *Science Education*, 86, 171-174.

Cobern, W. W., Schuster, D., Adams, B., Skjold, B. A., Mugaloglu, E. Z., Bentz, A., & Sparks, K. (2014). Pedagogy of science teaching test: Formative assessments of science teaching orientations. *International Journal of Science Education*, 36 (13), 2265-2288.

Cohen, L., Manion, L., & Morrison K. (2000). *Research methods in education* (5th Edition). London: Routledge Falmer.

Colburn, A. (2000). An Inquiry Primer. *Science Scope*, 23(6), 42-44.

Dickson, M. & Kadbey, H. (2014). 'That's not the way I was taught science at school!' How pre-service primary teachers in Abu Dhabi, United Arab Emirates are affected by their own schooling experiences. *Science Education International*, 24(3), 332-350.

Flick, L. B. & Lederman, N. G. (2006). Introduction. In L.B. Flick & N.G. Lederman (Eds.), *Scientific inquiry and nature of science* (pp. ix-xviii). Dordrecht: Springer.

Gijlers, H. & De Jong, T. (2005). The relation between prior knowledge and students' collaborative discovery learning processes. *Journal of Research in Science Teaching*, 42, 264-282.

Graves, C. & Rutherford, S. (2012). Writing a scientific research ("testable") question: the first step in using online data sets for guided inquiry assignments. *Journal of College Science Teaching*, 41(4), 46-51.

Haug, B. & Ødegaard, M. (2014). From words to concepts: Focusing on word knowledge when teaching for conceptual understanding within an inquiry-based science setting. *Research in Science Education*, 44(5), 777-800.

Herron, M. D. 1971. The nature of scientific inquiry. *School Review*, 79(2), 171-212.

Jiang, F. & McComas W. F. (2015). The effects of inquiry teaching on student science achievement and attitudes: evidence from propensity score analysis of PISA data. *International Journal of Science Education*, 37(3), 554-576.

Kang, N.-H., Orgill, M., & Crippen, K. J. (2008). Understanding teachers' conceptions of classroom inquiry with a teaching scenario survey instrument. *Journal of Science Teacher Education*, 19(4), 337-354.

Lakin, J. & Wallace, C. S. (2015). Assessing teachers' use of inquiry methods in the middle school science classroom. *Journal of Science Teacher Education*, 26(2), 139-162.

Leonard, J., Barnes-Johnson, J., Dantley, S. J., & Kimber, C. T. (2011). Teaching science inquiry in urban contexts: The role of elementary preservice teachers' beliefs. *The Urban Review*, 43(1), 124-150.

Marshall, J. C. & Horton, R. M. (2009). *Developing, assessing, and sustaining inquiry-based instruction: A guide for math and science teachers and leaders*. Germany: VDM Verlag.

Marshall, J. C., Horton, R., Igo, B. L., & Switzer, D. M. (2009). K–12 science and mathematics teachers' beliefs about and use of inquiry in the classroom. *International Journal of Science and Mathematics Education*, 7, 575-596.

Marshall, J., Horton, R. & White, C. (2009). EQUIPping teachers: A protocol to guide and improve inquiry-based instruction. *The Science Teacher*, 76 (4), 46-53.

McLaughlin, C. A. & MacFadden, B. J. (2014). At the elbows of scientists: shaping science teachers' conceptions and enactment of inquiry-based instruction. *Research in Science Education*, 44,927-947.

Melville, W., Fazio, X. & Bartley, A. (2012). Scaffolding the inquiry continuum and the constitution of identity. *International Journal of Science and Mathematics Education*, 11: 1255-1273.

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction-what is it and does it matter? Results from a research synthesis years 1984-2002. *Journal of Research in Science Teaching*, 47(4), 474-496.

Morrison, J. A. (2013). Exploring exemplary elementary teachers' conceptions and implementation of inquiry science. *Journal of Science Teacher Education*, 24, 573-588.

