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Investigation of the Effects of Arduino-Supported Analytical Chemistry Experiments on Pre-Service Teachers' Self-Efficacy toward Information Technologies*

Arduino Destekli Analitik Kimya Deneylerinin Öğretmen Adaylarının Bilişim Teknolojileri Öz-Yeterliğine Etkilerinin İncelenmesi

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ABSTRACT: Arduino is a tool which the data taken from sensors can be used. Temperature, humidity, distance, light, color and acceleration can be measured by Arduino connected sensors. It is aimed to determine the effects of analytical chemistry experiments supported by Arduino on pre-service teachers' self-efficacy toward information technologies. Participants of this study are 61 pre-service teachers. There are one experimental group (n_{EG}:34) and the other control group (n_{CG}:31) with random assignment method. In this study, "pre-test-post-test control group semi-experimental research design" has been adopted. In the experimental group, closed-ended experiments supported by Arduino were used. In the control group, closed-end experiments not supported Arduino were used. In both groups, confirmatory approach based experiment design was adopted. In order to measure self-efficacy perceptions of information technologies, "Information Technologies Self-efficacy Perception Scale for Pre-service Teachers (ITSPS)" was used. According to the results of the study, it was determined that the analytical chemistry experiments supported by Arduino has effects on their technology self-efficacy in a positive way. Arduino should be assessed on students' self-efficacy by testing in different chemistry-related trials. In addition, easier application of Arduino should be investigated.

Keywords: arduino, chemistry, self-efficacy, technology.

ÖZ: Arduino, sensörlerden alınan verileri kullanılabilen bir araçtır. Arduino'ya bağlı sensörler ile sıcaklık, nem, mesafe, ışık, renk ve ivme ölçülebilir. Bu çalışmada, Arduino destekli analitik kimya deneylerinin öğretmen adaylarının bilgi teknolojilerine olan öz yeterlikleri üzerindeki etkilerinin belirlenmesi amaçlanmıştır. Bu araştırmanın katılımcıları 61 öğretmen adayıdır. Bir deney grubu (n_{DG}: 34) ve bir kontrol grubu (n_{KG}: 31) rastgele atamayla oluşturulmuştur. Bu çalışmada "ön test-son test kontrol gruplu yarı deneysel araştırma deseni" kullanılmıştır. Deney grubunda Arduino destekli kapalı uçlu deneyler, kontrol grubunda ise Arduino'yu desteklemeyen kapalı uçlu deneyler yapılmıştır. Her iki grupta da doğrulayıcı yaklaşıma dayalı deney tasarımı benimsenmiştir. Katılımcıların bilgi teknolojilerinin öz yeterlik algılarını ölçmek için "Öğretmen Adayları İçin Bilgi Teknolojileri Öz Yeterlik Algılama Ölçeği" (BTÖYAÖ) kullanılmıştır. Araştırmanın sonuçlarına göre, Arduino destekli analitik kimya deneylerinin, teknolojinin öz yeterlik üzerinde olumlu bir etkisi olduğu tespit edilmiştir. Arduino, kimya ile ilgili farklı denemelerde test edilerek öğrencilerin öz yeterliliği konusunda değerlendirilmelidir. Ek olarak, Arduino'nun daha kolay uygulanması araştırılmalıdır.

Keywords: arduino, kimya, öz yeterlik, teknoloji.

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Introduction

One of the most basic needs for humanity throughout history is to reach knowledge. With the advent of new information reached by scientific studies, science and technology are expanding accordingly. In this context, the influence of technology in recent years has manifested itself in all areas of life. Technology can be described as all of the tools, methods and applications for the different fields of the industry. In other words, a design process arising from need is a process (Uluğ, 2000). Technology makes people's lives easier, and it also makes it easier to access the information in a shorter time.

It is possible to see technological applications in every point where difficult conditions are eliminated and daily life is facilitated. Technology is a process in which systems are developed in line with people's desires and needs. Technology offers significant opportunities in the development of scientific thinking skills. For this reason, the use of technology should be included frequently in the education process. Information technologies included in the training process make it easier to acquire, analyze and present the data; it also supports the active participation of students in the research process. At the same time, the teacher better manages the teaching techniques and makes it easier to record (Milli Eğitim Bakanlığı [MEB], 2006). Kesercioğlu, Balım, Ceylan, and Moralı (2001) found that integrating technology into science is very important for effective science education. In this context, the necessity of using effective technology in science education is emphasized (Yenice, 2003). Science requires an experiment-based education because it contains so many abstract concepts. Otherwise, students will not be able to conceptualize physical, chemical and biological events. As a result, science courses cannot go beyond instantaneous knowledge transfer. The main purpose is to construct and understand the information presented in the lessons. Given the fact that primary and middle school students are having problems in perceiving abstract expressions, the use of technology is important for the realization of these abstract information (Akpınar, Aktamış, & Ergin, 2005; Çakmak, 1999).

