USING THE ATTITUDE-BEHAVIOR THEORY OF REASONED ACTION TO UNDERSTAND SCIENCE TEACHERS' ATTITUDES TOWARDS PHYSICS, COMPUTER SIMULATIONS AND INQUIRY-BASED EXPERIMENTS

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ABSTRACT
The purpose of this paper was to investigate how use of an Interactive Computer-Based Simulation (ICBS) prior to performing a Laboratory Inquiry-Based Experiment (LIBE), in a conceptually oriented physics course, affects students' attitudes towards physics, the use of an ICBS, the use of a LIBE, and the use of a combination of an ICBS and a LIBE. The curriculum of the course focused on three physics topics, namely, Mechanics, Optics/Waves, and Thermal Physics. Each one of these three main topics had four subtopics. Twelve Interactive Computer-Based Simulations (ICBSs) representing each of the subtopics were used as introductory experiences before the Laboratory Inquiry-Based Experiments (LIBEs) were presented on each of the subtopics. The selection of the ICBSs and the LIBEs was based upon results reported in previous research studies and their use was based upon a self-control design where each participant was assigned alternatingly to the experimental and control treatments. The control treatment was an assignment to do additional problems in the same content area as the ICBS and required approximately the same amount of time. The data collection process involved structured interviews (pre- and post-interviews) that were administered before and after the course. The interview items were treated both quantitatively and qualitatively. The quantitative analysis focused on how students' attitudes towards physics, the use of an ICBS, the use of a LIBE, and the use of a combination of an ICBS and a LIBE change with time. The qualitative analysis investigated the participants' reasoning behind using an ICBS, a LIBE, or a combination of the two as part of the learning process. Students' attitudes towards physics, the use of an ICBS, the use of a LIBE, and the use of a combination of an ICBS and a LIBE were found to be highly positive.

KEYWORDS
Attitudes, computer simulations, inquiry-based experiments

INTRODUCTION

Reform proposals recommend comprehensive changes in science teaching (American Association for the Advancement of Science, 1993; National Research Council, 1996) and urge science teachers to meet content and pedagogy goals (Bybee & Ben-Zvi, 1998). However, any significant changes in practice that are needed will be difficult to attain because of science teachers' resistance to change (Lumpe, Haney, & Czerniak, 2000). In spite of this resistance, Zint (2002) raised the question "How can science education reform and other needed changes in science teachers' practices be fostered?" Lumpe, Haney, and Czerniak (1998a; 1998b) argue that the answer to this question requires an understanding of why teachers behave the way they do. One of the theories that seek to understand how and why individuals change is the attitude-behavior Theory of Reasoned Action (Fishbein & Ajzen, 1975; Ajzen & Fishbein, 1980; Fishbein, 1980). The Theory of Reasoned Action (TRA) has a relative ability to predict behavior, simplicity, and ease of operationalization (Sutton, 1998). The TRA further suggests that people's beliefs influence their attitudes, and that their attitudes influence their intentions to act. Albert, Aschenbrenner, and Schmalhofer (1989) characterized it as one of the most successful theories in attitude-behavior research. Similar arguments were made in previous attitudinal research studies in science education (i.e., Weinburgh & Engelhard, 1994).

This study investigated what effect the use of Interactive Computer-Based Simulations (ICBSs), the use of Laboratory Inquiry-Based Experiments (LIBEs), and the use of combinations of an ICBS and a LIBE, in a conceptually oriented physics course, had on science teachers' beliefs about and attitudes toward the use of these innovative approaches in teaching. Moreover, the study also examined the effect of these learning experiences on the teachers' intentions to incorporate these learning and teaching *tools*[1] in their own future teaching practices. Science teachers' attitudes towards physics, and the effect that the use of ICBSs and LIBEs had on their attitudes towards physics, also were investigated. In addition, it was examined if science teachers' beliefs about the use of the study's *tools* had any effect on their attitudes toward the use of these *tools,* and whether their attitudes had any effect on their intentions to use these *tools* in the future.

METHODOLOGY

Thirteen prospective physics teachers (postgraduates), four in-service and nine pre-service science teachers, attending a conceptual-based survey course in physics at a graduate school of education in New York City, comprised the sample.

