TÜRK FEN EĞİTİMİ DERGİSİ
Yıl 12, Sayı 1, Mart 2015

Journal of
TURKISH SCIENCE EDUCATION
Volume 12, Issue 1 March 2015

http://www.tused.org

Effect of Inquiry-Based Science Activities on Prospective Elementary Teachers' Use of Science Process Skills and Inquiry Strategies

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Received: 21.03.2014 **Revised:** 22.01.2015 **Accepted:** 13.02.2015

The original language of article is English (v.12, n.1, March 2015, pp.43-56, doi: 10.12973/tused.10132a)

ABSTRACT

In this study, the effect of science activities designed by inquiry-based approach on prospective elementary teachers' utilization of science process skills and inquiry strategies is investigated. The study was conducted by a group of prospective elementary teacher (N=119) established by mean of purposed sampling. Data was gathered pre and post instructional practices of the instruments "science process skills and strategies (S&S)- scale" and "science process skills (SS)-test". The data were analyzed by procedures of dependent group t-test and Pearson correlation test which pointed an effect of inquiry -based activities on the prospective teachers` use of science process skills and inquiry strategies. The study concludes with recommendations for further investigations to signify and overcome the barriers challenging the prospective teachers' adaptations and practices of science process skills and inquiry strategies.

Keywords: Inquiry-Based Teaching; Inquiry Strategies; Prospective Elementary Teachers; Science Process Skills; Science Teacher Education.

INTRODUCTION

Students from all levels of education witness through observation the various natural events which make them wonder. Student explanations based on intuitions on nature events are often away from consistency and reliability (Liu, 1998). Also, science textbooks inheriting abstract and prefabricated forms of knowledge contribute limited or none guidance to student experience with science activities and natural events (Lin et al., 2013; Stear et al., 1998). However the ways of investigation and discovery which scientist adopts to study the nature and problems provide students tracks to overcome limitations of traditional science teaching and materials. Reliable and valid explanations for science activities and natural events depend on students experience with the inquiry method framing the scientific studies.

Inquiry as an instructional approach was brought to discussion by progressive philosopher John Dewey at the beginning of 20th century (Abd el-Khalic et al., 2004; Polman & Pea, 2000). The approach signified the importance and essentiality of learning as an experience based on lived processes. Inquiry as a method is defined as the actual processes by which scientists unveil the reality (Chinn and Malhotra, 2002) and it is widely believed that its adaptation to science instruction helps students in understanding the natural events (Chen & Chen, 2012). Even though inquiry instruction seems to be resonating as hands –on and minds-on practices among science education community, the views hold on for the place and praxis of inquiry approach in science education are further perplexed by various perspectives. Abd el Halick et al., (2004) assesses inquiry perspectives in science education as a mean which shapes the instruction and helps students gain science content and as a gain which students can acquire through the science instruction. Anderson (2002) oversees inquiry first as the ways of investigation and discovery which were practiced by scientists, secondly as the instructional ways through which students can be able to learn science and lastly as various approaches of teaching science practiced by teacher.

What would be the most appropriate way to follow in science education to practice inquiry approach? Nonetheless there is no certain answer generated for such a quest however certain strategies can be followed to conduct inquiry teaching in science classroom. The strategies would be the ones of such: to produce and analyze a case or event which is scientifically focused and framed on a question, gathering evidence, producing explanations to answer the questions, evaluating and testing the results from various perspectives and communicating the outcomes objectively with a community of peers (Biggers & Forbes, 2012). Exemplars of instructional practices are benchmarked with existence of authentic questions originating from or in the vicinity of students´ lives (Keys & Brayn, 2001**;** Miri et al., 2007). Within such a context, science activities form an arena where students can experience the importance and meaning of inquiry at a personal level (Crawford, 2000). Students must be decorated with critical thinking abilities adequately to bring out and answer the questions inheriting some personal meaning as a life experience (Southerland, Gess-Newsom & Johnston, 2003). Therefore, in-class practices of inquiry instruction provide students with opportunities to be critical and skeptical to compare existing knowledge with observed events. At the same time, along with the discovery of facts of nature by check and balances of ideas and knowledge with the newly experienced phenomena at hand, the inquiry-based science activities organize the scientific content knowledge at personal levels (Entwistle & Ramsden, 1983, cited in BouJaoude, Salloum &El-Khalick, 1994).