Mugaloglu, E. Z. & Sarıbaş, D. (2010). Pre-service science teachers' competence to design an inquiry based lab lesson. *Procedia - Social and Behavioral Sciences,* 2(2), 4255-4259.

Mumba, F., Banda, A., Chabalengula, V. M., & Dolenc, N. (2015). Chemistry teachers' perceived benefits and challenges of inquiry-based instruction in inclusive chemistry classrooms. *Science Education International*, 26(2), 180-194.

Mumba, F., Mejia, W. F., Chabalengula, V. M., & Mbewe, S. (2010). Resident scientists' instructional practice and their perceived benefits and difficulties of inquiry in schools. *Journal of Baltic Science Education*, 9(3), 187-195.

National Research Council. (1996). *National Science Education Standards*. National Academy Press. Washington D.C.

National Research Council. (2000). *Inquiry and the national science education standards*. Washington, DC: National Academy Press.

Ramnarain, U. & Schuster, D. (2014). The pedagogical orientations of South African physical sciences teachers toward inquiry or direct instructional approaches. *Research in Science Education*, 44, 627-650.

Rankin, L. (2000). *Lessons learned: Addressing common misconceptions about inquiry, in Foundations*, Vol. 2, Inquiry Thoughts, Views, and Strategies for the K-5 Classroom, Washington, DC: Division of Elementary, Secondary, and Informal Education Directorate for Education and Human Resources, National Science Foundation.

Roehrig, G. H. & Luft, J. A. (2004). Constraints experienced by beginning secondary science teachers in implementing scientific inquiry lessons. *International Journal of Science Education*, 23, 3-24.

Sadeh, I. & Zion, M. (2012). Which type of inquiry project do high school biology students prefer: open or guided?. *Research in Science Education*, 42, 831-848.

Salter, I. & Atkins, L. (2013). Student-generated scientific inquiry for elementary education undergraduates: course development, outcomes and implications. *Journal of Science Teacher Education*, 24, 157-177.

Saunders-Stewart, K. S., Gyles, P. D. T., Shore, B. M., & Bracewell, R. J. (2015). Student outcomes in inquiry: students' perspectives. *Learning Environment Research*, 18, 289-311.

Sawada, D., Piburn, M., Judson, E., Turley, J., Falconer, K., Benford, R., & Bloom, I. (2002). Measuring reform practices in science and mathematics classrooms: The reformed teaching observation protocol. *School Science and Mathematics*, 102(6), 245-253.

Schwab, J. (1962). The teaching of science as enquiry. In J.J. Schwab and P.F. Brandwein (Eds.), *The teaching of science* (pp. 1-103). Cambridge, MA: Harvard University.

Schwartz, R. S., Lederman, N. G., Khishfe, R., Lederman, J. S., Matthew, L., Liu, S. (2002). Explicit/reflective instructional attention to nature of science and scientific inquiry: Impact on student learning. Proceeding of the International Conference of the Association for the Education of Teachers in Science: Charlotte, NC.

Shulman, L. S. & Tamir, P. (1973). Research on teaching in the natural sciences. In R.M.V. Travers (Ed.), *Second handbook of research on teaching*. Chicago: Rand McNally.

Smolleck, L., Zembal-Saul, C., & Yoder, E. (2006). The development and validation of an instrument to measure preservice teachers' self-efficacy in regard to the teaching of science as inquiry. *Journal of Science Teacher Education*, 17(2), 137-163.

Staer, H., Goodrum, D., & Hackling, M. (1998). High school laboratory work in Western Australia: openness to inquiry. *Research in Science Education*, 28(2), 219- 228.

Tatar, N. (2012). Inquiry-based science laboratories: an analysis of pre-service teachers' beliefs about learning science through inquiry and their performances. *Journal of Baltic Science Education*, 11(3), 248-266.

Tsai, C. C. (2003). Taiwanese science students' and teachers' perceptions of the laboratory learning environments: Exploring epistemological gaps. *International Journal of Science Education*, 25(7), 847-860.