In overall perspective, there were three instructional topics (Mechanics, Waves/Optics and Thermal Physics), each with four more subtopics. Each presentation of a subtopic had the same organizational plan. There was an introductory experience (differing for the experimental and control condition as explained below) followed by a LIBE that was the same for students in the experimental and control conditions. In the introductory experience, all participants had a reading assignment from the text and problem sets intended to orient them to the LIBE. However, the students in the experimental treatment assigned to the simulation condition (S) in addition used the ICBS. Whereas, the students in the control treatment, non-simulation condition (N), were given additional problems, comparable to the content, context and level of difficulty of the corresponding ICBS, to ensure comparability of opportunity to learn. A self-control design was used for assigning the participants to either an experimental condition or a control condition because of the small sample of the study. The assignment of the two conditions was random and followed an alternating pattern throughout the instructional sequence of the 12 subtopics.

The LIBEs were selected from the *Physics by Inquiry* curriculum (McDermott, 1996) and the *Tutorials in Introductory Physics* (McDermott and Shaffer, 1998) and the ICBSs were selected from simulations being available on the World Wide Web, based on previous research studies (i.e., Grayson, 1996; Hewson, 1985; Lea et al., 1996; Van Heuvelen, 1997). The LIBEs and the ICBSs were integrated into a sixteen-week semester physics content class. The objective of the study was to challenge science teachers' physics ideas in Mechanics, Waves/Optics, and Thermal Physics. In general, the course curriculum emphasized conceptual physics, instead of a more calculus-based approach [see Zacharia and Anderson (in press) for a sample of study's curriculum].

Science teachers' attitudes were assessed by individualized structured interviews. The construction of the interview items/questions followed techniques and procedures that were published in previous attitudinal studies (Ajzen & Fishbein, 1980; Atwater, Wiggins & Gardner, 1995; Chou, 1998; Fishbein & Ajzen, 1975; Fishbein, 1980; Hill, Atwater & Wiggins, 1995; Simpson and Oliver, 1990; Weinburgh & Engelhard, 1994; Zint, 2002). Interviews were carried out throughout the semester, twice for each

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[1] It refers to Interactive ICBSs, LIBEs, and the use of combinations of an ICBS and a LIBE. It also implies that these are *tools* that require special conditions for their implementation, such as, specific equipment (i.e., computers, apparatuses), users with particular skills (i.e., psychomotor, cognitive, meta-cognitive), applications of certain teaching and learning methodologies and strategies (i.e., exploratory learning, modeling) etc.. See *Methodology* for more details regarding the implementation of these tools in this study.

participant. The first interview was before the science teachers experienced the repeated use of ICBSs and LIBEs (pre-interview) and the second was immediately after the course finished (post-interview). The two interviews (pre- and post-) used the same interview protocol. However, in the pre-interview, information about teachers' history of using ICBSs or LIBEs in school or at home was also collected. The questions and items of the interview protocol were reviewed by a panel of experts (two science educators and a qualitative methodologist) for content and construct validity. Internal reliability data were collected, as well. Two science educators randomly reviewed 15% of the data that were collected and the amount of concurrence was computed as proportion of agreement. The reliability measures were greater than 0.95 across all of the questions/items assessed. The duration of each structured interview was about 60 minutes. Overall, 13 pre-interviews and 13 post-interviews were obtained.

RESULTS

The results of the present study confirmed previous research indicating that beliefs affect attitudes, and these attitudes then affect intentions and behaviors (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975; Fishbein, 1980; Weinburgh and Engelhard, 1994; Zint, 2002). In fact, these two patterns (beliefs affect attitudes, and attitudes affect intentions) were observed both before and after the study. A close examination of the teachers' beliefs and attitudes, before the study, revealed that the teachers believed that a LIBE was the most effective (had to offer more advantages) *tool* of the three to be used within a learning environment. In addition, their attitudes toward the use of LIBEs were found to be positive which confirmed their favorable disposition toward the LIBEs that was already portrayed through their beliefs and, also, confirmed TRA's expectancy-value model that beliefs influence attitudes. On the other hand, the teachers believed at that time (pre-interview) that the use of ICBSs and the combinations of an ICBS and a LIBE had to offer fewer advantages than the use of LIBEs and even for those advantages that were attributed to the two *tools* the prevalence was smaller than that of the LIBE. Moreover their attitudes toward these two *tools* were found to be within or close to the neutral range, much less positive than their attitudes toward the use of LIBEs, thus, further supporting Fishbein's expectancy-value model that beliefs influence attitudes. An examination of the teachers' attitudes and intentions before the study showed that the teachers' favorable disposition toward the use of a LIBEs (plus the fact that the teachers had neutral disposition toward the other two *tools*) appeared to have an effect on their intention to decide which *tool* they would consider incorporating in their own teaching practices. Most of the teachers during the pre-interview suggested that the LIBE was the tool that they would consider implementing in a physics curriculum and in their own teaching practices. This finding confirmed the second part of the TRA's expectancy-value model that attitudes influence intentions.

