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## Investigation of the Effect of the Integration of Arduino to Electrical Experiments on Students' Attitudes towards Technology and ICT by the Mixed Method

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**Abstract:** In this research, After I have realized some technological applications in the course of general physics laboratory II of the science teacher program, this research aims to examine the effects of the students' attitudes towards technology and the information of the communication technology (ICT) with the mixed method. For this application, after the introduction of Arduino was done, it was used as a measuring instrument in the laboratory; it also used the Fritzing program for circuit diagrams and the e-support system for sending poster studies. The research was carried out with the 50 first-year students of the department of science education at Kocaeli University. In this study, the attitude scales toward technology and ICT were used to collect the quantitative data, and a semi-structured interview form was used to collect the qualitative data. For the quantitative analyses in the study, "t-Test for Dependent Groups" and "A Two-Way ANOVA was used for Complex Measurements", for the qualitative analyses, "Descriptive Analysis" was used. The two analyses were combined according to the mixed method research model and interpreted. The results of the research showed that technological applications in the physics of the laboratory such as using arduino, fritzing program, and poster studies have a significant effect on the attitudes of students in the study group toward technology and ICT, and it was supported by the qualitative research.

**Keywords:** *Arduino, students of the science education program, physics laboratory, fritzing program.*

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### Introduction

To be conscious, productive and successful new generations and the importance of giving good education to children gains more importance every day. Moreover, the best teachers can only give the best education for productive generations. In order for a teacher to be effective in education, he should show behaviors that meet most educational expectations of the students. In order for the teacher to be able to meet expectations in every subject, the teacher needs to be able to constantly improve himself/herself, provide good classroom management and carry out classroom innovations. In order for teachers to have such equipment, the training they receive requires that quality. In this case, it is important that the education faculties where the teachers are educated are equipped in many ways, so that a good education can be given (Ozcan, 2011).

For a branch that constantly changes, develops, possesses scientific activities and technological developments and follows all kinds of new knowledge, laboratory courses that complement field and formation courses constitute an important part of science education.

A teacher who will make a habit of using simple or technological tools in the laboratory will be useful to guide his students in the projects they can produce with these technologies. Laboratories are also important in terms of understanding subject concepts for teacher candidates. It has been found that when laboratory courses are realized using technology, motivation towards lessons increases and students acquire more scientific process (Cayir, 2010; Senol, 2012).

Educational institutions have technological devices such as computers, smart boards and projectors where they can integrate laboratories with some technological tools; however, it seems that they could not make benefit of this technology as much as necessary. However, a new generation of such technologies can be used effectively in science,

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physics, chemistry and biology laboratories. An easier and more visual teaching environment can be provided to students by using information and computer technology software in order to bring concepts, principles and theories into description of nature and natural phenomenon more easily in science courses (Cepni and Ozmen, 2010). Some complex, difficult to understand or dangerous experiments in science can be carried out safely in a computer environment (Ayas, 2006). Experiments conducted with applications such as computers, smart boards can help students in the learning process and can improve permanence.

Various measurements and calculations in science and physics laboratories can be done with computer, these calculations can be evaluated in a simple way on the computer and more accurate results can be obtained quickly. Such programs will help students how to learn about the subject and will allow them to see more clearly and visually some applications that only students can do on problems. Besides, it has been determined that it is more attractive for students to teach laboratory applications using computer technology in studies carried out abroad (Cameron, 2005).

The need for technological materials to be prepared for use in science lessons in the age of technology is growing more and more every day (Cepni and Ozmen, 2010). The needs and changes in this area are reflected in the curriculum of Ministry of National Education. According to the new curriculum prepared by the Ministry of National Education, science and engineering applications are drawing attention as new course content within the science course. In the curriculum context, applications towards technology help students to establish connections between engineering and science, enables them to understand interdisciplinary interactions, and helps them to develop their worldview by making them learn experientially (MEB, 2017). From the fourth grade to the end of the eighth grade, science and engineering applications were added as the last unit of each period and students were asked to design new products from the end of each semester. In these workshops - where many coding activities were set up for science and engineering education - students began to learn coding at an early age. For coding, the applications of the students usually use non-complicated applications which can be given with a simple command system. Encoding should not be considered for engineering education only. Students can develop their design feelings and creative ideas with simple practices and get the chance to use this situation in every field.

Easy applications for coding increase day by day. Researches were done for the program to be used in this study and Arduino has been selected as a suitable device for teaching candidates easy accessibility, low cost, and coding for teaching.

#### *Arduino*

Arduino is an open source physical programming platform (Dokmetas, 2016). It can be considered as a stand-alone computer. Arduino does not only consist of microcontroller cards, it is also the most preferred project development platform with its extensive library, sample projects and easy-to-learn language. Arduino's programming language is the most common C / C ++ language (Dokmetas, 2016). Arduino can be downloaded for free from its official site (Arduino, 2017). Arduino cards are very easy to obtain and programming is becoming more fun. The Arduino card is shown in Figure 1.



*Figure 1. Arduino Uno cart.*

The microcontroller card that makes up the Arduino can be integrated into many circuits, such as various sensors, robots, and alarm systems and so on. Arduino card and computer connection is established by means of the codes written in the program that give various commands to the circuit. Arduino Uno card was used in these studies in consideration of these features.

When an Arduino application is installed, the desired application is available in the program and the appropriate algorithms can be written and tested by clicking on the compilation section. Errors in the writing of the codes should be corrected. Then Arduino computer connection should be checked; appropriate circuit should be prepared and circuit connection should be checked by clicking on the loading area. If the connection is correct, the installation of the codes on the computer to the Arduino card will be detected. When the installation is completed, the desired application will run in accordance with the commands coming in. If the loop is not stopped, the application will continue.

It is anticipated that many different professions will gain importance in the end after the technological developments and the changes in education due to this situation. When this is the case, students need to acquire science, mathematics, electronics and coding skills. Because Arduino is a unifying structure of many disciplines, education can be easily integrated. At the same time, the Arduino card's software and its hardware have been an important factor in the spread of features such as open source, cheap and easy accessibility, access to many applications from the library without knowing the coding, and the addition of advanced technologies to this card. With the increase of the Arduino and similar platforms, public and private educational institutions in Turkey clearly began to pay more attention to the coding and engineering education with the influence of these developments. In addition to the new curriculum in many private schools, basic coding courses are given to students starting from the primary school, and the students are given the opportunity to turn their designs into projects. In coding lessons, Arduino is preferred because it is mostly easy to understand. One of the most important elements for correct learning of such programs and for students to develop their projects is to guide them to the best way by taking the necessary training. Students learn Arduino skills such as analytical thinking ability, ability to work as a team and design.

#### *Fritzing Circuit Drawing Program*

Another tool used by students in this study is Fritzing. Fritzing is a computer program that can be programmed. Moreover, it is an open source code drawing on which many drawings can be carried out on a board. It contains various Arduino-like cards, basic elements such as boards, resistors, LEDs, diodes, batteries, capacitors and external equipment in advanced features. It is preferred because it is a program where all kinds of circuit can be drawn, easily learned, and it can be used in all fields of specialization. Since the Fritzing program is an open source, it can be downloaded by selecting the appropriate installation file according to the computer operating system through the website (Fritzing, 2017).

