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Creating Metacognitive Awareness in the Lab: Outcomes for Preservice Science Teachers

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This study investigated the influence of metacognitive guidance on pre-service science teachers' scientific knowledge, science process skills, and views about the nature of science. The sample included 48 pre-service science teachers taking a first-year chemistry laboratory course in a public university in Turkey. During the 11-week course, the students conducted 11 experiments. Four scales were administered to a control group and an experimental group as pre- and post-tests. Differently from control group, experimental group discussed the experimental design and completed a reflection form before and after each experiment. Moreover, experimental group answered questions about daily life implications. Results indicate that the inclusion of metacognitive guidance helped the students in the experimental group to improve their process skills and conceptual understanding.

Keywords: metacognitive awareness, learning outcomes, preservice science teachers

INTRODUCTION

The focus of the study is creating metacognitive awareness in a laboratory course. Specifically, it aims to examine the impact of creating metacognitive awareness during a lab course on pre-service science teachers' scientific knowledge, science process skills, and views about the nature of science (NOS). In order to create metacognitive awareness, the study makes use of metacognitivie prompts including questions, discussions, and reflections during the lab classes. In the study, "scientific knowledge" refers to science content knowledge including procedural, declarative, and conceptual knowledge. "Science process skills" refers to observation, experimentation, data collection, and interpretation. "NOS" refers to epistemological commitments underlying these processes (Abd-El-Khalick, Bell, & Lederman, 1998).

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Laboratory work has been considered indispensable to learning in science (Hofstein & Lunetta, 1982). Freedman (2001) found that students who had regular laboratory instruction acquired significantly more scientific knowledge than students who had no laboratory instruction. According to Tobin (1990), "Laboratory activities appeal as a way of allowing students to learn with understanding and, at the same time, engage in a process of constructing knowledge by doing science" (p. 405). It has been assumed that laboratory work helps students improve their analytical and critical skills as well as their creativity and enhances their interest in science through inquiry (Ottander & Grelsson, 2006). It seems that practical experience in the laboratory also helps students understand the nature of science (Ottander & Grelsson, 2006). In addition, the literature also suggests that (e.g., Mamlok-Naaman & Barnea, 2012) inquiry-based laboratory activities have a potential for students in fostering meaningful learning,

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State of the literature

- Increasing laboratory course hours and decreasing lectures hours are suggested in the literature for effective science teaching.
- Traditional "cookbook" laboratory practice (only hands-on) has been criticized because students verify the facts and concepts rather than being mentally engaged (also minds-on) in the learning process.
- For a deeper cognitive engagement in the learning process, laboratory instruction should engage students in the process of inquiry, identifying problems, designing investigations, and doing quantitative measurements; and provide them with opportunities for social interaction and reflection.

Contribution of this paper to the literature

- This study empirically examines whether metacognitive guidance during a laboratory work can develop pre-service science teachers' scientific knowledge, science process skills, and contemporary understandings of the nature of science (NOS).
- The results of the study showed that, in the experimental group, the inclusion of metacognitive guidance helped the participants improve their process skills and conceptual understandings.

conceptual understanding, and understanding of the nature of science.

Hone (1971) advocated the necessity of reducing the lecture courses. According to Hone (1971), "… teacher preparation in science must spring from direct involvement in the kind of science activities that can be used in the elementary classroom." (p.321). However, not all educators agree that laboratory work is an effective component of science teaching (Hofstein & Lunetta, 2004). "Cookbook" laboratory exercises have been criticized for focusing on procedures and information verification rather than cognitive engagement in learning (Hart, Mulhall, Berry, & Gunstone, 2000). This common form of laboratory experience may not contribute significantly to major aims of science education, such as improving science process skills. To be more effective, laboratory instruction should engage students in the process of inquiry, identifying problems, designing investigations, and doing quantitative measurements rather than following a "recipe" provided by the teacher (Shimizu, 1997). Additionally, providing students with opportunities for interaction and reflection can lead to more meaningful learning. Developing metacognitive skills could be an essential component of effective lab work (Baird, 1990). According to Sherman, et al. (1987), metacognitive abilities facilitate more sophisticated mental actions and cognitive development. Briefly, the literature suggests that learning is an active and dynamic process through which learners personally define learning tasks and apply their learning abilities for performing these tasks (Sherman, 1985) and in order for effective learning to occur, students should be exposed to metacognitive experiences.

In this study, we empirically examine if metacognitive guidance during a laboratory work facilitate acquisition of scientific knowledge, science process skills, and contemporary understanding of nature of science (NOS). The study uses a experimental design in which the experimental group is exposed to mecognitive prompts including questions, discussions, and reflections during the lab work. The influence of creating metacognitive awareness in the experimental group is discussed with a comparison to the control group.

METHOD

Sample

Forty-eight pre-service science teachers were the subjects of this study. They were in a first-year chemistry laboratory course at a public university in 2007-2008. This sample was divided randomly into two instructional treatment classes, one of which became the control group (n=26) and the other the experimental group (n=22).

Instruments

Five scales, namely the Motivated Strategies for Learning Questionnaire (MSLQ), the Test of Integrated Processes (TIPS), the Conceptual Knowledge Test (CKT), the VNOS-C, and an Achievement Test of knowledge of chemistry (AT) and were administered to the control group and the experimental group before and after the treatment.

Table 1. The research design

Group	Pre-test	Implementation	Post-test
Control group	VNOS, TIPS, AT, CKT	11 experiments, reports	VNOS, TIPS, AT, CKT
Experimental group	VNOS, TIPS, AT, CKT	11 experiments, reports, reflection forms, pre- and post-discussions	VNOS, TIPS, AT, CKT