How can technology be used in schools or different learning environments, especially in the science courses? Microcontrollers such as Arduino are very convenient tools in science and it can be used in different applications of the science with the integration of technology. When the researches in the field literature are examined, it is seen that there are different investigations with the Arduino processor. Arduino is a very convenient interface for producing different projects. For this reason, Arduino is one of many technological materials that can be used for an effective training process and learning environment. Arduino is a processor that can integrate sensors. With Arduino, a large number of experiments and projects can be tried in different areas (Arduino, 2014). Because Arduino offers multiple sensors, many different experiments can be performed with a single Arduino circuit. Because the Arduino cycle is easy to use and cost, it can be easily used in science education. In this context, this device is very economical for schools and it is also easy to buy. Considering the studies which has been done, it is implied that there are many comprehensive and different studies that can be conducted with the Arduino m. As the importance and necessity of technology integration becomes clear, research on the integration of technology will increase. In a study which was conducted by Süzen, Ceylan, Çetin, and Ulusoy (2017), a robot is modeled on the X-Y plane using Arduino development card. A software named "Digital

Painter" which transmits data via Bluetooth to this robot has been developed. The image to be drawn is first loaded into the computer software called "Digital Painter" and then transferred to the Arduino circuit via Bluetooth. In order to be able to draw the robot, it is necessary to fix it to the Arduino circuit. Thus, the image data from the card is drawn on the desired floor. Another example study is carried out by Walkowiak and Nehring (2016), an easy-to-use digital data collector "ChemDuino" was designed for the classroom environment. ChemDuino (*Chemistry-Arduino*) is the use of the Arduino hardware and software application to improve chemistry teaching and learning. In this study, it is demonstrated how Excel PLX DAQ can be used in visualizing the data collection process using ChemDuino. In this process, the relationships among sensors such as temperature, conductivity, and pH have been realized using different sensors. In addition, real-time data collection presentations are visualized with media tools such as smart boards. Thus, it is stated that real-time measurements can be easily applied to classes where chemistry topics are taught. This research allowed the recording and graphing of data on pH change due to temperature increase by combining pH and temperature devices in neutralization reactions. Similar studies of this research can be reproduced.

The fact that the integration of Arduino technology into education is important and it is necessary. The number of studies conducted in the educational literature increased consistently. The number of publications related to Arduino has been increasing especially with papers presented in Engineering Conferences from 2009 to 2016. Ardunio was the most preferred microcontroller in engineering education for the last 5 years. Also, the number of publications containing the Arduino platform has increased significantly over the years because Arduino has increasingly become popular among academicians. In these publications, how the Arduino was used in education (primary schools, high schools and universities) and suggestions were made for its use in schools were stated (El-Abd, 2017). Nowadays, recommendations on the necessity of integrating Arduino into educational environments has been becoming widespread (Numanoğlu & Keser, 2017). 90% of the teachers have the opinion that the usage of Arduino activities is important (Çengel, Alkan, & Çayır, 2018). In our country, programming and coding training has started since 2012 in the 5th grade (Pala & Mıhcı-Türker, 2019) and the usage of technologies such as Arduino have been increased in terms of robotic applications so as to be presented in national and international competitions in schools however, the usage is not enough in our country. Inadequate school infrastructure and lack of knowledge of teachers can be inferred as the reason for not using this adequately (Çengel, Alkan, & Çayır, 2018). The vast majority of teachers do not regard themselves competent in coding or just consider it basic enough. This may be caused by lack of courses in undergraduate education. Through researches, it was stated that there were some problems in programming education (Arabacıoğlu, Bülbül, & Filiz, 2007; Esteves & Mendes, 2004; Gomes & Mendes, 2007; Mıhcı-Türker & Pala, 2018; Ozoran, Çağıltay, & Topalli, 2012; Saygıner & Tüzün, 2017b). Most of the teachers do not take any training on coding, robotics coding and 3D design for middle school students and in their university years and subsequent professions (Çengel, Alkan, & Çayır, 2018). The integration of Arduino technology into education can be carried out on specific academic researches with the education of teacher and pre-service teachers

primarily within the scope of specific cognitive and affective objectives with appropriate learning approaches.

In researches carried out with different research designs, technology-supported teaching environments such as Robotics and Arduino positively affect the attitudes, interests, motivations and skills of the students both in cognitive and affective dimensions (Buluş Kırıkkaya & Başaran, 2019). For example, it has been observed that students' attitudes towards information communication technologies have increased in technology-supported physics laboratory (Arakliotis, Nikolos, & Kalligeros, 2016; Buluş Kırıkkaya & Başaran, 2019; Çömek & Avcı, 2016; Günbatar & Karalar, 2018; Merino, Ruiz, Fernandez, & Gil, 2016; Numanoğlu & Keser, 2017; Oluk & Korkmaz, 2018; Sohn, 2014). In addition to that, Sáez-López, Román-González and Vázquez-Cano (2016) investigated the use of Scratch between the 5th and 6th grades in Spain and found that high and positive attitudes and motivation emerged due to the use of Scratch. According to the interviews with the teachers, it was understood that there was an increase in the interest of the students with the educational robot applications and the skills of programming, problem solving and creativity. In addition, it was stated that it provided the students guidance on technology-related interest and career choice (Oluk & Korkmaz, 2018). It has been observed that scientific process skills and academic achievements have been developed in science courses conducted with robotic activities and with arduino supported activities (Çömek & Avcı, 2016). Numanoğlu and Keser (2017) have found that students can think more creatively in addition to their attitude and skill development. Attitudes and problem solving skills were examined in the studies conducted according to experimental design with control and experimental groups. It was concluded that there was a significant difference in attitude and problem solving skills of the students who applied with Arduino (Sohn, 2014). Analyzing some researches that relate problem solving and programming, it is stated that programming education contributes to the development of problem solving skills in students. It is the development of logical thinking skills in students as the reason for giving programming education in Europe. In the literature, computer programming education is emphasized to contribute to the development of this ability (Mains, 1997; Saygıner & Tüzün, 2017a; Sebetci & Aksu, 2014; Swain, 2013). It is concluded from the study examples that programming and coding trainings contribute significantly to the cognitive and affective characteristics of students. According to the related studies, it is understood that there are exemplary activities for science education and these activities have positive effects on attitude, success, motivation and skills. However, there is an uncertainty for self-efficacy, which is an affective variable while achieving positive progress in achievements such as attitude achievement, motivation and skill in the teaching of science education gains and it is supported by technologies such as robotics and arduino.

