Prospective Teachers’ Levels of Understanding Heisenberg Uncertainty Principle and the Impact of Writing Activities for Learning Purposes on Academic Success

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SYNOPSIS

INTRODUCTION

Writing activities help students establish better communication. In addition, writing activities may enable students to become more accustomed to writing styles regarded as necessary in various academic disciplines and different areas of expertise. The interesting point is that writing helps students to think critically and form new knowledge (Klein, 1999). Many studies have been conducted with regard to the use of writing as a tool to develop learning and thinking. In their studies about learning by writing, Langer and Applebee (1987) stated that writing about a topic helps the writer to increase his/her knowledge and to arrange the ideas to be written, and that this contributes to the experience of learning (Mason & Boscolo, 2000).

Writing activities force the writer to express his/her ideas more clearly. Use of writing as an intellectual activity is an important means of purposeful/planned learning (Bereiter & Scardamalia, 1989; Bereiter, 1990, 1994). Doğan and Çavuş (2008) conducted a study named as “Impact of writing activity on learning science topics in informal learning environments”. In this study, they reported that, thanks to the writing activity, students learned how to summarize their knowledge, organize scientific thoughts by expressing them with their own words, and associate main ideas in a topic; in short, they learned how to present the information by organizing it.

In recent years, science education researchers have been deeply interested in the learning and teaching of quantum physics. It is seen that pedagogical studies of this topic
focus on conceptual learning, visualization, mathematical thinking and problem solving (Didiş, Özcan, & Abak, 2008). Some researchers (Singh, Belloni, & Christian, 2006) researched misconceptions relating to Schrodinger’s wave equation. They found that these misconceptions come about as a result of wrong generalizations. Findings obtained by Mashhadi and Woolnough (1999) in their study about how high school students simulate the concepts of electron and photon in their minds indicated that students form various unscientific representations in their minds. Pospiech (2000) argues that the mathematical structure of quantum physics hides the philosophical aspect of the theory. Ireson (2000) emphasizes that mathematical structure does not lead to any problem, and the main problem is the interpretation. Ke, Monk and Duschl (2005) mentioned that students’ ability to solve mathematical equations in examinations cannot be considered an indicator of their comprehension of the concepts of quantum mechanics. Singh et al. (2006) found that, even though students can solve mathematical problems, they cannot make qualitative explanations with regard to the questions.

**PURPOSE OF THE STUDY**

1) To determine understanding levels of prospective teachers, taking the required introduction to modern physics course in university, regarding the Heisenberg uncertainty principle,

2) To research the impact of writing activities for learning purposes on academic success of prospective teachers.

**METHODOLOGY**

a) **Research Design**

The present study has qualitative and quantitative designs. In the present study, open-ended questions allowing teachers to freely express their opinions about the research topic and to explain their scientific thoughts in a simple way (Akgün, Gönen, & Yılmaz, 2005; Bauner & Schoon, 1993) were used. A semi-experimental research model was utilized in the present study. Within the scope of this model, a pretest and posttest with a control group were applied in order to determine opinions of students about the Heisenberg uncertainty principle, and the impact of writing activities for learning purposes on academic success. The lesson was taught by using the “verbal-written lecture” (Akdeniz, Bektas & Yiğit, 2000) model in the groups. In addition, each student in the experimental group wrote a letter to a senior high class student to explain the Heisenberg uncertainty principle in an understandable way. On the other hand, students in the control group solved the problems relating to the Heisenberg uncertainty principle in the course book.

b) **Sample of the Research**

The sample of the research comprised a total of 111 students, 35 students (16 male, 19 female) in the experimental group and 36 students (18 male, 18 female) in the control group, all of whom studied in 3rd year of the primary science program in an Education Faculty in a Turkish state university in the academic year 2007-2008, and 40 students (23 male, 17 female) who participated in the study just in the stage of determining the understanding level.

c) **Application**

The methods and application stages conducted in the research process are presented below:
1) A pretest comprising open-ended questions relating to the Heisenberg uncertainty principle was administered to the groups at the beginning of the semester.

2) Examining the results of the pretest, it is seen that the arithmetical averages of the pretest scores of the groups are close to one another (3.66 and 3.75). This indicates that the difference between the scores of the groups is not at a significant level, and the groups can be considered equal ($p=0.942$) before the application.

3) After teaching the topic being researched according to the program, instructions regarding the writing activity for learning purposes were distributed to the experimental group, and these instructions were read and examined by all the students. Meanwhile, necessary explanations were made, and the questions of the students were answered in detail. In the instructions, the fact that the writing must be scientific and in letter format, the person to whom and the topic on which the letter will be written, when and how it will be delivered, and how it will be assessed were explained clearly and in detail.