Sandoval and Reiser (2003) emphasize the experience and learning of scientific activity processes that paves way to inquiry learning for unearthing logical explanations as well as satisfying epistemological validity. Within the same framework, NRC (1996, 2000) provides the essential process and skills for students to be able to conduct inquiry successfully. Inquiry skills similar to science process skills describe the steps which students must be able to do within the learning environment. These are developing satisfactory explanations based on observations for events and phenomena in science courses, supporting scientific explanations with evidence and arguments and defending the outcomes before a group of peers with the scientifically established means of communications. Inquiry as a multifaceted methodology covers the process skills such as making observations, putting questions for research, planning investigations, comparing exiting knowledge with experimental results, comprehending the results, collecting evidence and using proper means and methods for analysis and interpretation, proposing and communicating answers, explanations and expectations. Therefore, the process skills in science education can be achieved along with the accomplishing inquiry based teaching.

Along with the change on teacher and student roles in learning in a constructivist learning environment, students' academic performance on science subjects is associated with acquisition and display of science process skills. Within such a framework of science instruction, science teacher`s role as a guide and facilitator has been required especially in science activities where the opportunities of observations and experimentations are provided for students. As a matter of fact, Rogers and Abell (2007) signify the change in teacher and student roles in science laboratory courses. Within such a context, student performances in stages starting with the subject of the inquiry investigation, continuing with gathering and interpreting evidence are valued as chances for students to make guided or independent decisions. However, drawbacks in teacher' intervention as a guide to students' learning process in inquiry-based science instructions challenges the practice of such an approach to extensive scale (Chin & Chia, 2004; Smith & Anderson, 1989).

Studies conducted with the science teachers of K-9 levels provide the barriers and limitations by the implementations of inquiry-based science instruction. Roehrig and Luft (2004) found that the middle school science teachers were confined with the lack of knowledge and skills to conduct inquiry teaching and were also concerned with the class management and curricular planning. Crawford (2007) revealed that deficiencies in teachers' conceptions on the conduct of science diminish their implementation of inquiry.

Studies conducted to investigate in-class inquiry instructions display the shifts in the focus of inquiry strategy. In a study with a sample of Nicaraguan primary school level teachers of science, Lucero, Valcke and Schellens (2013) showed that teachers preferred assisting students to pass through the stages of an activity instead of guiding them to think on different perspectives and decision making processes. Kim, Tan and Lee (2013) investigated teachers' perceptions on inquiry-based science teaching approach in Singapore national curriculum and found that teachers took students' acquisition of content knowledge as a benchmark to accomplish via science activities rather than the progression of skills and abilities to conduct an activity independently. From an overall perspective, inquiry practices is under scrutiny and questioned because of the recipe type science activities which are in confirmatory nature where students are the seekers of right and certain answers and effort to develop dexterity with science materials as skills (Crawford, 2007).

Findings provided by aforementioned studies can be interpreted such that the teachers instructing science might have been actually challenged by the lack of motivational and confidence related shortcomings, and not familiar with the required pedagogical training to conduct inquiry-based science teaching approach. In Turkey, science teachers were founded to be determined to teach science with inquiry approach but they lack experience and skills to put it into practice (Sahin, Isıksal & Ertepınar, 2010; Koksal & Berberoğlu, 2014). As a matter of fact, low scores gained by Turkish students in TIMMS exams for the science questions requiring some use of inquiry skills can be regarded as the indicator of that inquiry practices being implemented in the schools are not effective in acquisition of the skills by students foreseen by the curriculum (Koksal & Berberoglu, 2014). Overall, professional training and guidance is necessary for in-service and as well as prospective teachers to conduct inquiry based instruction of science activities. Moreover, Melville and Bartley (2010) signified the importance of professional learning opportunities designed for instructors of science courses to enrich their conceptions of inquiry teaching perspectives besides the mastery on inquiry teaching of a subject matter. Lin, Hong, Yang and Lee (2013) revealed with a group of Taiwan primary school instructors of science courses that at the first hand they have to learn inquiry strategies for their own need. As a result, this study accepts the view that teachers of science need to be decorated with science skills and inquiry strategies to teach science.

