Generating Students’ Information Seeking Questions in the Scholar Lab: What Benefits Can We Expect From Inquiry Teaching Approaches?

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Physics teachers use experimental devices to show students how scientific concepts, principles, and laws are applied to understand the real world. This paper studies question generation of secondary and under-graduate university students when they are confronted with experimental devices in different but usual teaching situations: reading about devices while studying still images or diagrams, watching an experimental demonstration, and handling the devices in the laboratory. The influence of the prior scientific knowledge on the questions asked is also analysed. Inquiry learning environments, involving lab projects, seemed to stimulate more inferences addressed to causality when students tried to build mental models, whereas reading about devices with the help of still images stimulate more descriptive inferences and inhibited predictive ones.

**Keywords:** basic physics, problem solving, experimental devices, question generation

**INTRODUCTION**

Teachers agree about the importance of experimental work in science education because it gives opportunities to develop some important competences in their students. First, practical work facilitates modelling reality with science (Truyol and Gangoso, 2012). Second, experimental situations in the Laboratory can be used to place the students’ work close to the scientists’ work (Chinn and Malhotra, 2002). Third, experimental work enables the developing of procedural competences such as using measuring techniques, controlling variables and relating numerical computing to real world. For their educational benefits, experimental activities in science education are a permanent focus of interest in many countries (see, for instance, Allen (2012) a special issue of the Eurasia Journal of Mathematics, Science & Technology Education devoted to practical work).
State of the literature

• Most of the literature emphasizes the gap between theoretical knowledge and practice in teaching. Gaining expertise in teaching narrows this gap.

• One instructional design theory that can be applied to provide increased development for pre-service teachers is expertise-based training (XBT).

• XBT is based on the idea that theories and findings of expert research can be used to create instructional strategies to enhance advanced learners’ expertise. Technology can benefit the presentation of these new methods.

Contribution of this paper to the literature

• This study is an example of how to use technology to present experts’ methods and strategies related to teaching in a real classroom.

• The current literature presents a consensus about decreased self-efficacy beliefs during classroom teaching. This study provides a method to bring real classroom experiences to teacher education courses.

• The literature reviewed on expertise in teaching and its effects on pre-service teachers’ self-efficacy beliefs was mostly theoretical articles. However, this study presents actual evidence of the effects of expertise in teaching on pre-service teachers’ self-efficacy beliefs.

Experimental devices are used in science education in different ways (Trumper, 2003; Holstein and Lunetta, 2004; Barolli, Luburu and Guridi, 2010 and references there in). This diversity is due, among other factors, to the varied conceptions that teachers have about what ‘science’ and ‘science learning’ are (Lederman, 1999). In fact, students faced experimental devices in science education, but not always in lab situations. Experimental devices appear in textbooks and are used in lecture demonstrations too. There are at least three basic different teaching situations involving experimental devices: a) Reading about the operation of experimental devices in a textbook, usually with the help of still images or diagrams; b) Watching the devices operation in a lecture demonstration or in a specialized movie; c) Handling the devices in a lab project. Reading about experimental devices or watching the devices operation in lecture demonstration are very frequent in science teaching but in these two ways students are not really engaged in experimental work. Both practices are typical in the ‘reception learning paradigm’ (Novak, 1979). Experimental projects, in which students are free to manipulate the devices, have been used in other teaching conceptions, as the ‘learning by discovery’ approaches or, recently, ‘inquiry teaching and learning’ (Anderson, 2002).

Inquiry learning has been defined as the educational process in which students being engaged in conceptual understanding, ask questions and construct solutions (Gunstone and Mitchell, 1998). According to Schraw, Crippen, and Hartley (2006), inquiry teaching promotes self-regulation because students have to activate “cognitive and metacognitive strategies to monitor their understanding (…) such as predict-observe-explain (Windschitl, 2002) or question-asking (Chin and Brown, 2002)” in investigation activities (p. 118).

In this vein, the present paper focuses on question-asking when students face experimental devices in inquiry environments. We would like to obtain support for inquiry teaching involving practical work, not only from epistemic but also from psychological grounds. Comprehension monitoring has been associated to academic success (Wang, Haertel, and Walberg, 1993) and deep comprehension (Chin and Osborne, 2008), and question generation has been defined as a monitoring mechanism. Therefore, developing students’ question asking in science education is essential to them to achieve deep understanding.

The aim of this paper is to obtain evidence about the type of questions generated when students are confronted with experimental devices handling them in the lab, as typical in inquiry teaching environments. We will use a cognitive approach to compare the above teaching situation to other usual teaching situations such as reading about experimental devices with the help of still images, and visualizing the devices operation in lecture demonstrations.

Students’ questions in science education

Scientific research begins with “a good question.” In fact, teachers agree on the educational potential of students’ questions (Chin and Osborne, 2008). Accordingly, students’ questions in science education have been analysed from several perspectives -didactic, epistemic, cognitive, procedural, etc. They have been classified using different criteria (Scardamalia and Bereiter, 1992; Watts, Gould, and Alsop, 1997; Anderson and Krathwohl, 2001; Chin and Chia, 2004), their quality has been studied (Graesser and Person, 1994) or they have been associated to comprehension, (Chin and Brown, 2002; Harper, Etkina and Lin, 2003). Other studies, apart from the ones in science education, have shown an improvement in comprehension and memory when students were instructed in question asking (Craig, Gholson, Ventura, Graesser, & the Tutoring Research Group, 2000; Rosenshine, Meister, & Chapman, 1996).

Finally, and related to the aim of this paper, questions about experimental devices have been also investigated. Students instructed in inquiry situations