The findings of programming and coding studies showed that teachers 'and students' self-efficacy perception scores related to programming affect the performance of programming (Altun & Mazman, 2013; Aşkar & Davenport, 2009; Davidson, Larzon, & Ljunggren, 2010; Kasalak, 2017; Ramalingam, LaBelle, & Wiedenbeck, 2004). In a study, mBLock developed self-efficacy perceptions of secondary school students in the program teaching (Günbatar & Karalar, 2018). It has been proven that technologies such as Arduino provide support to educators who develop engineers in

engineering faculties and improved their self-efficacy (Mallik & Rajguru, 2018). Yükseltürk and Altıok (2017) analyzed the effects of Scratch programming on pre-service teachers' views on computer programming. It was also concluded that participants generally had higher and more positive self-efficacy perceptions and attitudes. The fact that the self-efficacy of the teachers who participated in the education of information technologies is higher than the ones who did not attend the training, and it shows that the trainings on this subject have a positive effect on the self-efficacy of the teachers. In this respect, it is important to give trainings to teachers in order to increase their self-efficacy. Giving seminars to science teachers such as STEM and arduino can contribute to the literature (Görgülü & Küçükali, 2013). It is stated that because of their low self-efficacy perceptions in order to develop self-efficacy in students and teachers who do not have any experience in Arduino, the fact that the content has been designed from simple to complex in a way that does not reduce the motivation from the beginning will have a positive effect on shaping their self-efficacy perception (Altun & Mazman, 2013). Yükseltürk and Altıok (2016) analyzed the effects of programming with Scratch on the attitudes of Information Technologies pre-service teachers for programming. As a result, it was stated that Scratch platform had a significant positive effect on Information Technologies pre-service teachers' self-efficacy perceptions and attitudes. Based on their findings, it was recommended to redesign the programming trainings using Scratch in order to increase the logical computational skills and creative thinking skills of the beginner programmers (Kasalak, 2017). It is understood that the results obtained from different research patterns with different sample groups have a positive effect on the self-efficacy of the participants. However, in these researches, robotic coding and programming were applied in educational environments that are not related to the concepts of science education. The majority of the sample consisted of students studying in Engineering and Computer Technology pre-service Teachers. No teaching content was found in the development of the concepts of science to improve the self-efficacy of the participants and especially in the development of the concepts of chemistry. Therefore, the use of arduino-assisted teaching content in the analytical chemistry laboratory is essential in this study.

For the active use of technologies like Arduino, the teachers who are the main parts of education must have knowledge about this subject. Teachers can help their students use this technology as long as they know how to use this device efficiently. This can be achieved by increasing teachers' self-efficacy beliefs about the use of information technology. Self-efficacy is the subjective judgment of whether an individual has the necessary skills to perform a job (Bandura, 1997; Gawith, 1995; Zimmerman, 1995). In studies conducted on this field, it is seen that individuals with high self-efficacy beliefs about the use of technology are more desirous of implementing the activities using technology (Usluel & Seferoğlu, 2003). Teachers need to feel that they are competent enough to use technology in order to actively use technology. They cannot effectively use it when they think they are insufficient (Geer, White, & Barr, 1998). For this reason, it is very important for teachers to have a high self-efficacy belief in technology use. Otherwise, they tend to avoid using technology in their lessons. Teachers with a high self-efficacy belief in the use of technology have no difficulty in incorporating technological devices into the teaching process and offer their students a more productive learning environment. For this reason, it is important to

determine the self-efficacy beliefs of teachers and pre-service teachers for the use of information technology.

The use of the Arduino as an educational tool may be challenging. Studies have shown that the students who use Arduino for the first time find it not as easy as expected and have difficulty in developing applications. Furthermore, in some cases, students have judged that programming with Arduino cannot be taught. Arslan also stated that the widespread use of Arduino and the reality of availability on almost all subjects could prevent students from creating original studies (Arslan, 2018). Arduino related mechanical and physics project sharing is quite high. Chemistry and other areas remain in the minority. Therefore, Arslan's concern can be reduced by arduino studies in the field of chemistry.

It can be said that academic studies on the use of these technologies in engineering are very high, but academic studies in the field of science education have not reached a sufficient level. In particular, there is a need for experimental studies examining the effect of the use of robotic and arduino supported studies in science courses on student achievement, attitude and motivation (Çömek & Avcı, 2016). For this reason, it is rare to do experimental researchs or correlational researchs of Arduino in science education studies. The variables such as attitude, motivation, skill and self-efficacy are examined in different sample sizes in the academic researches which are mostly under the robotic and program coding studies. It can be said that the experimental researches on arduino and robotic coding are not sufficient. Science teachers are the educators who have enough education to perform interdisciplinary activities. Therefore, science teachers are the most competent individuals after the engineers to perform robotic technologies and Arduino supported applications. Especially in the field of electrical and mechanical applications, the robotic and Arduino studies can be applied in the classes of science teachers with an interdisciplinary approach (Kasalak, 2017).The spread of the educations supported by Robotics and arduino throughout the country can only realized with skillful and competent science educators. Robotic and Arduino supported studies are important in determining the obstacles encountered during the application as well as researching the self-efficacy of STEM and Science educators. When the literature is analyzed briefly, Arduino supported studies can be tested in experimental studies; It can be used in researches of attitude, interest, motivation, skills and self-efficacy. Generally, in the related literature, success, attitude, and skill research are found mainly, while there is a minority in self-efficacy. There are very few studies on the effects of the use of arduino and chemistry on person's attitudes and behaviors. The Arduino installation scheme is more suitable for the application of mechanical and electrical issues therefore, the use of arduino has been more of a physics issue. Its' use in chemistry subjects is very rare. It is also important to examine the effects of the use of Arduino with chemistry subjects in the concepts of skill, attitude and self-efficacy. In this context, this study may contribute to the integration of two disciplines in the field of education. Teachers have significant responsibilities to enable students to use technology efficiently and consciously. First of all, teachers need to be able to adapt to technological developments and have a high self-efficacy belief. In this context, it is aimed to investigate the effect of Arduino-supported analytical chemistry experiments on the self-efficacy of science pre-service teachers for the use of information technology.