While the importance of inquiry-based teaching and learning has been rising in science education, the studies have showed the limitations and barriers to its implementation of the inquiry approach. Teachers of science courses are instrumental in implementing the science curriculum at schools. Aforementioned studies globally depict a picture for the performances of teachers of science courses on curricular activities that inquiry practices by both in-service and prospective teachers must be investigated. Therefore the solutions for satisfactory inquiry based science teaching must be associated with the way actually teachers of science are educated to implement such a purpose.

In particular, any consideration for the answers and solutions to the challenging situation must regard the fact that prospective teachers of science subjects might have been obliged to start the profession before being educated properly on inquiry based teaching. The teachers need to be decorated with features of science process skills and inquiry strategies to manage a classroom with inquiry based learning environment. With such an impulse, this study investigated the effect of inquiry based science activities on prospective elementary teachers' use of science process skills and inquiry strategies.

In general, inquiry approach is implemented as guided and open inquiry sessions where students have chance of learning with teacher guidance in a constructivist environment. Inquiry learning is generally associated with extreme participation and responsibility of the students (Welch et al., 1981). Teachers of science are expected to be independent learners of science concepts to some degree. Such implementations emerge a question on the efficiency of teacher guidance in student science learning (Koksal & Berberoğlu, 2014). This study includes science activities designed by the prospective elementary teachers. The teachers brought the subject of the activities, did planning and investigation of the problem, decided on the analysis, interpret and display of the results. They were guided on necessity by the researchers to include certain stages such as science process skills and inquiry strategies. Following research questions were answered by this study:

1.1. How frequent and to what level are the science process skills utilized by prospective elementary teachers during science activities?
1.2. What changes occurred for the frequency and level of the science process skills utilized by prospective elementary teachers during science activities?
2.1. Which inquiry strategies are often used by prospective elementary teachers during science activities?
2.2. How do the utilization frequencies of inquiry strategies change during the science activities?
3.1. What are the correlations among inquiry strategies used by prospective elementary teachers during science activities?
3.2. How do the correlations among the inquiry strategies used by prospective elementary teachers changed during science activities?

METHODOLOGY

a) Sample

Sample of the study was chosen with the technique of purposeful sampling. Two criterions were established for the sampling procedure in a plain way. Firstly, prospective teachers who would be selected to participate in the study are expected to be the ones teaching science subjects at the elementary school level. Secondly they should have been enrolled in a university level science course. All 119 prospective elementary teachers enrolled in the third grade course Science and Technology Teaching II in a college of education in Turkey at the year of 2011-2012 were participated in the study. Forty-five of the participants (%37,8) were male and seventy-four of them (%62,2) were female.

b) Data Collection Instruments

Investigation of inquiry based science activities was conducted with the data gathered by two quantitative instruments. These are "science process skills and inquiry strategies scale (S&S-scale)" and "science process skills test (SS-test)". S&S scale was developed by the researchers and consists of two subscales on science process skills and inquiry strategies. In the first subscale, the participants are asked to provide information on how often in science courses they utilize the skills such as: observation, measurement, recoding data, interpreting data, classification, comparison, estimation, making hypothesis, identifying and testing variables and making a conclusion. The responses are marked as "the least" or "the most". The validity of this subscale is confirmed by two university level instructor in the field. Second dimension consists of eight statements on inquiry strategies regarding the critical perspective toward a new idea or observational event and confirmation of the truthiness of existing and newly admitted knowledge. Participants mark on Likert- scale indicating their use of each strategy in science courses. Development of these subscales included a trial of pilot study which was used to evaluate and refine the statements. Cronbach alpha values of these scales are 0, 60 and 0, 65 at the beginning of the study. These values may be regarded as right below the acceptable border value. Such low scores of reliability can be reasoned with on the fact that this study is not measuring achievement or performance but rather interested in the personal constructs such as attitudes toward or utilization of skills and abilities (Kline, 1999). Beside the prospective elementary school teachers' self reports, objectified data on their performances on the use of science process skills were evaluated with science process skills test (Çelik, 2013). The test includes 30 multiple choice items on science process skills which are in the focus of the study. KR-20 reliability value of the test was 0,80.