#### *Research Related With Arduino*

Arduino is generally used for robotic applications involving engineering and for integrating advanced technologies. Jamieson (2011) studied whether the Arduino platform is suitable for use in an embedded system teaching course for computer engineers and computer scientists. He argued that the use of Arduino is pleasing for the students because they could solve the complexity themselves and chose Arduino. Three experimental modules were developed using the Arduino development card in a thesis study conducted by Ali and these modules consisted of sensors and electronic motors. Thanks to this module developed by the researcher, the users could read the values from the sensors on the internet. They could move the motors to the required angle, speed and direction. They also could watch these motors with the camera system. Soriano et al. (2015) presented an example of an open source training platform that can be easily programmed by a different mobile robot with a robotic arm manipulator to provide a multidisciplinary, low cost open platform for automated control entry courses. El-Abd (2017), in his work, he examined the influence of Arduino on embedded systems education. This work stressed that Arduino was increasingly embracing courses in schools and colleges that cover different disciplines. Because Arduino is easy to understand, its use in education as well as engineering applications is getting widespread. It is generally preferred because it works in accordance with the program at many elementary school levels which can be used in coding courses in education. The most common of these programs is the so-called Scratch program, which is now becoming very popular, especially in most private schools and centers. *Scratch Program Arduino* allows you to select many complex codes that can be written in C / C ++ language, in command form and perform desired applications.

When the researches on Arduino are examined, a limited number of researches have been found in the field of education because it has become very widespread. However, the applications made in schools are increasing day by day and the results of these scientific researches are shared. The reflection of the education and teaching is expected. Shim, Ko and Shim (2014) conducted training on computer information and communication technology for students with short term related with Arduino. They have determined that the purpose of education is to improve the computer education that is taken as basis and to enable the students to discover different things. As a result, researchers have developed a meaningful integrated ICT curriculum with a high degree of usefulness in the short term, and found that the participating students completed 96% of the 10 creative tasks and had a high motivation. A study of the introduction of Scratch-Arduino programming to high school students by Gupta, Tejovanth and Murthy (2012) shows that these programs can be applied in high school in the Indian educational setting. In a study conducted by Hoffer (2012), she emphasized the need for high school students to get a better education in science, technology engineering, and mathematics. She prepared a series of laboratory work with a variety of electronic components to meet this need. As a result, the researcher has developed a project that high school students at secondary or higher performance can

imitate real-world applications using the Arduino C programming language and learn the concepts of science and mathematics together with technology.

Barrera (2014) reported his experience with a series of workshops that provide input to robotics work in a workshop. The research has been conducted with a group of high school students who have no prior knowledge of the applications and items to be offered at the workshops and who are located in the region where the study was conducted. The researcher has determined that the purpose of the workshop practices is to make use of the knowledge and skills acquired during the workshops to make robots for a sumo-robot competition held at college level. As a result, the students worked in teams and found that they had won these skills and were doing robots using the skills successfully in the competition. Heger and Bodarky (2015) in their research shared their workshops and suggestions on making these studies more effective. They have designed this work to demonstrate the engineering profession in schools through Arduino Uno, Raspberry Pi, Gemma kits and Flora kits. As a result, they have implemented components that vary according to the skill level available in each trial module, and have found that students enjoy working with hardware that they can program and display on clothing or accessory.

Medin and Petric (2015), in their work noted that the design and architecture of embedded systems offered a new approach to teaching basic measurements in the physics classroom in a laboratory setting. For these purposes, researchers have used Arduino and loudspeaker music, Arduino micro-controller and programming medium and HD44780 compatible LCD module, Ultrasonic sensors and measurement distance applications. Arakliotis, Nikolos and Kalligero (2016) in their study, they introduced Arduino and stressed that Arduino is an entry-level platform for the world of electronic circuits and systems. They also insisted that there are many programming environments lighten the burden of textual programming and it is well suited for young elementary school students. Merino, Ruiz, Fernandez and Gil (2016)'s study have included robotic educational tool and Arduino. The robotic educational tool has been designed to cover different features such as scalability, modular capabilities, re-configurability possibilities, and eligibility for motivating learners in the learning process. As a result, they emphasized that this developed program would be effective as a budget. At a time when technology is so prevalent, science teachers need to improve themselves during their undergraduate, education to guide children, to create an awareness of integrating technology into classes and to ensure that the students are the individuals who produce the technology, not just the user. The application and introduction of engineering platforms such as Arduino to prospective teachers at a basic level contributes to making the learning process easier and more fun. Being conscious of the existence of such programs is important in terms of making many projects and applications to students. Thanks to the developments in technology that made the teaching-learning process easier. As the need for teaching materials increased, many internet and computer applications entered learning environments. When studies about Arduino are considered, studies about the integration of Arduino into the lessons are rare. In addition, there were no studies using triple material such as designing the courses with Arduino, using the Fritzing program in which the circuit drawings were performed and carrying out the experiment reports with poster work.

Students' experience with technology is often limited to the use of technological applications, such as the Internet, mobile phone or computer. Therefore, as they use technology, their attitudes towards technology or ICT are positively affected (Cetin, Caliskan and Menzi, 2012; Maharaj-Sharma, Sharma and Sharma, 2017; Semerci and Aydin, 2018). However, will individuals' attitudes towards technology or ICT be positively influenced if they need to understand and make use of the hardware or programs that operate in the background of these technologies? The working group of this research is the teacher candidates who take the role for training individuals, not only using technology, but also producing technology. So, this study is considered important to understand the coding system on which computer technologies are based by using Arduino and to be proficient of teacher candidates in this field.

## Methodology

### *Research Goal*

In the consideration of the above information, after realizing some technological applications in the course of general physics laboratory II of the science teacher program, the research aims to examine the effects on students' attitudes towards technology and ICT with the mixed method. In these applications, after the introduction of Arduino was completed, it is used as a measuring instrument in the laboratory and it uses the Fritzing program for circuit diagrams and the e-support system to send poster studies. For this purpose, the research attempted to find answers for the following questions:

All these activities such as: Integrating Arduino into electrical experiments in the general physics laboratory, students making of circuits with using Fritzing drawing program in the experiment reports, preparation of test reports as poster and scoring by e-support system.

For first class students of science teacher program:

1. Is there a meaningful effect on attitudes toward technology of all these activities? Does the high school affect their attitudes towards technology?