Problem Situation

Nowadays, science and technology are developing rapidly and therefore individuals who can adapt immediately to innovations are needed. Education plays an important role in integrating technology into everyday life. In line with the development of technology, most of the countries have introduced innovations in order to develop their education systems in recent years (Balay, 2004). In order to benefit from technology in education systems, teachers should be trained in a qualified manner. (Kirschhner & Selinger, 2003; Şemseddin & Odabaşı, 2004). Otherwise, there will be no efficient technology integration.

In addition to technology, individuals with high self-efficacy are needed to train qualified teachers. Teachers need to develop their self-efficacy beliefs in order to fulfill their professions properly. Self-efficacy are the judgments of individuals about the level of being able to perform the necessary actions in some situations they face. If individuals' judgments are positive, the individual plans his / her actions about the situation he / she encounters in a way that will succeed him / herself, and if the judgments are negative, he / she experiences anxiety (Koballa & Crawley, 1985). In this context, teachers should have high self-efficacy in order to create an effective educational environment.

One of the basic requirements for the development of a country is to support science and produce technology. From this point of view, the importance of science courses emerges. The foundation of science education begins in schools. Individuals adopt scientific thinking, questioning, analytical and creative thinking during this training. Therefore, it is necessary to give importance to science education in order to educate individuals who can investigate, question critically and analytically, solve problems creatively and always renew themselves. Science courses generally cover subjects that require practice. Science courses are not sufficiently taught with traditional teaching techniques. In recent years, according to the inquiry-based learning approach, science is taught by doing and teaching science. At this point, the necessity of education based on technology integration arises. Teachers should have a high level of self-efficacy regarding technology in the efficient implementation of this integration. Because individuals' self-efficacy beliefs and actions are in the same direction. Teachers with high self-efficacy beliefs are more active and enthusiastic during the use of technology.

The integration of technology into the course contents does not mean that the responsibility of the teacher is reduced. This situation has a positive effect on students' technology attitude. Teachers who use technology efficiently increase the motivation and interest of students and become a role model for them (Halis, 2002). Therefore, teachers' having high self-efficacy in using technology is essential in terms of reflecting this to their teaching environment. At this point, the importance of developing teachers' self-efficacy about chemistry and information technologies is emerging.

Importance of Study

Technology has an important role to play in advancing education. For this reason, teachers need to combine their working areas with technology (Akkoyunlu, 2002). The inclusion of technology in educational content is particularly necessary in terms of effective learning for some courses. There are many abstract concepts in

science courses such as physics, chemistry and biology; and therefore, technology should be used to teach meaningful concepts. Because technology helps to connect science subjects and daily life (Çepni, 2005). With technology abstract concepts can be made more concrete and meaningful learning can be achieved. In this respect, the use of information technologies in science education should be included.

One of the most important points of social development is qualified and efficient education; and the cornerstone of this is teachers. Because teachers are one of the most important factors that regulate the learning process and learning environment (Akkoyunlu & Kurbanoğlu, 2003). In accordance with the objectives of the curricula, science teachers and pre-service teachers' self-efficacy towards technology should be taken into account in order to integrate technological innovations with education.

There is a need for teachers who have a high self-efficacy perception for an efficient learning process and technology integration. Because self-efficacy is the judiciary of individuals about the successful and systematic conduct of actions (Bandura, 1997). In other words, self-efficacy is their personal opinion about whether individuals will be successful in their action. At this point, there is internal motivation. Individuals' beliefs in their capacities and abilities influence their success. Therefore, teachers who have high self-efficacy perception in technology will not have difficulty in integrating technological devices in the teaching process; and provide a more efficient learning environment for their students. Therefore, it is important to determine the self-efficacy perceptions of science teachers and pre-service science teachers.

When the self-efficacy perception studies related to technology are reviewed, it is seen that mostly computer self-efficacy perception is emphasized. In this research, interdisciplinary interaction is provided by integrating Arduino in the content of analytical chemistry course. In this research, it is expected to determine the effect of chemistry experiments designed with microprocessor interfaces (example Arduino) on the information technologies' self-efficacy of pre-service science teachers. It is thought that this research will contribute to the literature in the field of technology integration with Arduino use and accordingly the change in information technologies' self-efficacy.

Purpose of Study

Nowadays, technology is constantly developing with the developments in scientific field. Therefore, there is a need for individuals who interrogate, criticize and think analytically. At this point, schools play an important role. There is a need for educational environments that allow students to interact with technology. In line with the scientific developments, technology integration has become a necessity rather than a privilege (Çiçek, 2006). For this reason, education systems should be reorganized according to scientific and technological developments in order to contribute more to its purpose.