An examination of the teachers' beliefs and attitudes, after the study, revealed that the teachers believed that all three *tools* had numerous advantages to offer in an educational experience, however, they designated the combination of an ICBS and a LIBE as the most effective (had to offer more advantages) *tool* of the three to be used within a learning environment. This was not a surprise since the combination of an ICBS and a LIBE could combine the advantages of an ICBS, a LIBE and its own. As expected, their attitudes toward this *tool* were found highly positive, confirming once again the first part of the expectancy-value model that beliefs influence attitudes. The examination of the teachers' attitudes and intentions after the study showed that teacher's favorable disposition toward the use of a combination of an ICBS and a LIBE, also, appeared to have an effect on their intention to incorporate/implement this *tool* in a learning environment. All of the science teachers during the post-interview suggested that the combination of an ICBS and a LIBE was the *tool* that they would consider implementing in a physics curriculum and in their own teaching practices.

A pre and post comparison of the results showed a shift from the use of LIBE to the use of a combination of an ICBS and a LIBE which resulted in corresponding shifts among the teachers' beliefs, attitudes, and intentions. This final finding indicated that an individual's attitude is a function of his/her beliefs (along with the implicit evaluative responses associated with these beliefs) and that an individual's intentions are a function of his/her attitude and beliefs, and confirmed that science teachers' beliefs, attitudes, and intentions could be studied and understood based on the Theory of Reasoned Action.

DISCUSSION

It is important to emphasize at this point that this as study was done in the natural setting of a classroom and included the ICBSs and LIBEs within a context of intensive physics study, not an isolated experience, thus adding additional validity to the findings. An important implication of this study for curriculum developers is that it highlights the science teachers' belief-attitude and attitude-intention relationships that could potentially influence teacher preparation (professional development), especially, in terms of the instructional methods in science content courses. The science teachers of the study believed that using combinations of an ICBS and a LIBE would lead to mostly positive outcomes and held a favorable attitude toward using combinations of an ICBS and a LIBE in their future teaching practices. Findings like this are particularly important because implementation of current science education reform requires considerable adaptation of teachers' beliefs, attitudes and intentions in order to align requisite practices with the philosophy of reform. Levitt (2001) argued that, "if teachers' beliefs are incompatible with the philosophy of science education reform, a gap develops between the intended principles of reform and the implemented principles of reform, potentially prohibiting essential change" (p. 1).

Researchers argued over the years that one of the factors that affects positively teachers' attitudes is courses that are specifically designed for science teachers (Appleton, 1995; Morrisey, 1981; Schoon & Boone, 1998; Westerback & Long, 1990). Results of this study confirmed this argument. Science teachers' attitudes towards the use of an ICBS, the use of a LIBE, and the use of a combination of an ICBS and a LIBE, shifted from slightly positive, positive, and neutral, respectively, to highly positive. In addition, their attitudes toward physics were found positive over time. These results are important because it was shown that teachers with positive attitudes toward science were found to teach an adequate amount of science and to use hands-on, student-centered approaches (Bohning & Hale, 1998; Enochs, Sharmann, & Riggs, 1995). Arguably, the efforts of the science education community should focus on research issues related to the development of favorable teacher attitudes toward science and its learning/teaching tools.

CONCLUSION

An effective physics instruction must encourage the kind of learning that promotes positive attitudes. Such learning occurs when physics teaching focuses on creating classroom interactive learning to facilitate student self-direction in constructing physical science understandings. According to the study's participants, ICBSs and LIBEs can be used to provide such interactive learning and, therefore, physics curriculum and instruction, at least at the postgraduate level, should include them.

In addition, science educators should be encouraged to use ICBSs and/or LIBEs in their own teaching and classroom as it appears from the data of this study that is worth trying. An ICBS and a LIBE assisted instruction was proven to be a departure from the traditional ways of learning, clearly a novelty effect that, allowed students (science teachers in this case) to control such dynamic and interactive combination, empowered them, and gave them control of their own learning.

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