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The Level of Understanding of the Photoelectric Phenomenon in Prospective Teachers and the Effects of "Writing with Learning" on their Success Rates*

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Abstract

This study examines prospective teachers' levels of understanding the photoelectric effect, and the impact of writing activities for learning purposes on the success of prospective teachers. These prospective teachers study in the science teaching program of the faculty of education and take the course Introduction to Modern Physics. In this study, a semi-experimental design with a 'pretest'- 'posttest' control group was used. The research data were obtained via a questionnaire comprising qualitative questions prepared by the researchers. In all the groups, the lesson was taught by utilizing the verbal-written lecture method. In addition, each student in the experimental group wrote a letter to a senior high school student to explain the photoelectric effect in an understandable way. On the other hand, students in the control group solved the problems relating to the topic in the course book. A total of 111 third year students studying in the academic year 2007-2008 participated in the study. 54 of these students were female and 57 of them were male. The research findings indicated that prospective teachers have low levels of understanding the photoelectric effect, and qualitative and quantitative comparisons of posttest results of the experimental group and control group, and success percentages in the written examination were in favor of the experimental group. In addition, the opinions of students about writing activities for learning purposes were determined by means of additional questions to the posttest. 91.7% of the students mentioned that they understood the photoelectric effect about which they wrote the letter. These students also stated that this activity helped in their learning of this topic.

Key Words

Comprehension Level, Photoelectric Effect, Writing to Learn, Preservice Science Teachers.

It is known that scientists or teachers develop and use many teaching methods and techniques that can be mediators for the inclusion of students in the learning process. Today, many studies are conducted in many countries in order to make the learning environment more effective. Different learning approaches are tried in line with the findings of these studies. The number of scientists who support the following approach is increasing: Students form their own learning styles in ways that enable them to carry traces of the social environment they are in by giving sense to situations they have recently encountered in the light of their previous experiments and preliminary information (Horzum & Alper, 2006). The American Research Council states that science education requires more than study based on already known rules and theories, and that science courses should be conducted in different ways to courses in psychology, philosophy and history (National Research Council [NRC], 1996). There are important activities which are believed to improve cognitive process skills in

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science lessons. Writing activities with the aim of learning is the principal one among them.

It was seen in the 20th century that two main trends in writing in curricula received great interest. The first one, beginning in the 1930's and continuing until 1950s, was the trend that originated from Dewey's progressive education philosophy. The second trend is the one that emerged in 1970s and has lasted until today. During this period, writing has become a widely used teaching method in various levels of education and in the field of science throughout the world (Anson, Schwiebert, & Williamson, 1993; Bazerman & Russel 1994; Fulwiler, 1986; Klein, 1999; Martin, D'Arcy, Newton, & Parker, 1994; McLeod, 1992; Pearce, 1984; Russell, 1991).

The "Writing-Across-Curriculum" scheme in the USA became one of the most common education programs to be applied in any phase of education for all lessons (science, literature, mathematics, history etc.) (Quinn, 1995; Young & Fulwiler, 1986). Many studies were conducted about the usage of writing as an instrument which improves learning and thinking. In their research on learning by writing, Langer and Applebee (1987) state that writing about a subject makes the author enhance his/her information and organize the ideas to be written and that contributes to learning experience (Mason & Boscolo, 2000).

Writing activity obliges the author to express his/her ideas more clearly and explicitly. The usage of writing as an intellectual activity is an important way for planned learning (Bereiter, 1990, 1994; Bereiter & Scardamalia, 1989). Researchers (Hand & Prain, 2002; Günel, Uzoğlu, & Büyükkasap, 2009) suggest that a writing activity, with the aim of learning, has five components: the subject of the writing, the type of writing, the objective of the writing, the writing addressee, and the text production method. A study conducted by Doğan and Çavuş (2008) examined "the effect of writing activity on teaching science subjects in informal learning environments". Students stated that they had learned how to summarize information by the writing process of "summing up", how to order scientific ideas by expressing them in their own sentences and associating the main ideas in a subject and concisely presenting the information by organizing it. In another study (Özer Keskin, Doğan, & Keskin Samancı, 2008), students were asked to write an explanatory text by taking into consideration the questions asked in pretests. Most of the students stated that they reviewed their ideas and organized their information while writing the explanatory text. Akçay and Hand (2008) suggest that students' written and oral expressions reveal what the students have learnt how they interpret what they learn and how they associate these things with the information they already have. The same authors suggest that devising activities such as painting and writing (poems, letters, etc.) in science lessons increases student motivation for science lessons.