Technology integration in the process of education is also very important for students. Students use technology to play an active role in selecting, acquiring and showing competence in learning objectives. The International Society of Technology Education (ISTE) has set some standards for the use of technology. ISTE is a community established with the aim of increasing the success of the teaching process with the efficient use of technology. The standards for the use of technology in education for students are as follows (ISTE, 2016):

a) Students set personal learning goals; develop strategies using technology to obtain them; and think about the learning process to improve learning outcomes.

b) Students can set up networks and organize learning environments in a way that supports the learning process.

c) Students use technology to inform, develop, and receive feedback to demonstrate their learning in a variety of ways.

d) Students will be able to comprehend basic concepts of technology processes; demonstrate the ability to select, use and troubleshoot existing technologies; and transfer their knowledge to discover emerging technologies.

Teachers have important responsibilities for the students to use technology efficiently and consciously. First of all, teachers should be able to keep up with technological developments and have high self-efficacy perception. In this context, the main aim of the research is to determine the effects of analytical chemistry experiments designed by Arduino on the information technology self-efficacy of pre-service science teacher.

Problem statement

The problem statement of the research was determined as "Is there any effect of chemistry experiments designed with Arduino microcontroller interface on the information technologies self-efficacy of pre-service teachers?"

Assumptions

1. It is assumed that the participants did not participate in a study using this method before.
2. It was assumed that the experimental and control group students participated in the study gave a sincere response to the scales used for Data collection.
3. It was assumed that the participants were not involved in another study during the study period.

Scope and Limitations of the Study

1. The Study is limited to students of Science Education at Dokuz Eylül University, Buca Education Faculty.
2. The Study is limited to the 2016-2017 academic year fall semester.
3. The Study is limited to 2nd year students of Science Education.
4. The Study is limited to the course of Analytical Chemistry Course Laboratory.

Method

Design of Study

In this study, "pre-test-post-test control group semi-experimental research model" which is one of the experimental research models has been adopted (Büyüköztürk, 2008; Çepni, 2007; Kaptan, 1998, Karasar, 2004). In experimental studies, one or more control groups and test groups, which are generally considered to be equivalent, are used. In the research process, the applications used in the hypothesis testing in the experimental group and the existing applications in the control group.

Before and after the application, the tests are applied as pre-test and post-test. In this way, the effect of the applications used in the experimental group is investigated (Çepni, 2007).

This study was carried out in Dokuz Eylül University Buca Education Faculty Science Teacher Education Department. One of the second grades was assigned randomly as the experimental group and the other as the control group. Before and after the application, the tests were applied to the pre-service teachers in the experimental group and the control group as pre-test and post-test. In the experimental group, closed-end chemistry experiments with Arduino support based on confirmatory approach; in the control group, closed end experiments based on confirmatory approach were performed.

Dependent variables of study are self-efficacy towards technology of pre-service teachers. The independent variables that can influence the dependent variable are the activities used in the control and experimental groups. Disruptive variables were controlled by providing training to the control and experimental groups with parallel sessions from the same teacher.

Participants

The participants of this study were 61 pre-service teachers in the 2nd year of Science Education program at Dokuz Eylul University. In the undergraduate program of Science Education, Analytical Chemistry course is given as 2 theoretical courses and 2 applications in the 2nd year of the program. In the theoretical part of the course, common lessons are taught in the experimental and control groups; during the application of the course, activities and experiments were carried out with different methods in common acquisitions. In this study, Arduino microcontroller applications were developed only in accordance with the levels of pre-service science teacher. Fifty three of the pre-service science teachers are female, and eight are male. This distribution was 26 females and 6 males for the experimental group, and 27 females and 2 males for the control group. Details of the participants are given in Table 1. Since distributions of classes were limited to the first year students enrolled in their programs, existing classes were determined as experimental and control groups. Therefore, the distribution of the equivalent male population was not realized. One of the classes was chosen as the experimental group (*n*: 32) and the other as the control group (*n*: 29). This study was designed according to "pre-test-posttest control grouped semi-experimental research design" from the experimental research methods. Within the scope of Analytical Chemistry Laboratory course, pre-test and post-test post-tests were applied to the students in the experimental and control groups. In the experimental group, Arduino supported closed-end analytical chemistry experiments were conducted based on confirmatory approach; in the control group, closed-end experiments (without the support of information communication technologies) were conducted based on the confirmatory approach.

Table 1

Personal Characteristics of Participants

	Characteristics	Experimental Group f(%)	Control Group f(%)	All Situation f(%)
Gender	Female	26(%81.3)	27(%93.1)	53(%86.9)
	Male	6(%18.7)	2(%6.9)	8(%13.1)
Age	19 and below	2(%6.3)	1(%3.4)	3(%4.9)
	20	19(%59.4)	17(%58.6)	36(%59)
	21	9(%28.1)	7(%24.1)	16(%26.2)
	22 and up	2(%6.2)	4(%13.7)	6(%9.9)
Region	Mediterranean	1(%3.1)	2(%6.9)	3(%4.9)
	Eastern Anatolia	2(%6.3)	3(%10.3)	5(%8.2)
	Aegean	16(%50)	11(%37.9)	27(%44.3)
	Southeastern Anatolia	1(%3.1)	1(%3.4)	2(%3.3)
	Central Anatolia	3(%9.4)	4(%13.8)	7(%11.5)
	Black Sea	2(%6.3)	1(%3.4)	3(%4.9)
	Marmara	7(%21.9)	6(%20.7)	13(%21.3)
Mean Course	G. Chemistry I	48.8	41.8	45.5
	G. Chemistry II	37.5	38.0	37.8