Turkish Ministry of National Education. (2013). İlköğretim kurumları (ilkokullar ve ortaokullar) fen bilimleri dersi (3, 4, 5, 6, 7 ve 8. sınıflar) öğretim programı. Ankara, Turkey.

Wilcox, J. & Kruse, J. (2012). Springing into Inquiry: Using student ideas to investigate seasons. *Science Scope*, 35(6), 26-31.

Windschitl, M. (2004). Folk theories of "inquiry:" How preservice teachers reproduce the discourse and practices of an atheoretical scientific method. *Journal of Research in Science Teaching*, 41, 481-512.

Yıldız-Feyzioğlu, E. ve Tatar, N. (2012). Fen ve teknoloji ders kitaplarındaki etkinliklerin bilimsel süreç becerilerine ve yapısal özelliklerine göre incelenmesi. *Eğitim ve Bilim Dergisi*, 37(164), 108-125.

Yoon, H-G., Joung, Y-J., & Kim, M. (2012). The challenges of science inquiry teaching for pre-service teachers in elementary classrooms: Difficulties on and under the scene. *Research in Science Education*, 42(3), 589-608.

APPENDIX-1: PEDAGOGY OF SCIENCE INQUIRY CONTINUUM TEST:

1. Factors Affecting Dissolving Rate (Problem/Question)
Teacher Ahmet is about to start on the subject of Factors Affecting the Dissolving Rate in the seventh grade unit of "Structure and Properties of Matter." If you were in Teacher Ahmet's place, in which of the following ways would you start the lesson knowing that he would like to have his students investigate this problem?

A. I would give them the problem they will be investigating. For instance, this problem might be, "Would a sugar cube dissolve faster in hot water or in cold water?"
B. I would offer the students different examples from daily life about the effect of heat on the rate of dissolving. I would want them to determine what they would like to investigate about the different factors affecting the rate of dissolving.
C. I would write down on the board a list of the factors that affect the rate of dissolving (a rise in temperature or an increase in the surface area in which the dissolving substance comes into contact with the dissolver). I would want the students to pick one of these problems to investigate.
D. I would ask the students what they would like to investigate about the factors affecting the rate of dissolving.

Why did you mark the above choice?

2. Protecting against the Effects of Erosion (Procedures/Design)
Teacher Ayşe has started on the fifth grade unit of "The Mystery of the Earth's Crust" on how to protect the earth from the adverse effects of erosion. With this in mind, if you were in Teacher Ayşe's place, which of the choices would you pick for an activity in class?

A. I would set up an experiment to show how the earth's covering of vegetation prevents erosion: I would put garden soil to fill up a one of two aluminum trays; in the other I would put an equal amount of soil that has grass growing on it. To place the trays on an incline, I would put wedges of equal size under them. Then I would ask the students what could be done after this. According to the answers I get, I would pour water of equal amounts from the same height into each one of the trays.
B. I would ask the students what the factors are that will have an effect on erosion. I would ask the students to tell me what kind of experiment they could carry out to test the factor each determined (e.g., the effect of vegetation on erosion). I would encourage them to test the variables they came up with.
C. I would set up an experiment to show how the earth's covering of vegetation prevents erosion: I would put garden soil to fill up a one of two aluminum trays; in the other I would put an equal amount of soil that has grass growing on it. To place the trays on an incline, I would put wedges of equal size under them. I would pour water of equal amounts from the same height into each one of the trays.

D. After writing the factors affecting erosion--characteristics of the soil and vegetation--I would choose one of these. I would ask the students to tell me what kind of experiment they could carry out to test the effect of vegetation on erosion. I would encourage them to test the variables they came up with.

Why did you mark the above choice?

3) Distance, time and speed (Results analysis)

Teacher Hatice is about to investigate the topic of the relationships between distance, time and speed with her sixth graders studying the unit on "Measuring the Size of Force." Which of the following choices do you think Teacher Hatice should pick at the data collection and analysis stage?