4) Four weeks following the explanation of instructions for the writing activity for learning purposes, the letters written to the senior high school students by the experimental group were submitted. During this time, the control group students were asked to solve the problems relating to the Heisenberg uncertainty principle in the course book.

5) The posttest was administered to both groups on the same day. Along with the posttest, additional questions were asked only to the experimental group in order to determine their opinions about the writing activity for learning purposes.

6) During the days following the posttest, interviews were conducted with some randomly chosen students following the “open-ended sensitizing interview” style (Rubin, 1983; Yıldırım & Şimşek, 2005). These interviews were about the benefits of the writing activity for learning purposes.

d) Data Collection

The data of the study were obtained by utilizing a questionnaire comprising three qualitative questions related to the topic prepared by the researchers. Prior to administering them to the research groups, a pilot study was conducted by asking the research questions to the fourth year students who took the same modern physics course a year ago. It was concluded that the questionnaire was suitable for administration. Then, it was administered to the groups before teaching the course as a pretest, and it was administered to the groups as a posttest towards the end of the semester. In addition, during the semester, a midterm covering all of the topics was conducted after the completion of the writing activities for learning purposes as required by the academic calendar. The experimental and control groups were compared by evaluating the answers given to the questions on the midterm.

e) Data Analysis

The “SPSS 13” statistical program package was used in the analysis of the research data. At the end of the application, a posttest was administered to both the experimental and control groups, and posttest scores were compared by interpreting them via two independent samples t-test. While analyzing answers given by students to qualitative questions asked in the posttest, answers were grouped according to their closeness, organized in charts, and evaluations were made. Some of the original written answers, given by students to the open-ended question “What do you think about the benefits of the writing activity for learning purposes (the letter)”, which was asked just to the experimental group along with the posttest, were scanned. They are discussed below.
RESULT and DISCUSSION

At the end of analysis of the qualitative pretest data, it was seen that 38.2% of students could not write any equation about the Heisenberg uncertainty principle. 78.9% of the students could not make any explanation about the Heisenberg uncertainty principle. At the end of analysis of the data obtained in the examination of the impact of writing activities for learning purposes on academic success of the students while learning the topic of quantum physics is examined qualitatively, it was determined that 80.0% of the experimental group could define the Heisenberg uncertainty principle. This rate was 11.1% for the control group. The rate of students who were capable of correctly writing any equation relating to the Heisenberg uncertainty principle was 94.7% for the experimental group and 50.0% for the control group. It is striking that while 2.8% of the experimental group students could not make any scientific explanation about the symbol ћ, this rate was 27.8% for the control group.

In the quantitative examination of the impact of writing activities for learning purposes on academic success, posttest scores of experimental and control groups were interpreted and compared using a two independent samples t-test. It was seen that results of this comparison displayed a significant difference in favor of experimental group students. Examining the results of an examination performed as required by the academic calendar after the completion of writing activities, it was seen that the experimental group has higher percentages of answering the questions asked with regard to the topic on which they wrote the letter, compared to the control group. In the comparison of experimental and control groups, these rates are in favor of the experimental group; 66.7% for the experimental group and 54.5% for the control group.

Results revealed by this study support and parallel results of previous studies conducted with regard to writing activities for learning purposes. Examining the opinions of students about writing activities for learning purposes they made with regard to the Heisenberg uncertainty principle which is a topic of quantum physics, 91.4% of them stated that the letters they wrote ensured long-term retention of scientific knowledge (Rivard & Straw, 2000) and helped to learn the abstract concepts which are normally difficult to understand (Hohenshell, Hand & Staker, 2004). Continuing to examine the positive opinions whose percentages were mentioned above: as reported in other studies (Doğan & Çavuş 2008; Uzoğlu, Günel, & Büyükkasap, 2008), it was seen that students stated that, thanks to the writing activity, they learned how to summarize their knowledge, organize scientific thoughts by expressing them with their own words, establish communication, make comments, and associate the main ideas of a topic; in short, they learned how to present the information by organizing it. Students also stated that they remembered the topics about which they wrote letters more easily. It was found that negative opinions (8.6%) resulted from the type of writing activity rather than writing activities in general. In short, those students stating negative opinions generally mentioned that writing a letter about the Heisenberg uncertainty principle, which is a topic of quantum physics, is not an appropriate writing activity for learning purposes.

In the present study, it was found that students learning the “Heisenberg uncertainty principle” via the verbal-written lecture method and writing activity for learning purposes (a letter) are more successful compared to the students learning the same topic via the verbal-written lecture method and solution of related problems. This indicates that writing activities for learning purposes can be used as an efficient activity in teaching the Heisenberg uncertainty principle. This is because these activities facilitate students’ conceptual changes (Mason & Boscolo, 2000) and enable related concepts to be constructed by students in a successful and permanent way.
REFERENCES