c) Data Collection and Analysis

The study is conducted as pre and post experimental design. The data in the study was gathered by pre and post application of the instruments S&S-scale and SS-test. In SS-scale, the responses to the first subscale regarding science process skills were coded as "1" for the least use and "2" for "the most use". The responses to the second subscale regarding inquiry strategies were coded as "1" for "the least", "2" for "seldom", "3" for "sometimes", "4" for "usually" and "5" for "always". The responses to science process skills test were coded as "0" for wrong and "1" for true responses. Then, all the data were entered and analyzed with SPSS 17 statistical program.

The evidence for the status and change of the utilization frequency of science process skills and inquiry strategies by prospective elementary teachers were obtained with the descriptive analysis of the responses to SS-scale items and as well as the comparison of their pre and post mean values with t-test analysis for dependent groups. Moreover, to obtain evidence on the question of that how successfully the science process skills were actually applied by the participating prospective teachers during the science activities, the responses to the SS-test and the self reported utilization frequencies of science process skills were analyzed with Pearson correlation analysis between the pre and post mean values of these items. Lastly, to reveal any relations among the utilization frequency of inquiry strategies by the teachers, the Pearson correlation analysis was conducted for the responses to the related items.

d) Instructional Process

The study was taken place in the course of Science and Technology Teaching II for a time length of twelve weeks. The course covers the science subjects which are thought to the fourth and fifth grade students in elementary school. The prospective elementary teachers were grouped as three or four and then each group planned, designed and applied a science activity on these subjects. The researchers are also the instructors of the course and provided guidance to the participants in the conduct of the activities. Duration of each activity is limited to one class hour. All activities are designed by inquiry based approach and included an experimentation phase. The activities started with a question to make other students wonder and motivate about the activity or its ending. The researchers guided the prospective teachers to include instances of observation, measurement, comparison in the activities therefore the peers who are following the activity have opportunity to practice and apply the related skills. Moreover, through questions or statements, the students conducting the activity tried to signify the contradicting results with daily life and intuition based ideas hold by people.

To involve students in active use of inquiry learning approach for science process skills and inquiry strategies, written and oral feedback instruments are used to motivate students to follow up and evaluate each activity carefully. To strengthen the teachers' involvement in the activity, they were asked to practice a technique of "Prediction-Observation-Explanation" phase and invited to share what they explored and discovered orally with the class. They were also involved in situations to answer the questions of such "what is interesting in my observation", "what is new and different from what I have already know", "what I can prove with what I already know" and "what are contradicting with what I already know". Thorough the oral and written sessions on such questions, the teachers faced with epistemological challenges and organized their knowledge and experience. Moreover, "the activity evaluation form" which is designed by the researchers was filled by the participants individually upon following the activity. The statements in the form asked to evaluate the discovery, argumentation, participation, creativity and genuine characteristics of the activity. The participants were also obliged to write a journal after each activity. The purpose of journal writing is to help them to evaluate activity outcomes with the questions of "what", "how" and "why". Along with such follow-up studies, a discussion and critical environment in the class was established and the participants were guided to experience inquiry as well as gain interest and awareness toward analyzing the activities.

FINDINGS

The findings of the study were based on the pre and post administration of SS-scale and SS-test during the course. The purpose of the findings is to reveal and address any perceivable effect of inquiry-based science activities on the utilization frequency of the science process skills and inquiry strategies by prospective elementary teachers.

Total score could be taken from the science process skills subscale is ranged between 10 and 20. Table 1 shows that the pre-instruction mean score was 16, 1. This value is close to the middle of "the least" and "the most" meaning that the teachers´ use of science process skills can be interpreted as being average before the instruction. At the end of the inquiry based instruction, the value was raised to 18, 1 level. This change was tested to be significant ($p<.05$). Therefore, inquiry-based science activities influenced the utilization frequency of the skills by the participants to some degree.

