Opinions of Prospective Teachers about Physics-Technology and Physics Teaching

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Abstract. In this age, the need for technology literate workforce has increased. The responsibility of teachers has increased in the education systems that will train this workforce. In order for individuals to be trained in accordance with the skills required for the 21st century, it is important to train prospective teachers for these skills. Physics course has an important place in science and accordingly technology. In this study, it was aimed to increase the awareness of prospective teacher candidates on this subject and to develop the skills of researching technology, understanding, and transferring them in accordance with the classroom environment. The study was carried out with a total of 21 students according to qualitative research methods in 2016-2017-2018 fall semesters. They were asked to research the two technologies they wanted, to identify the physics topics within the scope of these technologies, and to transfer this to the classroom environment. Findings were obtained from the data collected through observation, document review and semi-structured interview techniques. At the end of the study, it was determined that prospective teachers increased their awareness about the importance of technology and physics in technology in physics teaching. In addition, it was concluded that prospective teachers wanted to research new technologies and adopt the behaviour of discussing technology in their lessons. It is suggested that these results should be extended to other prospective teachers in order to train individuals not only using technology but also producing it.

1. Introduction
The contributions of science and technology produced based on science to the development of societies are enormous [1]. Technology is involved in every aspect of our lives and we live intertwined with technology. In fact, societies are now almost driven by technological products [2]. On one hand, life becomes easier with the developing technology, on the other hand it becomes difficult with a fast accumulation of knowledge. Therefore, a workforce with a higher level of science and technology literacy is needed today [3][4]. In order to train this workforce, the skills expected from students are beyond only achieving the school success. They are expected to be more productive individuals who can fulfill the requirements of the era they live in, in other words, who can use technology well and transform their knowledge into technology. In order for societies to be productive, developing technology skills of students is an important requirement [4]. For this reason, the importance of science education has increased in the 21st century and accordingly, the responsibility of science teachers has increased in schools [5],[6]. It is important for teachers to support their lessons with technology tools, but this is no longer sufficient alone. Teachers should also emphasize the importance of the subjects they teach for the technologies used in daily life. In this way, the student will comprehend how to use the acquired information, and the place and importance of this information in life. For this reason, it is very important for teachers to follow the latest developments in technology regularly. This behavior of the teacher will enable the students to realize the usability of the knowledge gained in the lessons in technology. As a result, technology literacy levels of students will increase.

Physics concepts and relations that have an important place in science are also frequently used in technology. Physics has a great place and importance in modern societies because an effective and permanent physics education is required for the correct understanding of technology [7]. In the studies of Whitelegg and Parry, it is seen that students older than 16 years of age do not prefer physics courses
due to reasons such as finding physics difficult, too mathematical and finding course content overloaded, and not being able to associate physics with society [8]. Field courses such as mechanics, electricity, quantum physics are particularly important, but they are no longer sufficient in the 21st century alone. Because students of this age should not only store information in their minds but also use that information. Students should be aware of the transformation of physics laws, which have an important place in science, from theory to practice. Therefore, there is a need for lessons on the place and importance of physics in technology in order to train future STEM makers. Thus, understanding the place and importance of physics in technology will form a basis for STEM Learning-Teaching [6]. In particular, increasing the awareness of prospective physics teachers on this subject will contribute to physics teachers in associating physics-technology and physics education with each other. Future physics teachers will take a more active role in educating students as individuals who not only use technology but also can produce it.

1.1. Purpose of the Research
While there is a close link between physics and technology, it is not possible to keep physics education away from this connection. Recognizing the latest technology based on the basic laws in physics will affect the motivation of prospective teachers towards lessons. In fact, real-life teaching will not only increase students' interest in the lesson but will also increase the skills required for this century, such as problem solving [9]. Considering this fact, it is important that the prospective physics teachers can use the physics-technology relationship both while learning physics and teaching their students in the future. In order to educate students with 21st century skills, teachers who not only use technology but also understand and teach are needed. Prospective teachers theoretically know that they should give examples from current life in lessons, but they cannot find a chance to practice. In this sense, the study gains importance with completing the deficiency in the literature and its contribution to the field. For this reason, the aim of this study is to improve the skills of prospective teachers to follow, understand and explain the technology in an appealing way. Another aim of the study is to increase the awareness of prospective teachers about associating physics-technology and physics education.

