THE PRIMACY OF OBSERVATION IN INQUIRY-BASED SCIENCE TEACHING

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Abstract. *Observation is a complex activity; that teachers of science should know how to make observation and how to apply it at all grade levels and finally how to monitor and evaluate their students as a guide. The aims of this experimental design study were to create observation methods and to develop student teachers' process skill of observation. The study was conducted with sixty one student teachers. The results of the study showed experimental groups' observation was more systematic, detailed, diverse and comprehensive than the control groups. The differences proved that systematic-observation enabled students to begin investigation and continued throughout it.*

Keywords. Inquiry-based science teaching, observation, systematic-observation, student-teachers.

1. Introduction

One of the recommendations of a European Union (EU) report on science education is the instruction of inquiry-based approaches in schools, actions for teacher training to inquiry-based science teaching (IBST), and the development of teachers' networks should be actively promoted and supported [3]. Therefore, many science education programs support the idea that active, hands-on (la main a la pate), and student-centered inquiry should be at the core of a good science education [2, 7, 9, 11, 17]. A major goal is to improve science education and ultimately achieve higher levels of scientific literacy for all students.

More than ever before, educators agree that science education should be based on asking questions, formulating research questions, conducting investigations, collecting data, and looking for answers [13, 14]. In addition, instead of memorizing the scientific facts, learners should be encouraged to use the scientific thinking process. The best way to succeed this strategy is teaching science by supporting to do science [8]. Strategies for doing science should focus on selecting projects of interest to the learners and having them apply concepts and skills from other content areas. Therefore, many educators and researchers focus on hands-on activities and especially on doing experiments [5, 6, 16]. However, science is about not only running experiments but also observing [4, 10, 12]. Observation is used at all stages of inquiry: as a stimulus for raising questions, in linking earlier experience to new encounters, in gathering information, in finding patterns and relationships between events and objects. Thus, IBST is a whole consisting of making observation and doing experiment. The authors shall not spend time making the case for importance of observation. What they are more concerned is examining and developing methods for observation, which was slightly neglected in hands-on science studies.

Enabling children touch in science at early ages could only be achieved by reducing science to their perceptional and sensational world. The interactions between the sense organs and the attribution of objects carry us data from the external world. These data are processed under the control of our mental activities and placed in our consciousness. Observations attach us not only the world that we are living in but also open the doors for scientific methods. Thus, systematic observation in science education is as crucial as experimental methods. Learning observation under the guidance of systematic teacher is essential not only for gaining scientific thinking processes but also for the quality of learning outcomes.

Nature education, nature observation, and sightseeing are some of the activities inspired from IBST. However, if determination of a research question is an inevitable scientific process for an experiment, the same process should also be adapted to observation. Bachelard [1] described that scientific activities always start with asking questions and continuous with observation. This is the origin of investigation. Developing the process skill of observing will enable learners to seek consciously for information that will extend their ideas. The teachers' role in this development is to provide opportunities for using the different aspects of observation, often through discussion or through providing problems whose solutions require a wide range of observations to be made and brought together. What these mean is that observation is a complex activity; that teachers of science should know how to make observation and how to apply it at all grade levels and finally how to monitor and evaluate their students as a guide. Therefore, the aims of this experimental design study were to create observation methods and to develop student teachers' process skill of observation.

2. Method

2.1. Participants

The study was conducted at a four year public university located in the Mediterranean region of Turkey with sixty one student teachers (thirty nine boys and twenty two girls) enrolled in the department of Science Education in Primary School Teaching. The students were selected to the college according to their scores on the nationwide centralized university entrance exam and their preferences. Generally coming from middle class working families, students come to college from the different parts of the nation. Students of this department had already completed the basic physics, chemistry, biology and an educational courses before the study was conducted.