Data Collection Tools

In order to measure the self-efficacy of pre-service teachers towards information technologies, "Information Technology Self-efficacy Perception Scale (ITSPS)" developed by Ekici, Ekici, and Kara (2012) was used. The self-efficacy scale is a 5-point Likert-type scale. The attitude items in the scale were rated as “Strongly Disagree”, “Disagree”, “Undecided”, “Agree” and “Strongly Agree”. In the validity and reliability studies, the draft scale consisting of 28 items was applied to 275 Science and Technology Teacher teachers in Denizli, Samsun, and Burdur. In item analysis, item-total correlation coefficient was removed from 1 scale item and factor analysis was performed to examine the construct validity. As a result of the explanatory factor analysis, the Cronbach-Alpha internal consistency coefficient of the final scale was found to be α=0.97. Common factor loadings of 27 items in the scale vary between “0.584” and “0.840”. At the end of the studies, a valid and reliable information technologies self-efficacy scale consisting of 27 items was developed for teachers and pre-service teachers. Within the scope of this study, Cronbach's α coefficient of ITSPS was calculated as 0.94. The reliability coefficient of a reliable Likert type scale should be as close to 1 as possible. According to these results, it can be said that the results to be reached from the scale are reliable.

Data Collection Process

1. Pre-service teachers participating in the study were randomly distributed to the experimental and control groups.

2. Both groups were pre-tested.
3. The participants in the experiment and control group were grouped into 5 groups to be suitable for the cooperative learning class. Experiments were carried out in weekly intervals, adhering to the instructions. Pre-service teachers were asked to write weekly test reports.
4. A weekly experiment with Arduino was carried out in the experiment group (see Appendix).

   Experiment 1-Anion-Cation Reaction in Salts (common with control group)

   Experiment 2-Chromatographic Analysis (common with control group)

   Experiment 3-Law of Lambert-Beer (Arduino) - (See Appendix, Example of experimental setup)

   Experiment 4-Viscosity (Arduino)

   Experiment 5-Chemical Equilibrium: Determination of Equilibrium Constant Kd (Arduino) - (See Appendix, Example Experiment Setup)

   Experiment 6-Acid-Base Titration: HCl Reaction with NaOH (Arduino)

   Experiment 7-Endothermic-Exothermic Reactions (Arduino)

   Experiment 8-Conductometric Chlorine Test (Arduino)
5. The participants in the control group performed the experiments suitable for the experiment gains in the experiment group without Arduino applications.

   Experiment 1-Anion-Cation Reaction in Salts (Common with Experiment Group)

   Experiment 2-Chromatographic Analysis (common with experimental group)

   Experiment 3-Lambert-Beer Law (without Arduino)

   Experiment 4-Viscosity (without Arduino)

   Experiment 5-Chemical Equilibrium: Determination of Equilibrium Constant Kd (without Arduino)

   Experiment 6-Acid-Base Titration: HCl Reaction with NaOH (without Arduino)

   Experiment 7-Endothermic-Exothermic Reactions (without Arduino)

   Experiment 8-Chlorine Test according to Mohr Method (without Arduino)
6. Last week, Post-test was performed on experimental and control groups.

Analysis of Data

The data were analyzed by SPSS 20 program. Descriptive statistics were used to determine the self-efficacy of teachers' information technologies.

In the process of analyzing the data collected to answer the research questions in this study; It was determined by using the Kolmogorov-Smirnov and Shapiro-Wilk normality test whether or not the parametric tests would be performed on the data obtained from the responses of the pre-service teachers to the information technologies self-efficacy scale (Razali & Wah, 2011; Ural & Kılıç, 2006). The normal distribution of the data and the homogeneity of the variances were examined by Kolmogorov-Smirnov, Shapiro-Wilk, Skewness, Kurtosis, and Levene tests, respectively. The value of p in the S-W tests was greater than .05, indicating that the scores did not differ significantly from the normal distribution and the distribution was normal

(Büyüköztürk, 2008). At the end of the study, it was decided that Mann Whitney U test, descriptive analysis and one-way ANCOVA were used to determine whether teachers' information technologies self-efficacy changed according to various variables. The data were evaluated at p=.05 significance level.

Internal Validity Threats and Precautions

In experimental research, it is possible that the result will be influenced by the threat factors arising from internal validity. The factors that threaten internal validity in experimental research: the duration of the study, the physiological and psychological development of the participants, the measurements done before the experimental practices, the use of different measurement tools, the stacking of the endpoint responders during the pretest / posttest application, the bias in the determination of the experimental / control groups, data loss (Baştürk 2009; Cook & Campell, 1979; Ercan & Kan, 2004; Fraenkel & Wallen, 2000). The threat of internal validity is related to the reality of the result obtained from the research and questions the deteriorating factors. Therefore, in the internal validity threat, "Is the result obtained from the research real?" and "What are the possible situations that change research results?" questions are asked. In this context, it is necessary to take necessary measures to identify and eliminate the threat elements that will affect the validity of the experimental design (Creswell, 2003).

Internal validity in experimental research means that the dependent variable is only affected by the independent variable and is only related to it. Internal validity is an indication of the fact that the change in the dependent variable is actually caused by the independent variable. Therefore, the researcher tries to control the factors that may affect the dependent variable except for the independent variable (Bal, 2019). One way to prevent the factors that threaten internal validity in experimental research designs can be by including the control group in the research design and by positioning it correctly (Karasar, 1998). Another factor that threatens internal validity is the determination of the experimental group and control groups by means of neutral assignment in the prevention of biased grouping. In addition, it is thought that the effect of maturation can also be controlled by the neutral assignment of the groups. Because, it is assumed that the effect of maturation through neutral assignment will occur equally in all experimental conditions (Aktaş, 2013; Buldur & Doğan, 2017). In this study, the classes of students in the experimental and control groups were not re-grouped since they were determined from the school enrollment period. Experimental and control groups have been formed by making neutral assignments to existing classes. In this study, although it is not a full experimental study, it is tried to provide internal validity by semi-experimental study. The study was carried out with pretest-posttest control grouped experimental design. Participant loss is another factor threatening internal validity. To eliminate this threat, experimental (n=32) and control (n=29) groups were formed and possible participatory losses were kept under control. In this study, data and participant loss was not experienced. In the other way to increase internal validity, validity and reliability measurement tools should be applied to all participants. The measurement instrument used in this study was first developed abroad. After Turkish adaptation, validity and reliability study was performed on a large sample. In this study, single measurement tool was distributed to both groups. No different measuring tools were used. In this way, it has been tried to prevent internal validity threat situations caused by