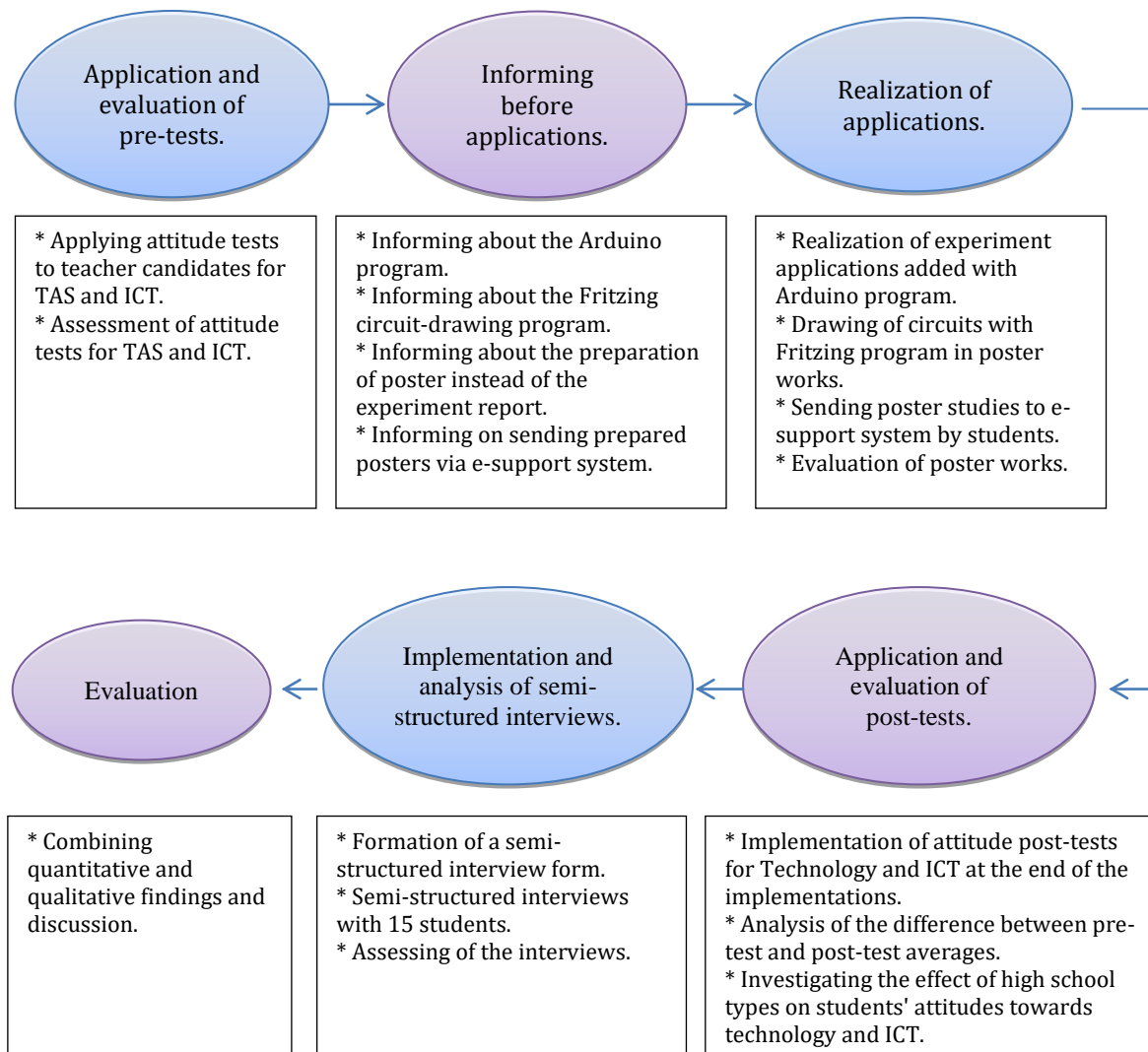
2. Is there a meaningful effect on attitudes toward ICT of all these activities? Does the high school affect their attitudes towards ICT?
3. What are the views on technology and ICT after these applications in the laboratory? How can these views help explain the results of quantitative data obtained with the scale of attitude of technology and ICT?

*Research Design*

The Mixed method is defined as a research design in which data collection, data analysis processes, quantitative and qualitative methods are used together in finding and writing results. Tashakkori and Teddlie (2003), Tashakkori and Creswell (2007), Johnson, Onwuegbuzie and Turner (2007) defined a mixed type of research as a type of research in which researchers combined the bases of qualitative and quantitative research methods. When examining qualitative and quantitative data in mixed method, many methods involve patterns appears. These methods patterns also present three different situations in the collection, analysis and interpretation parts of the study: These are the cases where qualitative data are dominant, quantitative data are dominant, and a third case where both data is treated equally. These situations guide the researcher how to make the data more relevant to the importance of studying the study phase.

The mixed method has various research patterns in itself. In order to use the mixed method correctly, the mixed method pattern types were examined. Nested mixed design was selected as the most appropriate pattern for this research and this pattern was processed appropriately. Nested mixed design occurs when the researcher collects data in quantitative and qualitative ways and analyzes them. Unlike other patterns, nested mixed design can continue by adding a quantitative step into the qualitative stage, the qualitative stage, or the qualitative stage. The nested experimental design was used to determine whether the programs applied to the study group were effective and to better explain the effect of the students in the group on their attitudes.

In this study, nested mixed method design is applied. A process diagram has been made to make the complexity of the mixed method more understandable. The diagram of this work is shown in Figure 2.



*Figure 2. The process diagram of study.***Sample and Data Collection***Research group.*

The research group was identified as the 50 students who took part in the General Physics Laboratory II course taught during the first spring semester of 2016-2017 academic years. Kocaeli University - Faculty of Education - Department of Mathematics and Science Education

Science Education Program: in this program, students are divided into groups of two and three during the applications. Pre-tests applied to obtain quantitative data of the study are given to the students in the groups before the beginning of the laboratory studies and the final tests were given to all the students in the groups after the end of the laboratory studies. Attitude tests of 9 students were canceled because some students did not attend laboratory in one of the pre-tests or final tests, or because they did not participate in all of their laboratory studies. The data obtained from 50 students participating in all of the laboratory studies and tests were evaluated. Qualitative data were obtained by interviewing 15 students in the same group. The "Information and Permission Form" was prepared before the start of the work, in order to get the views of the teacher candidates as written or voice recordings, to get their permission to use their pictures in the study and to give information about the research. 45 of the prospective teachers participating in the study are girls and 5 are boys. Teacher candidates stated that 20 of them were graduated from vocational high school and 30 of them were graduated from Anatolian and science high school.

*Data collection tools.*

The measurement tools used to obtain the data of the study are listed below:

1. "Technology Attitude Scale (TAS)" to measure how attitudes towards technology change.
2. "Attitude Scale for ICT" to measure how attitudes towards information and communication technologies change.
3. "Semi-structured Interview Form" to receive opinions about the practices made within the scope of the laboratory course.

*Technology attitude scale (TAS)*

The attitude scale prepared by Aydin and Kara (2013) was used in order to measure the attitudes of the prospective teachers towards technology in the research. In the literature, it is possible to find many technology attitude tests. However, this scale is preferred because of being developed directly for prospective teachers. The scale consists of a total of 17 substances, including 15 positive and 2 negative. In addition, the scale has a one-dimensional factorial structure. Scale development was conducted with the participation of 378 pre-service teachers (241 females and 137 males) in the departments of Science Teaching, Social Studies Teaching and Elementary School Teaching at Dumlupinar University. The Cronbach's Alpha reliability coefficient was found as  $\alpha=,87$  by the researchers. Also, the reliability of the data obtained by applying the scale to this research group was calculated as  $\alpha=,89$ .