One of the areas to have intensely engaged physics education researchers in recent years is the learning and teaching of quantum physics. Pedagogical studies in this subject may be seen to concentrate on conceptual learning, visualization, mathematical thinking and problem solving (Didiş, Özcan, & Abak, 2008). Styer (1996), confirms the conceptual mistakes of students about such quantum subjects as quantum states and identical particles. Some researchers (Singh, Belloni, & Christian, 2006) have examined the conceptual mistakes made about the Schrödinger wave equation and reached the conclusion that those conceptual mistakes resulted from wrong generalizations. In the same research, the authors determined that students could not make qualitative explanations of the questions even though they could solve mathematical problems. In his study of quantum physics lessons, Şen (2000) emphasized that teaching quantum physics subjects at high school physics lessons level could bring important benefits. The findings obtained by Mashhadi and Woolnough (1999) on how high school students imagine electron and photon concepts, showed that students were open to both scientific and non-scientific representation. Pospiech (2000) argues that the mathematical structure of quantum physics conceals the more philosophical aspects of the theory. Ireson (2000) stresses that the mathematical structure does not pose a problem and that the main problem is about interpretation. Strnad (1981) shows that the inadequate mathematical background of students to be the reason why teaching quantum physics subjects in high school is difficult. Ke, Monk and Duschl (2005) argue that solving mathematical equation in exams cannot be seen as an indicator that students understand quantum mechanics concepts. In their study, Didiş et al. (2008) revealed the variety in student ways of describing quantum physics. Their research revealed that students used the "microscopic system" the most and that the concept they considered to be the most important was the "Heisenberg uncertainty principle" in quantum physics.

In a study conducted by Akdeniz, Bektaş and Yiğit (2000), the comprehension levels of primary school students in the 8th grade for basic physics concepts were examined. In this study, it was determined that students had difficulty in understanding and expressing the concepts at 70% level in the subject of electricity and at 40% level in the subject of magnetism. The reasons shown for low comprehension levels are as follows: not understanding the language used, using the "written-oral expression" method mostly in the situation where the teacher is mostly active while the student is passive, and the low rate of using different strategies. Additionally, in the study by Sökmen, Bayram and Yılmaz (2000) of the physical and chemical change concepts comprehension levels of 5th, 8th. and 9th grade students, the inadequate use by teachers of teaching strategies, methods and techniques was shown to be one of the reasons why students generally leave blank the places on answer sheets where they should explain the concepts.

The studies to help teachers or university professors to understand the view of students about the subjects of quantum physics appear to be inadequate despite the fact that force and gravity are the first fields researched in physics (Berg & Brouwer, 1991), and that there are so many studies (Anderson & Karraquist, 1983; Boyes & Stanissreet, 1990; Cepni & Keles, 2006; Engelhardt & Beichner, 2004; Ericson & Tiberghien, 1985; Feher & Meyer, 1992; Galili, Goldberg, & Bendall, 1991; Gülçiçek, 2002; Harrison, Grayson, & Treagust, 1999; Kara, 2002; Osborne, 1983; Periago & Bohigas, 2005; Ramadas & Driver, 1989; Sencar & Eryılmaz, 2004; Shipstone et al., 1998; Solomon, 1985; Thomas, Malaquias, Valente, & Antunes, 1995; Watts, 1983; Yeo & Zadnik, 2001; Yıldız, 2000) in literature in such fields as electricity, heat and temperature, and energy and light.

Aim of the Study

1) To determine the photoelectric phenomenon comprehension levels of prospective science teachers who take the obligatory "Introduction to Modern Physics" course at university,

2) To research the effect of writing activities in relation to learning aims on the success of prospective science teachers.

Method

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 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-posttest control group design was applied in order to determine opinions of students about the photoelectric effect, and the impact of writing activities for learning purposes on academic success. The lesson was taught by using the "verbal-written lecture" (Akdeniz et al., 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 photoelectric effect in an understandable way. On the other hand, students in the control group solved the problems relating to the photoelectric effect in the course book.

Sample of the Research

The sample of the research comprised a total of 111 students, 36 students (18 male, 18 female) in the experimental group and 35 students (16 male, 19 female) in the control group, all of whom study in 3rd year of the primary science education faculty in a 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.

Application

The methods and application stages conducted in the research process are presented below:

1) A pretest comprising open-ended questions relating to the photoelectric effect was administered to the groups at the beginning of the semester.

2) Examining the results of the pretest, it was seen that the arithmetical averages of the pretest scores of the groups were close to one another (3.75 and 3.66). This indicated that the difference between the scores of the groups was not at a significant level, and the groups could 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 had to be scientific and in letter format, the person to whom and the topic on which the letter would be written, when and how it would be delivered, and how it would be assessed were clearly explained in detail.

4) 4 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 photoelectric effect 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.

Data Collection

The data of the study were obtained by utilizing a questionnaire comprising four qualitative questions relating 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 to be used. 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.

Data Analysis

SPSS 13, statistical software 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.

Results

At the end of the analysis of the qualitative pretest data, it was seen that 30.6% of students could not write any equation about the photoelectric effect. 32.0% of the students could not make any explanation about the systems in which photoelectric effect is used in daily life. 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 94.5% of the experimental group could define the photoelectric effect. This rate was 80.6% for the control group. The rate of students who were capable of correctly writing any equation relating to the photoelectric effect was 58.3% for the experimental group and 51.4% for the control group. It is striking that while 16.7% of the experimental group students could not make any scientific explanation about the systems in which the photoelectric effect is used in daily life, this rate was 31.4% 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 had 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 were in favor of the experimental group; 90.9% for the experimental group and 76.5% for the control group.

Discussion and Conclusion

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 photoelectric effect which is a topic of quantum physics, 91.7% 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 (8.3%) resulted from the type of writing activity rather than writing activities in general. In short, student stating negative opinions generally mentioned that writing a letter about the photoelectric effect, 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 "Photoelectric effect" 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 photoelectric effect. 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.

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