data collection tools. The measurement tool effect occurs when the measuring instruments differ in experimental conditions. This threat arises when the tests given to the participants are different, the tests are given by different people and the different observers do not evaluate objectively (Aktaş, 2013). In this study, the applications to the students in the experimental and control groups were performed on different days. In the laboratory environment of the students encounter each other is minimized. There was no data loss between pre-test and post-test. The students were fully involved in the practices. It is thought that students in the second year of university do not pose a threat to maturation. Students at this level have passed through the familiarization process and are in full effort to progress in their careers. A preliminary pilot application was not performed in this study. However, applications that could be used for pilot study were carried out. The first 5 weeks of the period were used in warm-up activities and the main applications were started in the sixth week. The instructor who carried out the applications had a 3-month trial period for the calibration and testing of the devices before the beginning of the semester. After experiments and activities were tried and the devices were calibrated, applications were made. In this study, the application days and hours of the tests in the experimental and control groups are the same. Both groups were trained in the same period. In this study, both groups were given the same instructor. The students in the experimental and control groups do not know each other and there is no material sharing. In this study, pre-tests were applied at the beginning of the fall semester and the final tests at the end of the fall semester. Therefore, it is thought that pre-tests do not have a guiding effect on the final tests.

Findings

In this section, findings of experiment and control groups are given. In the first study, the normal distribution and homogeneity of the data were examined to determine the suitability of study data for parametric tests. Normal distributions of data were evaluated for Kolmogorov Smirnov Normality Test, Shapiro-Wilks Normality Test, Skewness and Kurtosis values. In Kolmogorov Smirnov and Shapiro-Wilks's Normality Test, the table in SPSS is Assymp.Sig. (Significance) line is larger than 0.05, which is the limit value in the statistical significance calculations, the distributions of the examined variables are normal, whereas the values smaller than 0.05 indicate that they do not have normal distribution (Eymen, 2007). In addition, the values of Skewness and Kurtosis are also within the range (+1,-1), indicating that the data are normally distributed.

Table 2

Normal Distribution Analysis Results of ITSPS Data of Pre-Service Teachers in the Experiment and the Control Group

	Group	Kolmogorov-Smirnov			Shapiro-Wilk			Skewness	Kurtosis	Distribution
		F	*sd*	*p*	*F*	*sd*	*p*			
ITSPS Pre-test	CG	0.109	29	.200	0.981	29	.857	-0.387	0.729	Normal
	EG	0.148	32	.071	0.912	32	.013	-10.074	0.856	Normal*
ITSPS Post-test	CG	0.134	29	.192	0.959	29	.307	-0.417	-0.563	Normal
	EG	0.106	32	.200	0.972	32	.565	0.292	-0.653	Normal

** It has been accepted that the pre-test scores of the pre-service teachers in the experiment group are normally distributed because the pre-test scores exceeded the specified value of Skewness value and other criteria.*

As seen from Table 2, it can be said that the overall total scores of the ITSPS in the pretest and posttest in the experimental and control groups were normal. In order to provide a normal distribution in a data set, there should be a sample number of at least 40 people. However, in this study, non-parametric analysis may be required since there are less than 40 people in each group (Frankel & Wallen, 2000). For this reason, Mann-Whitney U test was used as a non-parametric statistical analysis technique, while descriptive statistical analysis, T-test and one-way ANCOVA (Analysis of Covariance) were used as parametric statistical analysis technique. The results of the analysis were compared with SPSS statistical program at 0.05 significance level and presented in tables.

Prior to the start of experimental practice, pre-service teachers' self-efficacy levels towards information technology were compared by using the independent sample Mann-Whitney U Test and T-test for the ITSPS according to the experimental and control groups and the results are given in Table 3.

Table 3

Independent Sample Mann-Whitney U Test and T-test Results according to Experiment and Control Groups of Pre-Test Scores of Pre-Service Teachers' ITSPS

Group	*n*	Mean	Mean Rank	Sum of Ranks	Mann-Whitney U Test	T test	*p*
CG	29	94.41	30.62	888.00	453.00	0.208	.874
EG	32	93.47	31.34	1003.00			

As seen in Table 3, the mean rank of the pre-test scores of the pre-service teachers' ITSPS in the control group was found as 30.62, and the mean rank of the pre-test scores of the pre-service teachers' ITSPS in the experiment group as 31.34. There was no statistically significant difference between the mean rank of the pre-test scores of the pre-service teachers' ITSPS according to the experimental and control groups

(U=453.00; p>.05). According to this result, it is seen that both groups were equal in terms of self-efficacy perceptions of information technologies.

After to the start of experimental practice, pre-service teachers' self-efficacy levels towards information technology were compared by using the independent sample Mann-Whitney U Test and T-test for the ITSPS according to the experimental and control groups and the results are given in Table 4.