*Attitude scale for ICT*

The ICT scale developed by Gunbatar (2014) and composed entirely of positive expressions was used in the study. Attitude Scale for Information and Communication Technologies, 23 items consist of five factors. These factors are general tendency (6 items), access to information in virtual environment (5 items), computer hardware (4 items), software usage (5 items) and communication in virtual environment (3 items). The items of the scale are answered in the 5-point Likert scale in which I never disagree, disagree, I undecided, I agree and I agree completely. The lowest score is 23 and the highest score is 115. The scale was applied to 381 university students by the researcher and Cronbach's Alpha internal consistency coefficient was found as  $\alpha=,92$ . For this study, reliability analysis was performed and Cronbach's Alpha value was calculated as  $\alpha=,82$ .

*Semi-structured interview form*

The interview form is prepared by experts in the field. While the qualitative questions are being prepared, it has been noted by the researchers that it was designed to explain quantitative data of the research. The interview form consists of five questions in the first section; they are prepared to take into consideration students' thoughts on technology and the applications and tools in the laboratory. In the second part are prepared to learn about the applications related to students' information and communication technologies.

*Arrangement of general physics laboratory II course*

12 experiments which were applied in General Physics Laboratory II course were reviewed and it was determined that Arduino codes could be used and it was decided that it would be appropriate to prepare 8 with Arduino codes. Written codes were verified and tested by two experts. Laboratory lessons were processed for a total of 13 weeks. During the first week of the program, lessons and presentations were prepared to introduce the Arduino card, the main codes to be used throughout the application, and how the Arduino card will be linked to other circuit elements. After each



experiment, guidelines were set to enable students to actively use the application by asking suggestive questions such as what changes can be made in the Arduino codes used in the experiment, how these changes can be reflected in the program. Realised application steps in the laboratory studies is shown in the table in figure 3.

1. week	<ul style="list-style-type: none"> <li>• Information to teacher candidates about the applications be made in the laboratory (presentations).</li> <li>• Implementation of pre-tests for TAS and ICT.</li> <li>• Loading of the 1. Experiment sheet to the e-support system.</li> </ul>
2. week	<ul style="list-style-type: none"> <li>• 1. Experiment: Beginning of electricity experiments. Introduction of course tools, materials, Arduino and Fritzing programs.</li> <li>• Loading of the 2. Experiment sheet to the e-support system.</li> </ul>
3. week	<ul style="list-style-type: none"> <li>• 2. Experiment: Ohm's law, current, voltage, resistance values measured by Arduino.</li> <li>• Evaluation of posters of 1. week.</li> <li>• Loading of the 3. Experiment sheet to the e-support system.</li> </ul>
4. week	<ul style="list-style-type: none"> <li>• 3. Experiment: Current, voltage and resistance measurement for series-connected circuits. repeating measurements with Arduino.</li> <li>• Evaluation of posters of 2. Experiment.</li> <li>• Loading of the 4. Experiment sheet to the e-support system.</li> </ul>
5. week	<ul style="list-style-type: none"> <li>• 4. Experiment: Measurement of current, voltage and resistance for parallel connected circuits with Arduino.</li> <li>• Evaluation of posters of 3. Experiment.</li> <li>• Loading of the 5. Experiment sheet to the e-support system.</li> </ul>
6. week	<ul style="list-style-type: none"> <li>• 5. Experiment: Arduino measurements of resistance, current and voltage in mixed circuits.</li> <li>• Evaluation of posters of 4. Experiment.</li> <li>• Loading of the 6. Experiment sheet to the e-support system.</li> </ul>
7. week	<ul style="list-style-type: none"> <li>• 6. Experiment: Kirchhoff rules and applications.</li> <li>• Evaluation of posters of 5. Experiment.</li> <li>• Loading of the 7. Experiment sheet to the e-support system.</li> </ul>
8. week	<ul style="list-style-type: none"> <li>• Mid-term exam</li> </ul>
9. week	<ul style="list-style-type: none"> <li>• 7. Experiment: Introduction of LED lamps and taking some measuring with Arduino related with flashing LEDs.</li> <li>• Evaluation of posters of 6. Experiment.</li> <li>• Loading of the 8. Experiment sheet to the e-support system.</li> </ul>
10. week	<ul style="list-style-type: none"> <li>• 8. Experiment: Potentiometer presentation and measurements; Observation of the potentiometer voltage value with arduino and adjustment of the LED brightness.</li> <li>• Evaluation of posters of 7. Experiment.</li> <li>• Loading of the 9. Experiment sheet to the e-support system.</li> </ul>
11. week	<ul style="list-style-type: none"> <li>• 9. Experiment: Introduction of capacitors and various measurements; determination of capacitor capacitance with Arduino.</li> <li>• Evaluation of the posters of the 8. Experiment</li> <li>• Loading of the 10. Experiment sheet to the e-support system.</li> </ul>
12. week	<ul style="list-style-type: none"> <li>• 10. Experiment: Charging and discharging of capacitors.</li> <li>• Evaluation of posters of 9. Experiment.</li> <li>• Loading of the 11. Experiment sheet to the e-support system..</li> </ul>
13. week	<ul style="list-style-type: none"> <li>• 11. Experiment: Finding the inductance of coils with different windings.</li> <li>• Evaluation of posters of 10. Experiment.</li> <li>• Loading of the 12. Experiment sheet to the e-support system..</li> </ul>
14. week	<ul style="list-style-type: none"> <li>• 12. Experiment: Determination of L inductance of a Coil.</li> <li>• Evaluation of posters of 11. Experiment.</li> <li>• Application of attitude tests for TAS and ICT.</li> </ul>
15. week	<ul style="list-style-type: none"> <li>• Evaluation of posters of 12. Experiment.</li> <li>• Final exams.</li> <li>• Performing semi-structured interviews.</li> </ul>

Figure 3 Application steps in laboratory studies.

### *Preparation of poster works.*

Students were asked to prepare an electronic poster that summarizes Arduino codes and responses to questions about the use of the applet and laboratory work, instead of writing classical reports covering laboratory practices every week. The necessary information for this was shared with the students in the first week's experiment. For the posters that the students will prepare in the course of General Physics Laboratory II, poster samples were shown to the students during the first week presentation and program options that can be used to prepare posters are introduced.

### *Introducing the electronic support system and loading the experiment sheets*

The Electronic Support System offered by our university has been used very effectively in terms of sharing documents and making students active outside the classroom. The experimental paper prepared for the laboratory course is shared weekly homework and questions are directed through this system. The weekly sharing of all experiments is important in terms of making some changes according to the readiness of the students and raising curiosity for the experiment. The images of the students being taken during the experiments are shown in Figure 4.