Eight items comprising the frequency of the prospective teachers´ use of the inquiry strategies scored between 8 and 40. Table 1 shows that the mean value for the utilization frequency of the strategies by participants was 25, 6 before the course started. This value marks a point near to "sometimes". At the end of the course, the value was raised to 29, 3 level. This change was tested to be significant ($p<.05$). Therefore, inquiry-based science activities influenced the utilization frequency of the inquiry strategies to some degree.

Table 1. *T-Test Results for the Science Process Skills and Inquiry Strategies Subscales in S&S*

Subscales	MUF	Std	P
Skills- pre	16,13	1,66	,001
Skills- post	18,16	1,17	
Strategies- pre	25,68	4,41	,000
Strategies- post	29,03	3,27	

MUF: Means of utilization frequencies

Further descriptive analysis was administered to investigate the item-wise change among science process skills. Percentages of the reported utilization frequencies of the science process skills were happened to be raised between pre and post instruction as seen in table 2. The investigation was advanced to a point that there might have been some skills which were challenging and actually proportioned least in comparison to the changes in others. At the pre-instruction, the participants were challenged with the skills of "measurement", "interpretation", "hypothesis construction" and "identifying and testing variables". The post-instruction values depicted that the difficulties with the skills "measurement" and "variable identification and testing" were still exist to some degree. Overall, the changes were observed for the skills upon the regular inclusion of skills in inquiry-based science activities in the course.

Table 2. *Pre-Post Percentages of Science Process Skills in S&S-Scale.*

Item	Pre		Post	
	Least (%)	**Often (%)**	**Least (%)**	**Often (%)**
1(Observation)	16,8	83,2	4,2	95,8
2 (Measurement)	45,4	54,6	31,9	68,1
3 (Data Recording)	39,5	60,5	21,8	78,2
4 (Data Interpretation)	52,9	47,1	20,2	79,8
5 (Classifying)	37,8	62,2	17,6	82,4
6 (Comparison)	20,2	79,8	1,7	98,3
7 (Making Estimate)	24,4	75,6	10,1	89,9
8 (Making Hypothesis)	70,6	29,4	33,6	66,4
9 (Identifying and Testing Variables)	58,0	42,0	42,9	57,1
10(Making Inferences)	24,6	74,6	2,5	97,5

Table 3. *T-Test Results for the Pre-Post Values of Utilization of Science Process Skills.*

Item	Pre	Post	p
1(Observation)	1,83	1,95	,004
2 (Measurement)	1,55	1,68	,032
3 (Data Recording)	1,60	1,78	,003
4 (Data Interpretation)	1,47	1,79	,000
5 (Classifying)	1,61	1,82	,001
6 (Comparison)	1,80	1,98	,000
7 (Making Estimate)	1,75	1,90	,003
8 (Making Hypothesis)	1,29	1,66	,000
9 (Identifying and Testing Variables)	1,41	1,56	,022
10(Making Inferences)	1,78	1,97	,000

The mean values of the pre and post instruction utilization frequencies of the each skill by participants were analyzed to test for any significant change before and after the instruction in the study. The t-test results presented in table 3 indicate that the utilization frequencies of the skills by the participants were changed significantly during the instruction of inquiry based science activities (p<.05).

The percentages of the utilization frequency of the inquiry strategies at the pre and post instructions were investigated descriptively to anticipate the ones which might be difficult or challenging to the prospective teachers before and after the instruction. Table 4 displays that the raises in the percentages of the use of inquiry strategies by the participants were incident following the instruction. Some of the strategies were reported to be used extensively at the end of the instruction. These are "discovery of phenomenon by observation and experimentation", "benefiting from scientific sources", "explaining a situation with scientific reasons", " not refusing a different idea or knowledge conflicting with the existing belief or idea", "revealing similarities and differences between existing ideas and observed phenomena", "trying to produce scientific explanation for a daily life event". Moreover, at the end of the study none of the participants mentioned the investigation of observed events with the approach of "not appealing to scientific reasoning". Similarly, at the end of the study, the teachers were not to be readily to refuse a situation just because of the fact that it conflicts with what he or she knows or believes. A peak-like rise in the awareness to use such strategies shows that inquiry-based instruction of science activities help the teachers in adopting and addressing them during learning cases.