1.2. Research Questions
The main questions of the research are as follows:
(1) Which technologies are prospective teachers most interested in? Which physics topics are encountered when establishing a connection between physics and technology?
(2) What is the level of prospective teachers' skills to follow technology, relate technology and the physics involved in it, transfer this relationship to the classroom environment, and their awareness on this issue?
(3) What are the opinions of the prospective teachers about the relationship between physics-technology and physics education and about the course?

2. Method
2.1. Study Group
The study was carried out at a public university, faculty of education. The study group is senior students enrolled in the "Applications of Physics in Technology" course in the fall semesters of 2016-2017-2018. The "Applications of Physics in Technology" course is an elective course and it is provided only in the fall semesters. Students from other departments are allowed to take the course. Thus, students from different departments interested in Physics and Technology can enroll in this course. However, the target group for this study are prospective teachers. In the years of 2016-2017-2018, in which the study was carried out, a total of 21 prospective teachers (15 females, 6 males) and 1 electrical-electronics engineering student (1 male) enrolled in the course.
2.2. 

Data Collection Tools

The study was carried out with qualitative research methods. In the study, three different techniques such as document review, observation and semi-structured interview were used. In this way, it was aimed to increase the validity of the research by providing data diversity [10]. According to this;

2.2.1. Document. At preparation stage, a detailed information about the activities to be carried out during the semester was provided to the students. Firstly, students were asked to conduct research on two topics of interest about the applications of physics in technology. Students are free to choose the topic they want. They were asked to prepare reports (draft documents) about their research in accordance with a structured format. The purpose of drafting a document appropriate to a structured format is related to the lack of a standard format, which is one of the limitations of document analysis, and to eliminate the effect of coding difficulty.

Accordingly, prospective teachers were asked to comply with the following steps:

1. First, the physics basis of the researched technology should be addressed, and definitions, concepts and relations should be given about the related physics topic. The topic should be supported with visual materials such as figures, graphics, videos etc.
2. The researched technology should be introduced; its contribution to daily life should be addressed, and it should be associated with the physics issues described in the previous step.
3. It should be evaluated how the researched technology can be used in physics teaching according to the physics topics.

At document drafting stage, students are given 2 weeks to draft their research reports (documents) in accordance with the format expected from them. During the document drafting stage, they were guided by the researcher on the issues they needed support.

At sharing of the document in classroom, the students presented the documents they prepared in the classroom. Presentations are limited to one student for each course. At the end of the presentation, related subjects and research results were discussed among students.

At document review stage, the finalized documents are examined by the researcher and the obtained data are detailed in semi-structured interviews.

2.2.2. Observation. It was observed by the researcher that the students presented their research results in the classroom environment and shared them with their friends. In this process, an observation form was created for prospective teachers' skills to follow technology in daily life, to understand it and to transfer it to the classroom environment. Observations were made regarding these determined skills. Observation was carried out as a natural environment study (field study) by the researcher by taking notes to the observation form without interfering with the classroom environment. The role of the researcher is “participant as an observer”. In this type of observation, the researcher explains the fact that he is an observer at the beginning of the research [11].

2.2.3. Semi-structured interview. A semi-structured interview form was planned by the researcher to elaborate document and observation data and to get the opinions of prospective teachers about the subject of the research and the course. The interviews were completed in the last two weeks.

2.3. Data Analysis

21 prospective teachers and 1 electrical-electronics engineering student who enrolled in the Technology Applications of Physics course in 2016-2017-2018 fall semesters researched a total of 44 technology topics.

Considering the number of prospective teachers interested in the course during the research years, 3 prospective physics teachers enrolled in the course in the first year. However, the number and branches of prospective teachers increased in the following years. Number distribution and branches of the prospective teachers enrolled in the course in 2016-2017-2018 are given in Table 1. It was observed that not only prospective physics teachers but also prospective science teachers and prospective preschool
teachers showed interest in the course. In 2017, 1 student of electrical electronics engineering enrolled in the course. This student also emphasized the importance of coding and robotics courses in physics education through research on electrical circuits and robots. However, this student was not shown in the data analysis and tables, since the student was not included in the study group determined for the research questions.