Figure 4. Studies of students related with Arduino circuits

Students can access the experimental sheet by entering their own pages. They can see their homework and upload their posters to the system. When students upload their posters, they are seen through the system. There is a scoring chart for each student, and after the posters are examined, their grades are entered into that division and shared with the students. This situation continued every week during the application period.

### *Analyzing of Data*

#### *Analysis of quantitative data*

For the quantitative data of the study, it was first decided whether to use parametric or non-parametric tests. It is generally recommended to use parametric tests in over 30 study groups (Can, 2017). In order for a test to be parametric, some conditions must be met. First of all, homogeneity tests are examined in which the data in the tests are normally distributed and the variance equality is checked. Two tests are used in SPSS to find the normal distribution of the data. When the number in the study group is below 30, Shapiro-Wilk, 30 and above, the Kolmogorov-Smirnov test is recommended (Ak, 2014). Since the study group in this research was  $N = 50$ , the Kolmogorov-Smirnov test was preferred for the normality test. The results of the tests are given in Table 1.



Table 1. Kolmogorov-Smirnov normality test results of pre-test, post-test for TAS and ICT.

		Kolmogorov-Smirnov		
		Statistic	N	p*
TAS	Pre-Test	,80	50	,20
	Post-Test	,70	50	,20
ICT	Pre-Test	,90	50	,20
	Post-Test	,60	50	,20

\*p&gt;,05

In Table 1, it was determined that the pre-test and post-test of the data obtained for the two attitude tests used in the study were normally distributed ( $p>,05$ ). After that, the equality of the variances of the groups was checked by the Levene Test. If the resultant value of the Levene Test is greater than ,05, it is assumed that the variances are equal, ie the homogeneity of the data is obtained. Levene Test results are given in Table 2.

Table 2. Levene test results.

		Levene Test	
		F	p*
TAS	Pre-Test	,00	,98
	Post-Test	1,95	,17
ICT	Pre-Test	,05	,82
	Post-Test	,00	,99

\*p&gt;,05

The equality of variances is determined by the p values. It is seen that the variances are equal, that is to say the data are homogeneously distributed, in both of the pre-test and post-test of TAS given in Table 2. ( $F=,00$ ,  $p>,05$ ) and ( $F=1,95$ ,  $p>,05$ ). The second test, the ICT attitude pre-test and the final test, were examined for the Levene test and it was found that there was no significant difference between the group variances, that is, group equations were found to be equal ( $F=,05$ ,  $p>,05$ ) and ( $F=,00$ ,  $p>,05$ ). The parametric test was decided to be used because the homogeneity and normality of the data in the tests used were obtained.

The statistical path followed in the analysis of the quantitative data used in the research:

- "Cronbach's Alpha coefficient" for the reliability of the attitude test used in the research,
- "Levene test" for the calculation of the homogeneity of the data obtained in the study.
- "Kolmogorov-Smirnov Test" for the calculation of normality of data obtained in the study,
- Whether there is a difference between pre-test and post-test of the TAS and ICT with the "t-test" for all the students in the study group,
- "Two-way analysis of variance for mixed measures" to investigate whether the effect of kinds of high school on TAS and ICT,
- If the differences are meaningful, the magnitude of the effect is looked at. The magnitude of effect indicates the magnitude of the difference between the means of the data in the study or the total amount of variance in the dependent variable (Tabachnick and Fidell, 2013). The most common effect, calculated for the comparison of groups in the statistics is eta square. Eta square value; ,01, ,06, and ,14 are expressed as "small", "medium", "wide" effect magnitudes, respectively (Buyukozturk, 2009).

#### Analysis of qualitative data

Semi-structured interviews were conducted with 15 students selected randomly from volunteers for the interviews with the students and the data obtained there. After interviews were made for data analysis, It was turned voice recordings into text without spoiling their originality by the researchers. In the analysis of the qualitative data in the research, descriptive analysis method was used. The purpose of this analysis method is to present and interpret the data obtained after the observation or interview (Yildirim & Simsek, 2008). Descriptive analysis method was used to transfer the student's opinions and for some questions opinions were tabulated using the original answers given by the students and the percentage and frequency values were calculated.

#### Consolidation of quantitative and qualitative data

Creswell and Plano Clark (2011) have proposed various methods that describe how qualitative and quantitative data can be combined into which phase of study. When explanations for merging data were evaluated, it was decided that the appropriate method for this study was merger in during interpretation. This method suggests that qualitative and quantitative data should be collected and analyzed, and then the research should be combined during interpretation of finding.

### Findings / Results

In this section, with to the applications carried out in the General Physics Laboratory II course, the findings of the students' attitudes towards Technology and ICT and their views related with this application are given according to the order of the research questions. The combination and interpretation of quantitative and qualitative data obtained by the mixed method has been performed in this section.

#### *Findings Related To The First Sub-Problem.*

All this activities are realised such as: Integrating Arduino into electrical experiments in the general physics laboratory, students making circuits with using Fritzing drawing program in the experiment reports, preparation of test reports as poster and scoring by e-support system. For first class students of science teacher program, Is there a meaningful effect of all this activities on attitudes toward technology? Does the high school type they graduate affect their attitudes towards technology?

The data from answers of these questions were analyzed by t-test and by two-way analysis of variance for mixed measures. The descriptive statistics and t-test results of the vocational high school, Anatolian-science high school and the whole study group of the pre-test and post-test averages of TAS are presented in Table 3.

*Table 3. Descriptive statistics of pre-test and of post-test and results of dependent t-test of data obtained from TAS relative to groups.*

	Group	M	S	N		M	S	N	t	p
Post-Test	vocational high school	3,65	,56	20	All Groups	3,6	,48	5	6,13	0,00*
	Anatolian-science high school	3,61	,44	30		3	0			
Pre-Test	vocational high school	3,26	,58	20	All Groups	3,2	,60	5		
	Anatolian-science high school	3,18	,61	30		1	0			

\*p<,01

Table 3. Shows that, Without distinction of high school, test average of TAS of all students rises from  $\bar{X}=3,21$  to  $\bar{X}=3,63$ . It is seen that there is a significant difference between the pre-test and post-test of the whole group for the t-test result for the dependent samples. ( $t_{(49)}=6,13$ ,  $p<,01$ ).

For obtaining reliable results, one of the conditions of the two-way analysis of variance for mixed measures is to ensure the normality and homogeneity of the data obtained from the TAS tests. As for another condition of this test, whether it is difference between the covariances of the groups for the dual combinations, which is the results of the analysis, which is found by Box test. According to the test results, there is no difference between group covariances for dual combinations of measurement groups ( $F=2,00$ ,  $p>,05$ ). The results of two-way ANOVA for the mixed measures examined in the light of these results are given in Table 4.