Table 4. *Mean Values of Utilization Frequencies of Inquiry Strategies*

	None		Seldom		Sometimes		Often		Always	
Strategy	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
11	4,2	1,7	26,1	11,8	33,6	29,4	25,2	42,0	10,9	15,1
12	3,4		19,3	1,7	35,3	47,1	31,1	43,7	10,9	7,6
13	2,5		16,8		46,2	47,1	25,2	38,7	9,2	14,3
14	5,1		19,5		23,7	36,1	29,7	42,0	22,0	21,8
15	12,7	7,6	26,3	16,0	35,6	34,5	17,8	25,2	7,6	16,8
16	5,9		10,9		37,0	31,9	31,9	51,3	14,3	16,8
17	0,8		10,9		45,4	32,8	29,4	47,1	13,4	20,2
18	4,2	1,7	27,7	17,9	42,0	36,8	18,5	35,9	7,6	7,7

Table 5. *T-test Results for the Pre and Post Instruction Utilization Frequencies of Inquiry*

Item	**Pre**	**Post**	**p**
11	3,12	3,57	,001
12	3,26	3,57	,006
13	3,21	3,67	,000
14	3,44	3,85	,001
15	2,81	3,27	,002
16	3,37	3,84	,000
17	3,43	3,87	,000
18	2,95	3,29	,007

The strategies used by the participants to conduct inquiry at the pre and post instruction levels were compared with t-test for dependent groups to reveal the access levels succeeded by the prospective teachers during the inquiry-based learning of science activities. Table 5 displays that the utilization frequencies of the strategies by the participants to conduct inquiry changed significantly between the pre and post instruction levels (p<.05). This shows that inquiry based science activities helped the teachers to adopt and employ these strategies.

Table 6. *Pre-Post Test Correlation Results for the Utilization of Inquiry*

Pre-Instruction							
Item	12	12	14	15	16	17	18
11	,255*	,216**	,048	-,038		,221**	,492**
12		,283**	,279**	,091	,163*	,171*	,294**
13			,157*	,090	,273**	,317**	,385**
14				,175*	,159*	,252**	,106
15					,162	,196*	,083
16						,375**	,159*
17							,215
Post-Instruction							
11	,330*	,262**	-,008	,103	,130	,109	,334**
12		,401**	,285**	,075	,212*	,121	,251**
13			,208*	,028	,314**	,299**	,435**
14				,257*	,191*	,183*	,034
15					,099	,171*	,072
16						,441**	,189*
17							,251**

During the study of science activities, inquiry strategies are needed to be employed as a whole rather than as a single. Therefore, correlation investigation of the utilization frequencies of the strategies was conducted at the pre and post instruction levels. Table 6 showed that significant correlations exist among the strategies 21, 22, 23, 27 and 27 at the pre and post instruction (p <.05). Correlations were detected among some strategies at the pre and post instructions showing that the strategies were employed mutually by the participants. The strategy 21 (I try to discover natural events and phenomena through observation and experimentation) was correlated with 22, 23 and 28 at the pre and post instruction. The strategy 22 (I try to discover natural events and phenomena through scientific sources) was correlated with strategies 23, 24 and 28 at the pre and post instruction. Strategy 23 was correlated with strategies 24, 26, 27, and 28 at the pre and post instructions. Strategy 25 was correlated with strategy 26 at the pre and post instruction. Strategy 26 was correlated with strategies 27 and 28 at the pre and post instructions. The prospective teachers reported that they seemed to start using some strategies at the post-instruction level. Strategy 27 was correlated with the strategy 28 only at the post instruction level. Correlations exist at the pre instructional level seemed to be vanishing at the post instructional level. Strategies 21 and 22 both were correlated with strategy 27 at the pre-instruction level. No new correlation was detected at the post-instruction which was not seen at the pre-instruction level. Rather than the emergence of decaying correlations through the inquiry based activities from pre to post instruction, the overall correlation results seemed to provide strength into that the prospective teachers used them in a holistic way.