Table 1. Number and branches of prospective teachers participating in the research by years.

| Year | Prospective Physics Teacher | Prospective Science Teacher | Prospective Preschool Teacher |
|------|-----------------------------|----------------------------|----------------------------|
| 2016 | 3                           | 0                          | 0                          |
| 2017 | 6                           | 0                          | 2                          |
| 2018 | 7                           | 3                          | 0                          |
|      | Total: 21                   |                            |                            |

The results were interpreted by making content analysis of the data obtained. For this purpose;

1) Documents prepared by prospective teachers on the topics they researched were examined, and the physics topics included in the research topics were grouped. Physics topics and concepts frequently encountered in technology are categorized into related basic physics fields.

2) Observational data were also evaluated and interpreted. The data were evaluated according to the sub-categories such as prospective teachers' skills of following the technology, associating the technology they are interested in with the concepts in physics, and using this relationship in physics education. The data obtained from the document analysis were compared with the data obtained from observation in the classroom environment.

3) At the last stage, the data obtained from the document review and observations were detailed with the semi-structured interview method. In this regard, how prospective teachers associate Physics-Technology and Physics Education with each other, how their awareness on this subject has changed, what their views on the course are discussed.

3. Findings

According to the content analysis of the data obtained from 3 qualitative research methods applied for data collection, the following findings were obtained. Accordingly;

3.1. Findings Obtained During the Document Review Stage

A total of 42 research documents belonging to prospective teachers were examined. When the data are compared by years, it has been found that some topics are preferred almost every year. Frequency of prospective teachers to prefer technological topics is given in Table 2.

Table 2. Frequency of prospective teachers to prefer technological topics

| Research Topics       | Frequency |
|-----------------------|-----------|
| TrackIR               | 1         |
| Projection Keyboard   | 1         |
| Fiber Optics          | 3         |
| Lasers                | 2         |
| LEDs                  | 2         |
| Superconductivity     | 3         |
| Ion Propulsions       | 1         |
| Imaging Techniques    | 3         |
| Spectroscopy          | 2         |
According to the findings obtained from the frequency distributions, it has been found that the topics discussed every year are fiber optics, superconductors, imaging techniques, nanotechnology, thermal cameras, and quantum computers. Almost all of the technologies researched include more than one physics concept. The physics concepts included in each technology are given in Table 3.

Table 3. Physics topics related to the researched technologies

| Research Topics                  | Physics subtopics                                                                 |
|----------------------------------|----------------------------------------------------------------------------------|
| TrackIR                          | Infrared rays                                                                    |
| Projection Keyboard              | Red laser diode, sensor, infrared rays                                           |
| Fiber Optics                     | Electromagnetic waves, reflection, and refractions laws                         |
| Lasers                           | Photons, light, atoms                                                            |
| LEDs                             | Diode, Optoelectronics device                                                    |
| Superconductivity                | Electricity Field, Magnetic Field                                               |
| Ion Propulsions                  | Ions, Electricity Field, Magnetic Field                                          |
| Imaging Techniques               | Properties of matter, electron, neutron, X-ray                                  |
| Spectroscopy                     | Light, sound                                                                     |
| Vacuum cleaner                   | Electricity, Electric Motor                                                     |
| Smart board                      | Infrared Sensors                                                                |
| Photocell                        | Optoelectronic circuit elements, photons                                         |
| Cooling Systems                  | Thermodynamics                                                                   |
| Nanotechnology                   | Atoms, Molecules                                                                 |
| Quantum Computers                | Spin of electron, superposition, Qubits                                          |
| Thermal Cameras                  | IR energy, lens, sensors                                                         |
| Printers                         | Laser beam, magnetic field                                                      |
| Drones                           | Rotor spin, Newton’s 2nd and 3rd laws, Thrust                                    |
| Shock Absorber in Vehicles       | Mechanics                                                                        |
| Ghost Planes                     | Electromagnetic waves, Radar, Insulating material                               |
| X-ray                            | Electromagnetic waves, Photons                                                  |
| Diodes and Transistors           | p-and-n type semiconductors, active circuit elements                             |
| Hologram                         | Laser beam, optics matters,                                                     |
| Solar Cells                      | Photons, electron, current, Semiconductors                                       |
The physics sub-topics of Table 3 were re-classified, and the basic physics fields related to the research topics were determined. According to this, the basic physics fields that prospective teachers encounter during their research are Electricity and Magnetism, Optics, Mechanics, Atomic Physics, Quantum, Thermodynamics, Waves, Electromagnetic Waves, Semiconductor Physics.

