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Pre-service science teachers’ competence to design an inquiry based lab lesson

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Abstract

Science teachers are expected to design inquiry based lessons which include most of the science process skills. The present study examined 21 pre-service science teachers’ scientific process skills and their competence to design inquiry based lab instruction. A six week program was developed and implemented to improve competence of preservice science teachers to design an inquiry based lab lesson. During the intervention, there were interactive lectures, discussions, metacognitive prompts, assignments and micro-teaching practices related to science process skills and designing an inquiry based lab. The participants were administered the adapted version of TIPS-II and asked to design an inquiry laboratory instruction based on a predetermined authentic problem ex-ante and ex-post. As a result of the intervention, competence of the preservice science teachers to develop an inquiry based lesson plan improved substantially whereas there was no improvement in their process skills.

Keywords: Inquiry based lab lesson; process skills; pre-service science teachers.

1. Introduction

The term “inquiry” can refer different meanings in different contexts. In the context of science, it refers to scientific inquiry that scientists do (Schwab, 1960 in Settlage & Southerland, 2007). In this view, students were considered as junior scientists with less sophisticated knowledge. In other words, “it refers to the abilities students should develop to be able to design and conduct scientific investigations and to the understandings they should gain about the nature of scientific inquiry” (NRC, 2000, p.XV). Another way describes inquiry within the context of instruction. It refers to “the teaching and learning strategies that enable scientific concepts to be mastered through investigations” (NRC, 2000, p.XV). This approach differentiates between inquiry done by students and inquiry done by scientists. In this respect, The National Education Standards emphasizes the importance of lab instruction by a broad definition of inquiry: “Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in the light of experimental evidence; using tools to gather, analyze, and interpret data;
proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations” (NRC, 1996, p. 23).

In 1960s and 1970s Joseph Schwab played a key role in the development of inquiry curriculum. According to Schwab (1960 in Settlage & Southerland, 2007) it is important for students to participate in activities with an emphasis on process skills such as posing questions, gathering data, and interpreting results to appreciate inquiry. Schwab (1962, in Settlage & Southerland, 2007) developed a scale of inquiry in science instruction (Table 1). In this scale, Level 0 is the lowest level of inquiry in which the teacher has a great control over questions, methods and interpretations. Colburn (2000) identified this level of inquiry as structured inquiry. At level 1, interpretation of the results were student generated while the teacher still has control over posing questions and the procedure used to answer them. At level 2, the teacher only determines the question to be answered, but the students are given freedom to use the methods to answer the question and to interpret results. Colburn labeled Level 1 and Level 2 as guided inquiry. At Level 3, students controlled all these three components. Colburn labeled this level as open-inquiry. This framework is useful for teachers to plan activities for their students. As students have more competence at doing science, the teacher will gradually give the control to them (Settlage & Southerland, 2007).

| Level | Question/Problem | Ways  | Results |
|-------|-----------------|-------|---------|
| 0     | Given           | Given | Given   |
| 1     | Given           | Given | Open    |
| 2     | Given           | Open  | Open    |
| 3     | Open            | Open  | Open    |

Inquiry-based lab activities have a potential to facilitate students’ conceptual development (Hofstein & Lunetta, 2004). However, many in-service and pre-service courses in science teaching do not provide the teachers with the necessary skills to act as facilitators to guide inquiry. Teachers are often not informed enough about new learning models such as inquiry-based learning and their implications for teaching and curriculum. So, many teachers still prefer a conventional way of teaching in which knowledge is directly transferred to the students (Hofstein & Lunetta, 2004). Therefore, developing and applying inquiry based lesson plans should be included in teacher education program.

Within this framework, this study aimed at developing a six-week program to improve inquiry process skills and to enhance competence of preservice science teachers to design an inquiry based lab plan. In order to increase the effectiveness of the intervention, metacognitive prompts, reflections and discussions were integrated as suggested in the literature (Saribas & Bayram; 2009; Zion, Michalsky, & Mevarech, 2005).

2. Method

2.3. Sample

The sample of the study was 21 pre-service science teachers who took the third year science laboratory applications course. Figure 1 shows the gender distribution of the participants.
2. Method

2.2. Procedure

The 6-week program consisted of interactive lectures, discussions, assignments and micro-teaching practices related to process skills and designing an inquiry lab. The Table 2 shows the weekly focus of the programme. In the first week of the program, a lecture followed by a discussion was given about the types of lab work and its importance. In the second week, the program continued with a lecture and discussions about inquiry design in the light of Schwab’s levels of inquiry. In the third week, in addition to a lecture about science process skills preservice teachers participated in activities in which they had to use process skills such as observation, classification and communication. Moreover, during these three weeks, preservice teachers in a group work were responsible for choosing and conducting an experiment as well as designing a lab plan for the experiment. In the last three weeks, each group applied their lab plans as a microteaching activity to their peers. Following each microteaching activity, the class discussed the applied plan in the light of the topics of the course.

| Week | Focus                     | Applied instruments                  |
|------|---------------------------|--------------------------------------|
| 1    | What is lab work          | Reflective forms, TIPS, ID           |
| 2    | Inquiry design            |                                      |
| 3    | Process Skills            |                                      |
| 4    | Microteaching             |                                      |
| 5    | Microteaching             |                                      |
| 6    | Microteaching             | Reflective forms, TIPS, ID           |

During the intervention metacognitive prompts were used to facilitate learning out of experience. Specifically, participants had the chance to reflect their expectations, beliefs and experiences regarding inquiry in science education. For example reflective evaluation forms were filled by the pre-service science teachers to create metacognitive awareness about teaching science in labs. Moreover, after their microteaching, they were required to write a reflective paper about their experiences as an assignment.