The prospective teachers' responses to the SS-test were analyzed to find out any changes between pre and post instruction. For this purpose, a t-test for dependent groups was conducted to compare the responses to the multiple choice test items. The table 7 shows for the pre and post-instruction levels that the means scores were 14, 72 and 18,01 respectively out of a maximum possible score of 30. T-test analysis revealed that the change in the mean score is significant (p<.05). The access levels to the science process skills achieved by the participants were actually changed significantly before and after the inquiry-based science activities. During the instruction, the teachers were not taught explicitly on how to solve any science process skill questions. However, the effective change in the scores was followed upon the inquiry-based science activities providing the instances of identification and practice of science process skills.

Table 7. *T-Test Results for Pre and Post Instruction Results of Science Process Skill Test*

	Mean	N	Std.	p
Pre	14,72	77	3,28	0,000
Post	18,01	77	4,14	

Table 8. *Pre and Post Test Percentages of the Responses Given Some Items in the SS-Test*

Test Items	Pre		Post	
	Correct %	Incorrect %	Correct %	Incorrect %
3 (Measurement)	30,9	69,1	80,9	19,1
4 (Observation)	59,0	41,0	78,7	21,3
6 (Identifying and Testing Variables)	72,7	27,3	75,2	24,8
7 (Estimation)	48,9	51,1	53,9	46,1
10 (Making a Conclusion)	36,0	64,0	70,2	29,8
15 (Making Hypothesis)	61,2	38,8	86,5	13,5
19 (Data Interpretation)	27,3	72,7	48,9	51,1

Table 9. *T-Test Results of Some Items in the SS-Test*

	Pre	Post	p
3 (Measurement)	0,30	0,80	,000
4 (Observation)	0,58	0,79	,000
6 (Identifying and Testing Variables)	0,27	0,74	,000
7 (Estimation)	0,48	0,53	,380
10 (Making a Conclusion)	0,35	0,70	,000
15 (Making Hypothesis)	0,64	0,85	,000
19 (Data Interpretation)	0,61	0,86	,000
3 (Measurement)	0,27	0,85	,000

A further analysis was conducted to establish the relation between the instruction and the participants' responses to the SS-test. For this purpose, the responses to certain items of the test in congruence with the science process skills of measurement, observation, identifying and testing variables, estimate, making a conclusion, making a hypothesis, and interpreting results were selected and then responses to these items were compared at the pre and post instruction levels. Table 8 shows that the responses were mostly incorrect at the pre-instruction level for items 3, 7, 10 and 19. On the contrary, the responses to these items were mostly correct at the post-instruction level. The change might be taken as a support to establish an influence of inquiry-based science activities on the test results. The pre and post instruction response to items 6 "identifying and testing variables" were changed least during the instruction. The participants were still challenged with the items 7 and 19 related to the skills of making predictions and conclusions, the substantial part of the responses these two items were incorrect even after the instruction. For all seven items congruent with the science process skills, an item-wise analysis was conducted to investigate the occurrence of significant individual changes. The results displayed in table 9 illustrate that the significant changes ($p < .05$) were occurred for the items except item 7 "making predictions".

DISCUSSION

The data based on the results was discussed to answer the changes and relations between the prospective elementary teachers' use of the skills and strategies upon the inquiry-based science activities on these variables. The current study was driven by the fact that science process skills and inquiry strategies are mutual and necessary to be excelled to reach any knowledge with observation.