*Table 4. Results of variance analysis for mixed measures (two way ANOVA) of TAS measurements of students.*

Source	Measurement	Sum of Square	Sd	Mean Square	F	p	$\eta^2$
Measurement	Linear	4,11	1	4,11	34,75	,00*	,42
Measurement Group*	Linear	,01	1	,01	,08	,78	,00
Error	Linear	5,67	48	,12			

\*p<,05

In the measurement section in Table 4, regardless of the type of high school type (vocational high school and Anatolian-science high school), all activities performed before and after realizing the activities in the laboratory, between all TAS end-test averages and pre-test averages of all participating students a significant difference was found in favor of the end-test. ( $F_{(1-48)}=34,75$ ,  $p<,05$ ). The magnitude of the effect has been looked at to determine whether this difference is due to the work done. It has been found that new studies in the laboratory have a significant effect on the students' attitudes toward technology ( $\eta^2=,42$ ). This situation can be said to be in parallel with some studies in the literature. (Yavuz and Coskun, 2008; Metin, Birisci and Coskun, 2013). Similarly, a number of technological applications have been carried out and researchers have found that there is a positive change in the attitudes of the student groups in which activities are performed.

According to Table 4, being graduated from Anatolian-science high school or vocational high school shows no significant effect on students' pre-test and post-test of TAS ( $F_{(1-48)}=,08$ ,  $p>,05$ ).

#### *Findings Related to the Second Sub-Problem.*

All this activities were realised such as: Integrating Arduino into electrical experiments in the general physics laboratory, students making circuits with using Fritzing drawing program in the experiment reports, preparation of test reports as poster and scoring by e-support system.

For first class students of science teacher program, Is there a meaningful effect of all this activities on attitudes toward ICT? Does the high school type they graduate affect their attitudes towards ICT?

The data from answers of these questions were analyzed by t-test and by two-way analysis of variance for mixed measures. The descriptive statistics and t-test results of the vocational high school, Anatolian-science high school and the whole study group of the pre-test and post-test averages of ICT are presented in Table 5.

Table 5. Descriptive statistics of pre-test and of post-test and results of dependent t-test of data obtained from ICT relative to groups.

	Group	N	Mean	Sd		N	Mean	Sd	t	p
Post-Test	vocational high school	20	3,70	,51	All Groups	50	3,61	,55	7,14	0,00*
	Anatolian-science high school	30	3,54	,46						
Pre-Test	vocational high school	20	3,35	,59	All Groups	50	3,24	,55		
	Anatolian-science high school	30	3,17	,52						

\*p<,01

Table 5 shows that, Without distinction of high school, test average of ICT of all students rises from  $\bar{X}=3,24$  to  $\bar{X}=3,61$ . It is seen that there is a significant difference between the pre-test and post-test of the whole group for the t-test result for the dependent samples. ( $t_{(49)}=7,14$ ,  $p<,01$ ).

For obtaining reliable results, one of the conditions of the two-way analysis of variance for mixed measures is to ensure the normality and homogeneity of the data obtained from the ICT tests. As for another condition of this test, whether it is difference between the covariances of the groups for the dual combinations, which is the results of the analysis, which is found by Box test. According to the Box test results, there is no difference between group covariances for dual combinations of measurement groups ( $F=1,29$ ,  $p>,05$ ). The results of two-way ANOVA for the mixed measures examined in the light of these results are given in Table 6.

Table 6. Results of variance analysis for mixed measures (two way ANOVA) of ICT measurements of students.

Source	Measurement	Sum of square	Sd	Mean square	F	p	$\eta^2$
Measurement	Linear	3,11	1	3,11	46,20	,00*	,49
Measurement Group*	Linear	,00	1	,00	,05	,82	,00
Error	Linear	3,23	48	,07			

\*p<,05

In the measurement section in Table 6, regardless of the type of high school type (vocational high school and Anatolian-science high school), all activities performed before and after realizing the activities in the laboratory, between all ICT end-test averages and pre-test averages of all participating students a significant difference was found in favor of the end-test. ( $F_{(1-48)}=46,20$ ,  $p<,05$ ). The magnitude of the effect has been looked at to determine whether this difference is due to the work done. It has been found that new studies in the laboratory have a significant effect on the students' attitudes toward technology ( $\eta^2=.49$ ). This suggests that studies on computer technology in the laboratory have a significant impact on attitudes of all students. This result is shown similarity to a series of studies using computer technologies in laboratories (Ozdener, 2005; Bozkurt and Sarikoc, 2008; Tanel and Onder, 2010; Gul and Yesilyurt, 2011; Aktamis and Arici, 2013; Cinici et al, 2013).

According to Table 6, being graduated from Anatolian-science high school or vocational high school shows no significant effect on students' pre-test and post-test of ICT. ( $F_{(1-48)}=.08$ ,  $p>,05$ ).

#### Findings Related to the Third Sub-Problem.

What are the opinions of students about technology and computer communication technologies in general after all these practices in the laboratory? How do these views help explain the results of quantitative data obtained with TAS and ICT? Six questions were asked to students for this sub-problem.

##### First question;

The following questions were asked by students with regard to their contribution to the daily life of technology. "What kind of contributions can technology have to you in everyday life? Can you evaluate the technologies that you have learned in laboratory (Arduino, Fritzing, poster preparation) in this respect? "The answers are in the following conversations:

Melike: "I did not know how to make a poster with PowerPoint. It is effective to prepare presentations in different lessons."

Kadir: "I am going to try to show Arduino to my students when I am a teacher. I can make applications of sound-sensitive."

Ahmet: "various circuits can be installed with Arduino."

Mustafa: "I can teach my brother all the applied activities of Arduino"

Ayse: "This mechanism is easier to remember when I am teaching my students in the future; this is how I learned. By doing the theory myself, I can record the visual memory. By setting up the circuits myself, the learning process can be more efficient and fun."

Nihal: "In the future, namely when I'm a teacher, I have always wanted to do the same thing to my students. Maybe I can add something better. Perhaps, I can go to an Arduino course. I can teach better things and I can explain better with better examples. It can be used in everyday life."

Gulcin: "I do not think that I can do something in everyday life about technology."

Sinem: "I also used the multimeter at home; I already have an interest in those topics. I did not use Arduino and Fritzing. I might consider using them in everyday life."

Zeynep: "Preparing a poster will contribute to all kinds of us. It contributes to everything we do during our education period. At least we learned how to do a little better and a little faster."

Selim: "They made our life easier."

Fatih: "If we can be educators in the future, we can draw the students' attention to programs related to technology."

Merve: "There was more impact in the sense of field knowledge. For example, I have better understood the concepts. It was supplied differently"

Canan: "Technological applications have facilitated our work. So in a short time we were able to do more things. Fritzing has provided us with a better understanding of circuit elements in terms of many circuits. Related to making posters, when I become a teacher, I can use them in my presentations.

Berna: "My curiosity about the electricity has increased. I want to learn more."

Figen: "We use technology everywhere in everyday life. In the future, when we are teachers, our students will know better. Then the use of technology will give us a plus."

When the opinions of the students are examined, it is noticed that there are very different ideas and opinions about the use of technology in daily life. Some of them can be listed such as; technology has facilitated their work, many programs practices were used in the laboratory that contribute to learning about technology-related programs and their information about electricity increased. The students' expressions show that they have positive thoughts towards technology, they want to use what they learn in the future and they are making an effort about it.