2.2. Strategies for data collection

Students were divided into control (thirty students) and experimental (thirty-one students) groups. First researchers instructed students to understand the difference between an observation empirically made (through the use of our senses) and other nonscientific statements. After emphasizing that "good" observations are detailed and involve the use of our senses (sight, touch, taste, hearing, smell), a blind paper was given to control group students and an observation sheet was given to experimental groups. The observation sheet was developed by the researchers. The paper consisted of four main parts: preparation, process I, process II and interpretation. During the preparation part students were asked to decide their research question(s) and to limit their observation domain. Then students were asked to make quantitative and qualitative observations during the processes one and two respectively. And finally, students were asked to write their inferences. Each parts of the observation sheet formed sub-questions.

Control and experimental groups' students were given any kind of materials they needed for their observation such as camera, lenses, or measurement apparatuses and informed to record as many details about their observation domain. During this time, the role of the researchers is to guide, facilitate, and continually assess student work. Students had approximately one hour for observation. In this study, the researcher attempted to provide more comprehensive data. Thus, in addition to the observation sheets, the researchers interviewed with the students and taped it at the beginning, during and after the activity. The qualitative data, which was in the form of paper and pencil and transcripts of record analyzed by iterative process of, open coding [14]. Two researchers constructed the coding schemes of the qualitative data to establish the reliability.

3. Results and discussion

The data evaluated by comparison the control group that had done nonsystematic-observation and the experimental group that had done systematic-observation. The results summarized below by given examples from students' data.

3.1. Control group results (nonsystematic-observation)

Students in control group defined their observation zone according to their first impressions. The students focused on macro dimensions that were eye catching and more than one objects at a time. Three students (10%) observed dog behavior (see figure 1); nine students (30%) observed insects such as ants, flies, bees and etc.; and twenty-eight (60%) students observed plants, flowers, or trees (see figure 2).

Figure 1. A group of control group students observing dog behavior

Figure 2. An example from control group students' observation zone

The outcomes of the control group data summarized below:

1- The observations based-on students' biology content knowledge.
2- The observations were descriptive.
3- Students only used their sense of sight during the observation.
4- Some students focused on more than one thing at a time without making any connections. For instance, a student observed a leaf and insects on that leaf, but s/he neglected to observe the interactions between the insects and the leaf.
5- Students likely to observe what they have already known.
6- A few students (only two out of thirty) tended to make hypothesis during their observations.

In conclusion, control group students made their observations without research questions. They only described what they saw. Therefore, they focused on more than one objects at a time. During the observations, students looked for what they have learned in the classes. Accordingly, they limited themselves to observe the possibility of new facts. Students were far away from investigation.

3.2. Experimental group results (systematic-observation)

Experimental group students' observations were more systematic, detailed, diverse and comprehensive than the control group. Even though they had difficulties to formulate the research questions, all students in experimental group tried to define one. The problem with the research questions were:

1- Students could not limit them.
2- Students had uncertainty while define them.
3- Students' research questions were impossible to find an answer at a certain time.
4- Students could not make a distinction between a question and a research question.

One of the sub-questions of the observation sheet was "what makes you to choose that certain research question?" Thirteen students (42%) wrote it was their curiosity, four students (13%) thought it is a problem; four students (13%) wanted to learn it, eight (26%) students tented to investigate it and only one (2%) student wrote he did not know.

Experimental group students (87%) tended to do both qualitative and quantitative observations. Only four students out of thirty-one (13%) did only qualitative observation.

If the students' research questions were good defined, the results were clear and detailed. Contrary, if the research questions were poor the results were deficient and unclear.

Examples for above statements were presented below by pointing the consistence between the students' research questions and the results of their observations.

<u>**Student 6-**</u>

Research question: *Why flowering plants' structures and number of their flowers are different?*

Result: *I have observed that stamen in plants with multiple flowers were adapted in terms of leaving the pollens on stigma while those pollens were moving by wind in plants with single flowers (con-poppy)… The number of flower might be a factor caused by pollination.*

Student 6 data is an example for undefined and unrestricted research question. The observation included some conjectures without data. On the other hand, student 25's data could be an example for a good research question.

<u>**Student 25-**</u>

Research question: *How do antirrhinums pollinate even though their petals cover the stamen and pistil?*

Result: *I observed it! …My research question was in terms of the observation that I am doing right now. Antirrhinum's petals cover its stamen and pistil. Therefore, it does not pollinate by wind. The pollination happens when the insect go into the flower to have its nectar. But I have to do more observation to prove it.*

Student 25 limited her research question on one task and focused on to find an answer. Even though not all her statements were true, there was a consistency between the research question and the results. Conversely, student 18's research question was good, but her result was not related to her research question.