2.3. Instruments

In this study, TIPS and ID were administered to the sample before and after the program to evaluate science process skills and competence of the participants to design inquiry based lab plan. The details of the instruments are as follows:

TIPS: In order to investigate pre-service science teachers inquiry process skills, adapted version of TIPS-II were given before and after the intervention. This test was originally developed by Okey, Wise, and Burns (1982, in Geban, 1990). The test consisted of 36 multiple-choice questions which fall into five subsets. The subtests were identifying variables, operationally defining and identifying testable hypotheses, data and graph interpretation, and experimental design. The test, then, was translated into Turkish and adapted by Ozkan, Askar & Geban (1989, in Geban 1990). The reliability coefficient of this test, computed by Cronbach Alpha estimates of internal consistency, was found to be 0.81 (Alparslan, Tekkaya, & Geban, 2003).

ID instrument: The instrument developed by the researchers aimed to assess pre-service teachers’ competence to design inquiry based lab plan. The instrument consisted of one open-ended question in which participants were required to design an inquiry laboratory based on a given authentic problem. The answers given to the question were scored with a rubric developed on the basis of Schwab’s inquiry levels. The rubric is presented in Table 3.

| Inquiry level | Problem and question are given | Only problem is given | All of the components are open |
|---------------|-------------------------------|-----------------------|-------------------|
| Formulating introduction (defining problem, aim) | No introduction | Unclear introduction | Clarifies aim or problem | Leads to inquiry (motivating and encouraging) |
| Formulating procedure | Insufficient | Procedure is strictly given | Partially defined | Guide students to define their own procedure scientifically |
| Formulating results and conclusion | Insufficient | Structured | Guides students to make conclusions (posing questions) | Guide students to make evidence based conclusions |

Table 3. Rubric for ID
Using the rubric, both researchers analyzed and scored pre and post ID instruments of 21 participants. The consistency in pre-ID and post ID scorings was 88% and 72% respectively. After having a discussion on these scorings, researchers had a full agreement on all of them.

3. Results

The mean score of pre- and post-TIPS results were 28.52 and 27.71 respectively out of 36. The minimum score for pre-TIPS was 23 and for post TIPS was 21. So, pre-service science teachers, level of process skills were high as expected. Moreover, the results of pre- and post-test analysis of TIPS showed that there was no significant change in students’ process skills after the treatment ($t=1.19$, $df=20$, $p>0.1$).

In contrast to pre-service science teachers’ process skills, their competence to design inquiry based lab was substantially low. The mean-score for pre ID and post ID were 3.14 and 5.67 respectively out of 12. On the other hand there was a significant difference between the participants’ pre- and post scores of ID ($t=3.51$, $df=20$, $p<0.05$). Table 4 indicates that pre-service teachers had a significant improvement in terms of the level of inquiry in general and designing an introduction part for an inquiry based lab design specifically.

| Paired Differences                  | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | t      | df | P  |
|------------------------------------|------|----------------|-----------------|------------------------------------------|--------|----|----|
| Pre-level – Post-level             | 0.81 | 0.87           | 0.19            | 1.21 – 0.41                              | 4.25   | 20 | 0.00* |
| Pre-intro - Post-intro             | 1.05 | 1.43           | 0.31            | 1.70 – 0.40                              | 3.36   | 20 | 0.00* |
| Pre-procedure - Post-procedure     | 0.38 | 0.92           | 0.20            | 0.80 – 0.04                              | 1.90   | 20 | 0.07 |
| Pre-conclusion – Post-conclusion   | 0.33 | 1.15           | 0.25            | 0.86 – 0.19                              | 1.36   | 20 | 0.20 |

According to the pre-ID results only 1 student designed the lab instruction in inquiry level 2 and one student designed an instruction in level 1. The rest of the participants designed a structured lab instruction or just wrote a procedure for the experiment. After the 6 week program, 5 of the participants designed the lab in inquiry level 3 and 2. 8 of them designed it in level 1. Moreover, the preservice science teachers showed an improvement in planning particularly introduction section of their lesson plans. Before the intervention only 5 students out of 21 made a clear introduction. After the intervention, this number increased up to 13, nine of which stated a motivating introduction that leads to inquiry.

4. Conclusions and Recommendations

It is plausible to argue that designing and implementing an inquiry based lesson requires an ability to integrate process skills into the lesson plans. In this research, although preservice teachers got high scores from a science process skills test, they were unable to design an inquiry based lab plan before the treatment. So, having high process skills were not a sufficient condition for designing an inquiry based lab lesson. After the treatment, preservice science teachers’ competence in designing an inquiry-based lab instruction improved substantially whereas there was no significant difference in their process skills. This implies that a lab-based intervention including metacognitive prompts, reflections, discussions and micro teaching practices could have a role in providing pre-service teachers with the necessary skills to develop an inquiry based lesson plans. Yet, this does not guarantee that preservice teachers would successfully facilitate and guide inquiry in a real classroom setting. For further studies, it is suggested that preservice teacher should be encouraged to apply inquiry based lesson plans in their practicum courses. So, preservice teachers could have an experience of inquiry discourse as suggested by
Oliveria (2009). It would also be an interesting and useful extension of this topic to investigate how the intervention program could be developed so as to improve its impact power.

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