A. I would divide the students into groups and take them out to the schoolyard. I would ask the students to determine a straight line for themselves. I would ask them to find how much time it takes them to travel a certain distance, to record their data in a table, draw a distance-time graph and calculate their speed.

B. I would show my students just once how to measure distance and time while walking in a straight line. I would divide the students into groups and take them out to the schoolyard. I would ask them to find how much time it takes them to travel a certain distance, to record their data in a table, draw a distance-time graph and calculate their speed just like I did.

C. I would ask my students to look at the distance an athlete travels and how long it takes in the table shown below. I would ask them to draw a distance-time graph and calculate the speed.

Distance (m)	10	20	30	40	50
Time (s)	2	4	6	8	10

D. I would ask my students to look at the distance an athlete travels and how long it takes in the table shown below. I would ask them to draw a distance-time graph and calculate the speed.

Distance (m)	10	20	30	40	50
Time (s)	2	4	6	8	10

Why did you mark the above choice?

4. Heat Flow (Conclusions)

The eighth grade is looking for the answer to the question, "How does heat flow take place when two substances of different temperatures contact each other?" in the unit on "The States of Matter and Heat." An experiment is carried out for this purpose in the classroom and data are collected. Which of the choices below is close to what you would want to do after the data collection?

A. I would want the students to examine the data collected and express the conclusion they drew from the experiment.

B. I would explain to the students how, when two objects come into contact with each other, heat will flow from the hot one to the cold one and ask them if their data verifies this.

C. I would ask the students to decide which direction heat will flow by taking into consideration the initial and the last temperatures of the objects in contact. I would want them to express the conclusion they drew from the experiment.

D. I would tell the students the initial and the last temperatures of the objects in contact. I would ask them which object got hotter and which dropped in temperature. Then I would ask them to explain the direction of the heat flow.

Why did you mark the above choice?

5. Brightness of Lamps (Alternative Conclusions)

Teacher Burcu has come to the fifth-grade unit on "An Indispensable Part of our Lives: Electricity" which treats one of the factors changing the brightness of a lamp--the number of lamps connected to the circuit--and sees that some of the lamps in the same group are brighter than others whereas in other groups connected to the same circuit, some lamps light up but others do not. If you were in Teacher Burcu's place, which of the choices below would be the way you would assess this situation?

A. I would tell the class the different conclusions the different groups reached. I would explain the topic of resistance to the students so that they could clarify the results or I would give them different sources to look up the subject of resistance.

B. I would ask the other groups of students to review the conclusions of the experiment. I would ask the students to find the differences and similarities between their own conclusions and the others, to find the reasons behind the differences from various resources, and to present what they have learned to the class.

C. I would tell the class the different conclusions the different groups reached. I would first tell the students that they need to know the subject of resistance in order to explain the results and then I would explain this subject to them.

D. I would tell the class the different conclusions the different groups reached. I would make ready the resources the students could study in order to explain the results.

Why did you mark the above choice?

6. Vision Defects (Results communication)

Teacher Ercan has asked the question, "How do vision defects develop and how are they treated?" as part of the seventh grade "Systems of the Body" unit. Which choice of the ones below would you recommend to the teacher at the time when the results of the investigation are being presented?

A. The students can look into encyclopedias, the Internet, newspapers, magazines and other resources for information. When the results are being presented to the students, I would tell them that they will understand more if they make use of tables and images.

B. I would classify vision defects as myopia, hypermetropia, astigmatism, cataracts, and presbyopia. I would explain each vision defect with pictures, figures, videos and texts. I would draw sketches to explain how these defects can be corrected.

C. The students can look into encyclopedias, the Internet, newspapers, magazines and other resources for information about vision defects. I would make sure the students decide themselves about how they will present the information, share and discuss their ideas with their friends.

D. I would ask the students to classify vision defects as myopia, hypermetropia, astigmatism, cataracts and presbyopia and direct them to different resources for information such as encyclopedias, the Internet, newspapers and magazines. In presenting the results to the students, I would tell them that they can make use of tables and images.

Why did you mark the above choice?