3.2. Observational Findings

In the category of following technology, prospective teachers completed their research on time and made their presentations. Since they were free in choosing topics, they researched technologies that are suitable for their own interests. The research method they used was generally in the form of internet research. In their documents, they provided websites as a resource. Video links were mainly used in presentations. Prospective teachers wanted to watch interesting videos again.

Prospective preschool teachers requested support from the researcher in the category of associating the technology they are interested in with the concepts of physics. These prospective teachers who prepared their documents with support, made their presentations on time. Prospective teachers used the figures and videos while associating the technology with physics.

In the category of using technology and physics in physics education, the prospective teachers made their evaluations in the classrom environment after presenting the documents they prepared. According to this, each prospective teacher evaluated how the technology they researched could be used in physics teaching. The prospective teachers exchanged ideas at this stage.

3.3. Findings Related to the Semi-Structured Interviews

Findings of the interview form prepared for detailing the answers to the research questions and investigating the grounds of the data obtained from the documents and observations are given below. Accordingly, the opinions of prospective teachers regarding the use of technology in physics education by associating the concepts with technology are given in Table 4.

Table 4. Prospective teachers' opinions on the question "Should the relationship between physics and technology be used in Physics Education? Please explain why".

| Theme      | Subtheme*                                      | f |
|------------|------------------------------------------------|---|
| Positive   | It increases motivation                        | 18 |
|            | It provides new learning outcomes              | 2  |
|            | It must be used                                | 20 |
|            | Physics course will be more popular            | 17 |
|            | Permanent and effective learning is provided   | 8  |
| Negative   | It is time consuming                           | 1  |
|            | It is not always applicable                    | 1  |

* Some of the prospective teachers' answers include more than one theme. Similar statements were evaluated in the same category.

Two prospective teachers stated negative views. Those prospective teachers approached the question of "Will you use the context of physics and technology in your professional life? negatively (f=2)". The opinions of other prospective teachers (f=19) were positive.

Themes of prospective teachers' opinions about the applications of physics in technology course are given in Table 5. Prospective teachers did not state negative opinions.
Table 5. What are your opinions about the "Applications of Physics in Technology" course?

| Theme                              | f* |
|------------------------------------|----|
| Providing new learning outcomes    | 6  |
| Gaining experience                 | 11 |
| Contribution to professional life   | 11 |
| Learning new technologies          | 13 |
| Finding fun                        | 2  |

*Prospective teachers' answers include more than one theme.

Some statements taken from prospective teachers' opinions about the course are given below (T: Prospective Teacher).

T1) "By means of the applications of physics in technology course, I attained a lot of new learning outcomes. I learned how a teacher should connect technology and physics in class."

T2) "The Applications of Physics in Technology course I attended at Hacettepe University has provided important learning outcomes for prospective teachers, especially for students studying physics education. I think it is the responsibility of the teachers to convey the information obtained from this course in an intriguing way instead of conducting a boring and rote learning."

T3) "As a Physics Teaching student, what I have learned in the Applications of Physics in Technology course will be useful in my professional life in terms of motivating my students, developing their imagination, and making them love physics. Today is the age of technology and new things are being developed every day. In order for us not to be unaware of these, the Applications of Physics in Technology course is vital and necessary in this regard."

T4) "As a person who uses the internet a lot in the daily life, fast internet service is important for me, but I have not done a research on this topic even though I frequently heard the term "internet at the speed of light". By means of this research conducted within the scope of the course, I had the opportunity to learn the differences between the use of copper wire and fiber optic cable and the place of fiber optics in our lives."

T5) "This course has given us a perspective to address such issues, which we wonder and make us think, astonished, ask the question of "how" and often come across in daily life, with different people from different perspectives. I express my sincere thanks to our professor and the University for providing this opportunity."

T6) "In this course, I had the opportunity to keep abreast of all the latest developments in technological products. I had the chance to learn the operation principles of the products I use in daily life but do not think how they operate, their changes over time, their features based on physics."

It has been determined from the interviews that prospective teachers are more interested in technologies that are frequently encountered in daily life. According to the findings obtained from the documents and observations, prospective teachers use the internet for their research. According to the findings obtained from the interviews, the reasons for this can be summarized as fast access to information through the internet, ease of writing reports and lack of current news in books.