The pre-instruction application of BSB-scale and BSB-test showed that the teachers did not use science process skills so often. Particularly, the skills of measurement, interpreting data, hypothesis, identifying and testing variables, making estimate and conclusions were the ones by which the teachers struggled to utilize during the events of daily life and in-class. In case of utilization of inquiry strategies at the pre-instruction level, the teachers were determined to not to take a critical or skeptical approach as a guideline to compare and contrast the already known with the witnessed phenomena at hand. Particularly, the strategies the teachers' use of them were limited are related to discovering facts with observation and experimentation, producing explanations on a scientific base, and explaining daily life events with science. This result is corresponding with the fact articulated by Koksal and Berberoglu (2014) that the science teachers in Turkey lack the training to practice inquiry abilities. Similarly, the studies by Melville and Bartley (2010), Lin, Hong, Yang and Lee (2013) showed that teachers of science were need of professional training and support to overcome the drawbacks caused by lack of practices on inquiry learning and teaching. Salient factors which could explain the teachers´ low level implementation of inquiry strategies are ineffective learning environment where inquiry practices are conducted (Hofstein, Nahum & Shore, 2001; Liu & Treagust, 2005), and cultural and social beliefs which shape educational attitude and interest (Dkeidek, Mamlok-Naaman & Hofstein, 2012; Roehrig & Kruse, 2005).

This study found that the teachers' use of science process skills and inquiry strategies were frequent at post-instruction level. The changes could be influenced by techniques adopted and enforced in the inquiry-based science activities planned and conducted by the teacher candidates. They were guided by the researchers particularly to include science process skills. The peers following the activities were cautioned to be elaborative and meticulous and therefore critical and skeptical on what they were witnessing in the class. The prospective teachers need guidance and special courses specifically on what and how to be a critique and skeptic of their own experiences (Dkeidek, Mamlok-Naaman & Hofstein, 2012).

The skills which seemed to be not improved enough during the instruction are related to interpreting the data, making predictions and making conclusions. These skills may require more active involvement as doers rather than a role of an audience as an observer. Similarly, the teachers were still refusal of explanations for situations which conflicts with existing knowledge, or belief. The teachers might be need of more cases of observation and experimenting because of the strength of accommodated unscientific ideas and beliefs. Teachers may be involved in inquiry practices as an apprentice and therefore obtain the chances to acquire the skills and strategies by observing other at work (Groendijk & Bandura, 2013). The study shows that only being in the vicinity of a science activity as an observer is not enough to excel in practicing inquiry teaching and learning. Brown et al (2006) cautioned for the fact that science teaching at university level, even though the instructors were eager to teach science course with inquiry approach, because of the limitations of time and sources the plans were usually been tailored. Such barriers and forced adaptations of inquiry practices in the teacher education programs might lead to the lack of abilities to learn science and the need for courses to teach teachers how to design, develop and improve science activities (Song & Schwarz, 2013). Education faculties on teacher education must consider a continuum of courses which enforce prospective teachers to personalize inquiry learning through.

Any strategy as a key to do inquiry cannot be singled out from a variety ones but on the contrary numerous strategies can be needed to excel the inquiry approach. Coordination and integrity among the inquiry strategies shows that variety of cognitive tools is being actually employed to seek and discover. However, intricate and complicated nature of inquiry practices prevents the implementation of each strategy during learning and as well as teaching science (Marshall, Horton, Igo & Switzer, 2009; Puntambekar, Stylianou & Goolstein, 2007). While at the pre-instruction level the multiple use of strategies were self-reported among the prospective teachers, the inquiry-based science activities seemed to strengthen the integrity of the inquiry strategies at the post instruction level. However, further studies are recommended on the wholeness of utilization of strategies by learners.

CONCLUSION

Inquiry based science teaching has been planned to be a curricular target at national level in Turkey (MEB, 2013). The quality of science education and the abilities the teachers of science were equipped with have been issues of widespread discussions. The barriers and limitations the teachers face when they intend to conduct inquiry teaching are needed to be emerged. Upon the emergence of such difficulties, the valid and reliable models of professional training and instructional materials can be foreseen for in-service and prospective teachers. One of many hypothetical questions on the practice of inquiry based science teaching, this study was interested in one to answer the status and change in prospective elementary teachers' use of science process skills and inquiry strategies during the inquiry-based science activities. This study also offers a model for inquiry teaching in the teacher education in science courses. New and genuine models need to be brought before the science education community and must be tested. Studies are also required to investigate thoroughly the preparation of the teachers of science at the education departments. Teacher education is the place where attention must be paid and efforts must be focused to obviate further problems. This study also recommends the longitudinal studies along with data in qualitative nature to elaborate on teachers' use of skills and strategies in science classes.

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