Student 18-

Research question: *In selected area how many different tree are there and how their leaves different from each other? Can there be a reason for that?*

Result: *If the tree species are different, then the leaves are different.*

Student 18 wrote a conclusion without observing either the number of tree's species or their leaves. Although she wrote a good research question, some problems detected through her procedure. On the contrary, student 9's data was a good example both for the research question and the result.

Student 9-

Research question: *Why some pine cones' scale clasped together and some are separated?* (see Figure 3).

Figure 3. Pine cone scale clasped together and separated

Result: …*Even though I could not reach the exact result such a short time, I am sure intact pine cone is the primary phase of separated one. Wind, heat, or irrigation are some independent variables that I could not control during my observation…*

The student organized a well-defined research question. With the help of observation sheet, he followed the scientific thinking processes and reached scientific outcomes.

Finally, the researcher looked for whether the student with undefined research question made a scientific conclusion. The researchers found no evidence for that. In below examples student do not know the differences between question and a research question and as well as scientific result:

Student 3-

Research question: *What insects (any kind of insect) do?*

Result: …*In fact I could not find an answer…*

Student 14-

Research question: *What does an ant do during a day and what kind of difficulties they encounter?*

Result: *Ants tried to find food and stay alive whole their life…In short the only thing ants do is working and working…*

Both students tried to observe the insects, but they could not formulate the research question. Consequently, they could not follow their observation sheet and could not find any answer. However, student with a well structured research question about insects reached scientific result and some sub-questions based on her observation.

Student 30-

Research question: *Ants lineup in a certain path. If a similar path forms, do they change their direction into that route?*

Result: *…I formed a similar path and a burrow by the end of path…Some time later, a number of ants changes their route into the new one and even some of them reached the burrow…I should continue my observation whether all the ants will change their route. Then I should observe the ants changed their route will back into their old path. By the end of those observations, I could only reach the answers of my research question…*

Experimental group students' observations were not only about the living thing, but also about the phenomenon. Such as;

Student 9-

Research question: *How could be the sun rays' coming angles measured with a stick that stands on a plane?*

The overall results stated that research questions enable students to do systematic observation. Even though well structured research questions made students to reach scientific conclusions, some students could not had the same success because of their lack of knowledge about scientific methods. However, the data presented that students' with poor research question could not reach any results.

4. Conclusion and implication

The results of the study showed that the experimental groups' observation was more systematic, detailed, diverse and comprehensive than the control groups. The differences proved that being systematic and following a method during the observation enabled students to begin investigation and continues throughout it. During the interview, experimental groups' students stated that making a systematic observation enabled them to learn gathering evidence, to organize their ideas, and to propose explanations about the world around them. By challenging the students to use their five senses to make detailed observations, researchers were encouraging students to collect and organize information about natural phenomena that they naturally find compelling.

Observation is the cornerstone of the inquiry process. If the educators or researchers get teachers to understand the primacy of observation in science education, their students might directly benefit from this. Therefore, the systematic observation for children would be a step not only for true understanding of the world we are living in but also for starting doing science. Human beings who tend to reach external world with synergy of sensation and processed mental data will not only analyze the nature better but also find answers easily to their problems.

The number of the participants might be considered as a limitation for the study. However, the study was aimed to cope with creating observation methods and to develop student teachers' process skill of observation rather than generalizing it. Taken collectively, the study provided promising insight and evidence for IBST depends partly on the quality of observation. The evidence showed that only teachers who encourage their students to follow scientific methods could succeed this. Moreover, providing opportunities and invitations to observe, asking appropriate questions to focus observations, and discussing what students observe are some other methods that teachers could follow for quality observation.

The results of this study raise two issues for further exploration. First, conducting the study to larger participants with different age groups and second, applying and creating observation strategies for different subject matter and concepts. All these variables were left for future studies.

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