#### *Second question;*

In response to the question "What are your positive or negative opinions about using technology in lessons", the answers given by students are presented below.

Melike: "People must be forced to use technology. First, if you put a subject in front of them, they will wonder and investigate. I would not have wondered if I had not learned Arduino here. But I am more curious now. It is more important that the useful technological practices are learned since childhood."

Kadir: "My opinion is positive. Increasing the efficiency of the lesson will increase the students' interest. I will also use it when I'm teaching, because it increases interest (by setting up the circuits)."

Ahmet: "I am positive. We learned to use PowerPoint. We learned the technology that will be very helpful when we are teachers"

Mustafa: "It was positive. If we had drawn the circuits, the reports would have been too long. Whereas, it was easily realized with Fritzing. Technology should be used in lessons."

Nihal: "I am positive; our works were accelerated. It was more advantageous to write and delete something."

Gulcin: "It Changes according to the situation. Not necessarily on a computer, I mean because I sometimes prefer to do it manually. That is, it may actually vary."

Sinem: "As our lessons are limited in terms of time, it is of course beneficial to use the technology."

Zeynep: "Yes I am positive. It must be used."

Selim: "I am optimistic.

Fatih: "It should be used even more. Some of the teachers never use it. Perhaps they are afraid that they cannot use it, but I think it is necessary."

Merve: "Positive. Motivation enhancer."

Canan: "Positive. It provides convenience and reduces time lost."

Berna: "I think it must be used because it makes our life so much easier.

We spent hours working on the report, but it was easier after I started making the poster."

Figen: "Positive. I think that it makes the lessons easier."

When the answers given by the students to the questions about the use of technology in the lessons are examined; most of the students stated that the technology should be used in lessons. This suggests that students have a positive attitude towards technology.

#### *Third question*

"In this period, after learning about the laboratory work by preparing posters. Do you want to write a report by hand in the laboratory work or you want to prepare a poster on a computer? Why?"

Responses given to the question:

Melike: "I prefer posters; they are easier to prepare."

Kadir: "Poster work is easier and visually more beautiful."

Ahmet-Mustafa: "It's easier to make a poster."

Ayşe: "I prefer making a poster; it is more interesting. I am learning how to use The PowerPoint Program; it works, but we are bored after a while when writing the report by hand or we forget what to do."

Nihal: "Of course, the poster is easier to write. At first, it was very difficult but now it is very easy."

Gulcin: "It's better to make a poster now. We are more active we both share something. Previously, we were writing by ourselves, we finished."

Sinem: "If we take the lab lessons again, I will prepare a poster again because it's beautiful."

Zeynep: "Make a poster because it's more comfortable and easier."

Selim: "It's better to make a poster. We are gaining time."

Fatih: "I prefer to make a poster. It easier and takes less time."

Merve: "Make a poster. Because there is no concept of time. We can send it at the desired time. It is more efficient because we have prepared it with our friend."

Canan: "It's easier to do on a computer. In other words, posters are more practical and visually better."

Berna: "It's easier to make a poster. Visually more beautiful and more organized. It takes less time to prepare a poster than to write a report by hand."

Figen: "Make a poster because we are more active on the computer. It is now hard to write by hand."

In the direction of the answers given, all of the students seem to prefer to prepare and send posters after their laboratory work. It is easier and less time consuming for students to prepare a poster; it is visually more beautiful and it improves the students' use of the computers. They found it positive because of poster works being uploaded by them to the system (during the time given), whenever they wanted. When the opinions were examined, the Poster study contributed to positive development of students' attitudes towards computer technologies.

#### *Fourth question*

For the use of Arduino this question was directed to students: "Did you feel insufficient in using computer technology while using Arduino? Why?" Their replays for this question were as follows:

Melike: "I felt satisfied. We had the necessary information in the shared files. Maybe we could have made some changes in the code."

Kadir: "I was afraid to make mistakes at first, but our professor and assistant supported us a lot. This support helped me do better afterwards."

Ahmet: "I did not have much difficulty, partly."

Mustafa: "I did not have any trouble because the instructions in the experiment manual were very clear and well explained."



Ayse: "I just felt that I am not eligible enough to use the code. I sometimes had trouble understanding the codes, but when I opened the files in a succession, I did not have any trouble seeing the data that came out."

Nihal: "I found myself too ineligible. At first, I did not know what to do; I could not make the measurements. When I began learning, I could understand better."

Gulcin: "Actually, I feel more inadequate after I used Arduino because at first, I said it was very easy, we just set some circuits. In fact, I realized later that this is not all about it; we must have learned how to write these codes. For this reason, I am saying that I am ineligible."

Sinem: "I was good on the computer. There was no trouble."

Zeynep: "At first we were confused and we were not good at using computers, but we got better later on."

Selim: "No, I felt well because we do similar things mostly."

Fatih: "I was not very inadequate. I was getting better with time"

Merve: "No, I did not feel insufficient because the instructions in experiment sheets were very clear. I followed the steps of the process."

Canan: "At first, I had difficulty reading the card on a computer. I felt ineligibility, but as I practiced more, I began to get even better. I did not have any trouble later"

Berna: "In the early days, I felt inadequate for not understanding. I learned a little later and did not have any trouble getting used to it."

Figen: "At first, I felt inadequate. I felt better day by day but I still find myself inadequate."

When looking at the answers given by students regarding the use of Arduino, It seems that most of them stated that, they felt themselves inadequate. When they started to use Arduino, it is stated that, some students have begun to understand and grasp better in the following weeks. It has been seen that some students use expressions that they need to improve themselves even after the applications are over.

#### *Fifth question*

It asked the students some questions about the Fritzing program. "Another innovation in their laboratory work was to use the Fritzing program in their circuit drawings. Have you ever used this program before? Do you think it is useful? Do you think you have developed yourself on this issue?" The views of students related to these questions are as follows:

Melike: I have not heard about this program before and this is the first time I use it. I noticed that most of you knew this program. Yes, it was useful in terms of experiments we did. I learned some basic things better than others such as resistance and LED."

Kadir: I have not heard about this program before and this is the first time I use it. I think it is extremely useful and I could only learn the basic elements."

Ahmet: "I have not used it before. This is the first time I use such a program. It is Useful for the lab. We use the program to draw instead of drawing by hand. That is to say, I was able to develop myself. If we use this program later, we can develop ourselves and become better."

Mustafa: "No, I have not used it before. This is the first time I use such a program. I think it is useful and I could improve it. I think I will be better in the future."

Ayse: "No, I have not used it before. This is the first time I use such a program. I have seen how connections are made on the computer. At first, I was scared. I could draw simple or moderate circuits, usually connected in series and parallel."

Nihal: "No, I have not used it before. This is the first time I use such a program. Yes, I think it is definitely useful. I think that I have developed myself."

Gulcin: Yes, I think it is definitely useful. I think that I have developed myself. I learned most of their places. I can place them right."