4. The Results and Suggestions

In this study, it was aimed to improve the skills and awareness of prospective teachers to follow, understand and use technology in classroom environment and to determine their opinions on physics-technology and physics teaching.

Prospective teachers coded the elective course, "Applications of Physics in Technology", on their own will. It can be interpreted that prospective teachers have a certain awareness about the subject of the course at the beginning of the course. The findings of the semi-structured interviews reveal that the course has increased the awareness of the prospective teachers as they stated their opinions as "they had the opportunity to gain experience" and "the course contributed their professional life". This result can
be interpreted as prospective teachers gained perspective for the place and importance of technology in physics teaching instead of just wondering and following technology.

The increase in the number and variety (different branches) of the prospective teachers participated in the research can be interpreted as the interest in the applications of physics in technology has also increased. For example, it is very important for prospective preschool teachers to be interested in a technology course. In the interviews, they stated that they have now grasped the innovations, which they did not have the opportunity to wonder and understand the way those innovations are used in daily life. As a consequence, their opinions about the course are positive. Today, there is a need for a conscious teaching staff who can teach technology to our young children effectively. Considering that kindergarten age children are also growing up with technology, it is particularly important to teach them that technology is not just playing games from mobile phone or tablet. Teachers who can use technology correctly in their lessons play a significant role in developing technology curiosity in young age groups. For this reason, it is recommended to increase the activities for prospective teachers' technology literacy in preschool education programs. As another example, we can consider the electrical and electronics engineering student's emphasis on the importance of coding and robotics courses in physics education as an approach that combines physics and technology in physics education. This connection established by the electrical and electronics engineering student can be interpreted by the fact that an individual studying at a different department internalizes the content of the course. This result may be attributed to reasons such as the frequent use of the related topics in daily life, their frequent media coverage, and providing these topics as examples in different theoretical courses. This issue can be addressed further in future studies with a different research. It is recommended for prospective teachers to research different topics to learn new things. In this way, they can use different examples in physics teaching.

The main physics fields that prospective teachers encounter in the research process are Electricity and Magnetism, Optics, Mechanics, Atomic Physics, Quantum, Thermodynamics, Waves, Electromagnetic Waves, Semiconductor Physics. According to the findings given in Table 3, it has been concluded that the most common physics fields are optics, electromagnetic waves and semiconductor physics, and the least encountered topics are thermodynamic and quantum physics. It is recommended to prospective teachers that they should conduct the lesson with a more life-based technology, while teaching the topics of optics, electromagnetic waves, semiconductors.

According to the findings in the document review and observation stage, it was concluded that the prospective teachers mostly use the internet environment in following up the technology. Prospective preschool teachers needed support in establishing the physics basis of the researched technology, but this condition did not prevent them from completing their research. Each prospective teacher discussed the evaluation part of their reports at the end of their presentation. During the interviews and presentations conducted with prospective teachers, they expressed their opinions on how to use physics and technology in their lessons as teachers in the future. The science and preschool teachers made their evaluations by adapting the issue to their own fields. In conclusion, this stage is important because it is the stage where prospective teachers gain experience and awareness about how to use physics and technology in the lesson.

According to the findings of the structured interviews, almost all prospective teachers have an opinion about the necessity of using the physics-technology relationship in the classroom environment. Two prospective teachers expressed negative opinions. The prospective teachers want to give their lessons by associating them with technology in their professional life (except for the above mentioned two students). These results can be interpreted that prospective teachers will continue to keep up pace with the technology.

Findings regarding the opinions of prospective teachers about the "applications of physics in technology course" were mostly obtained from the categories of "learning new technologies", "gaining experience", "contributing to professional life". Based on these findings, we conclude that prospective teachers make positive evaluations about the course. Two prospective teachers who have a negative approach to using the physics-technology relationship in the lessons also expressed a positive opinion
about the lesson. In line with the opinions expressed by the prospective teachers, we can say that the course and the research have achieved their objectives. It is recommended for this course that the course content should be updated frequently, the follow-up of new technologies should be left to prospective teachers who attended the course and by this way, it is also recommended that the skills of researching new technologies should be developed and adopted as a behavior. Thus, it will be ensured that individuals who not only use technology but also produce it can be trained.

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