Sinem: "I knew another drawing program but not Fritzing. It is easy to place the circuit elements. I think that I have improved myself using this program."

Zeynep: "No, I have not used it before and never heard of this name either. This is the first time I use such a program. Yes, I think it is useful. Yes, I have developed drawing and placing."

Selim: "No, I have not used it before. This is the first time I use such a program. Yes, I think it is useful. Yes I have developed an ICT."

Fatih: "No, I have not used it before. This is the first time I use such a program. Yes, I think it is useful. I certainly think that I was improved."

Merve and Canan: "No, we have not used it before. This is the first time we use such a program. Yes, we think it is useful. We think that we were improved."

Berna and Figen: "No, we have not used it before. This is the first time we use such a program. Yes, we think it is useful. We have developed ourselves and we can be better."

It is obvious that none of the students had already heard about The Fritzing Circuit Drawing Program until so far. All of the students thought that using Fritzing is useful. Regarding the use of the Fritzing program, some of the students think that they are developing themselves. In addition, they think that they learned basic elements and can draw simple circuits. Some of them have used expressions that they can learn to make better drawings and develop more.

#### *Findings Related to Third Sub-Problem*

The research about the change in attitudes towards ICT and technology is completed. It is due to the effects of the work done in the laboratory and tries to explain this according to the students' replies in the interviews. The results obtained are summarized in Table 7.

*Table 7. Summary of data obtained on attitudes towards ICT and technology according to the mixed method research model.*

<i>Quantitative analysis of the effects of the practices in the physics laboratory on the technology and ICT attitudes of the students.</i>	<i>Qualitative analysis of the effects of the practices in the physics laboratory on the technology and ICT attitudes of the students.</i>	<i>Mixed Method Interpretation.</i>
Through the applications related to the electrical experiments in the General Physics Laboratory II course and according to the result of the tests (the attitude tests towards the technology and ICT) applied to the students, there was a significant difference in favor of the final test between the pre-test and the post-test.	<ol style="list-style-type: none"> <li>1. Students are satisfied with all the technologies. Starting with preparing the experiment reports in the form of a poster and ending up with the setting up of Arduino circuits, They think they have developed themselves using the Fritzing program. Realizing how the electric circuits work using Arduino is seen as an achievement. This situation has positively affected the attitude towards the technological and ICT.</li> <li>2. All the students liked and preferred poster preparation.</li> <li>3. They themselves have indicated that they felt inadequate about Arduino at first, but they made it easier with time.</li> <li>4. The students have expressed that they have not heard about the Fritzing program before, but after learning about it, they could draw circuits on the basic level in this program.</li> </ol>	The results from the interviews support the results from the quantitative data.

### **Discussion and Conclusion**

The research shows that the applications made using the technology in the physics laboratory had an effect on the attitudes of the students towards the technology and ICT. A significant difference is found in favor of the post-tests according to the analysis of variance for the mixed measurements. It is determined that students do not have certain attitudes toward technology and ICT or any meaningful effect with regard to the sort of their graduated high school. During the interviews, it is seen that most of the students has shown an increasing interest towards technology and ICT due to their curiosity about Arduino and the Fritzing drawing program. Apart from laboratory work, students demonstrate that they have developed a positive attitude by investigating many applications related to Arduino and acquiring Arduino card and materials made of circuit elements. Most of the students stated that they would use technological practices when they start to teach. They also stated that when they start teaching, they would set up circuits, take measurements, and want to do the same measurements with the Arduino circuit. In a study conducted with this subject, it is seen that students likewise stated that the Scratch-Arduino applications they learned were fun and that they would continue to use it even after practice (Gupta et al., 2012).

It is stated in similar studies about Arduino abroad that the students' motivation is increased and it is preferable because it is a cheap program (Arakliotis et al., 2016; Merino et al., 2016). In another study, activities were organized with Arduino to introduce the engineering profession (Herger and Bodarky, 2015). In a similar study, Arduino was preferred for a series of robotic studies with high school students (Barrera, 2014). It is also important to learn and teach the program because Arduino is also used in robotic applications; the robotic education is applied in schools and the interest towards robotics is increasing. These practices have enabled students to think about their experiments in the laboratory and they made the students more enthusiastic.

As for The Arduino Program that students have never heard about before, they expressed their ability to do a lot of applications. This situation shows that the students are very different from their initial state against ICT. Most students have stated that they did a lot of research on the internet in addition to the Arduino circuits applied in the laboratory, and they used magazines, brochures, and social media about technology. The research concludes that teaching the technological applications to prospective teachers also eliminates their fears about using technological devices and believes that they can perform many applications safely. The students have stated that they were positive about the use of technology in the courses and have stated that they would also use these applications in their professional lives. All of these situations can be considered as an indicator and proof of the necessity of technological applications in teacher education and that these practices provide students with awareness of new developments in technology. Some researchers observed the positive expressions of the students towards the use of the computer technology during the laboratory studies. In a study, it was emphasized that students have positive views about using ICT in education (Onal, 2014). The students clarified that realizing the applications with Arduino were easier as time goes by. These findings are similar to a study in literature (Shim et al., 2014). At the beginning of the laboratory studies, the research states that programs are introduced to the students carefully, discussed the ease of applications and informed the students about all the applications in the laboratory. This has a great impact on the occurrence of all positive results. From this situation, it was concluded that when necessary opportunities and motivation are provided to students, they can achieve many things, see themselves as sufficient and can break prejudices against computer technologies. Another new application applied in the laboratory is to prepare the data obtained from electrical experiments as poster. It is seen that they have preferred more than according to the previous reports writing. In posters sent from the electronic information system, it has been noticed that in the first weeks, students experienced some difficulties, but in the last weeks they have learned, have improved and became more appropriate in terms of arrangement.

None of the students have previously heard of the Fritzing program used during laboratory drawings. The students stated that they had used the Fritzing program actively in posters, found it useful and learned many features that could draw simple circuits.

The answers to all interview questions show that most of the students have positive opinions about the use of technology and that the applications in the laboratory have a great contribution in the formation of this situation. It is supported by the answers given in the interviews that, the meaningful difference in favor of the students in their ICT and technology attitude are a result of the practices performed in the laboratory.

### *Suggestions*

1. The attitudes towards technology and ICT related to the applications in the study obtained from scales for quantitative data are investigated and analyzed. It may be advisable to look at features such as academic achievement and motivation in other studies where similar practices can be made.
2. Within the scope of the study, many applications with Arduino has performed in electrical experiments, but some robotic applications that students want cannot be done because the duration of the courses is limited. Students' interests and curiosity about robotics are clearly articulated in their attitudes and views in the laboratory. In this context, researchers may be encouraged to conduct research on such robotic studies that will stimulate students.
3. Students in the study were asked to prepare poster works instead of the classical experimental report for laboratory experiments. Most of the students have expressed positive opinions about poster study. According to this result, it is suggested that students should be able to work on posters in the laboratories to ensure being well informed about computer programs and being more willing to do experiments.

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