Table 4

Independent Sample Mann-Whitney U Test and T-test Results according to Experiment and Control Groups of Post-Test Scores of Pre-Service Teachers' ITSPS

Group	*n*	Mean	Mean Rank	Sum of Ranks	Mann-Whitney U Test	T test	*p*
CG	29	93.66	22.19	643.50	208.50	-4.467	.000
EG	32	107.34	38.98	1247.50			

According to Table 4, a statistically significant difference was found when the mean rank of post-test scores of the pre-service teachers' ITSPS were compared according to experimental and control groups (U=-208.50; p<.05). The mean rank of post-test scores of the pre-service teachers' ITSPS in the control group was 22.19; the mean rank of post-test scores of the pre-service teachers' in the experimental group was determined as 38.98. When the mean rank of post-test scores of the pre-service teachers' ITSPS were taken into consideration, it was determined that this a statistically significant difference was favored by the experimental group.

At the end of the experimental applications, the pre-test scores of the pre-service teachers' ITSPS were subtracted from the post-test scores of the pre-service teachers' ITSPS. The difference scores of the pre-service teachers' ITSPS were compared with the independent sample Mann-Whitney U Test and T-test according to the experimental and control groups. The results are given in Table 5.

Table 5

Independent Sample Mann-Whitney U Test and T-test Results according to Experiment and Control Groups of Post-Test/Pre-Test Difference Scores of Pre-Service Teachers' ITSPS

Group	*n*	Mean	Mean Rank	Sum of Ranks	Mann-Whitney U Test	T test	*p*
CG	29	-0.76	23.48	681.00	246.00	-3.475	.002
EG	32	13.88	37.81	1210.00			

According to Table 5, a statistically significant difference was found when the mean rank of post-test/pre-test difference scores of pre-service teachers' ITSPS were compared between experimental and control groups (U=246.00; p<.05). The mean rank of difference scores of pre-service teachers' ITSPS in the control group were 23.48; and

the mean rank of difference scores of pre-service teachers' ITSPS were 37.81. When the mean rank of post-test/pre-test difference scores of pre-service teachers' ITSPS were taken into consideration, it was determined that this a statistically significant difference was favored by the experimental group.

Generally, ANCOVA is used to test whether there is a meaningful difference between the post-test measurement scores of the experiment and control group in experimental designs with pretest-posttest control group (Büyüköztürk, 2008). ANCOVA corrects the mean of post-test scores according to the mean of pre-test scores and then compares adjusted the mean of post-test scores between the groups. For this reason, in this study, the mean of post-test scores of pre-service teachers' ITSPS were compared between the experimental and control groups by covariance with the mean of pre-test scores of pre-service teachers ITSPS in the one-way ANCOVA.

In the one-way ANCOVA, the mean of post-test scores of pre-service teachers' ITSPS were made covariate according to the mean of pre-test scores of pre-service teachers' ITSPS and adjusted the mean of post-test scores of pre-service teachers' ITSPS were tested according to the experimental and control groups. The results are given in Table 6.

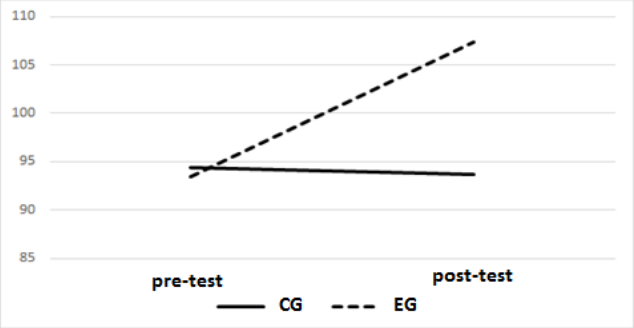
Table 6

One-way ANCOVA Results according to Experiment and Control Groups of Adjusted Post-Test Scores of Pre-Service Teachers' ITSPS

Source of Variance	Sum of Square	*df*	Mean of Square	*F*	*p*	η^2
ITSPS pre-test	1633.412	1	1633.412	13.944	.000	0.194
Group	2966.632	1	2966.632	25.325	.000	0.304
Error	6794.358	58	117.144			
Total	631521.000	61				

According to the one-way ANCOVA results, the mean of the post-test scores of pre-service teachers' ITSPS adjusted by the mean of pre-test scores of pre-service teachers' ITSPS showed a significant difference between the experimental and control groups ($F(1\text{-}58)$=25.325; p<.05). To determine the significance level of this difference, the "effect size" is examined. The effect size (η^2: eta square) ranges from 0.00 to 1.00. This value is small effect if η^2<0.01; it is medium effect if 0.06< η^2<0.14; it is large effect (Büyüköztürk, 2008). At the end of the experimental application, it was determined that the applied method provided a high effect (η^2= 0.304) on the pre-service teachers' ITSPS in the experimental group.

Figure 1. Graphical Representation by the Mean of Pre-Test and Post-Test Scores of Pre-Service Teachers' ITSPS in the Experiment and Control Groups



Discussion

In this study, the effect of using technology on the pre-service science teachers' self-efficacy perceptions towards information technologies (example electronic circuits working microprocessor such as Arduino) was examined in the application of analytical chemistry experiments supported by Arduino. In the study, Arduino was chosen from the microprocessor interfaces. At the beginning of the study, it was determined that the experiment and control groups were equal level according to the mean of pre-test scores of pre-service science teachers' the self-efficacy perceptions. As a result of the study, closed-end chemistry experiments supported by Arduino based on confirmatory approach were found to have a positive effect on pre-service teachers' self-efficacy perceptions according to the mean of the post-scores of their ITSPS.

In this study, the publications examining the effects of different independent variables on attitude, skill, success and self-efficacy development were examined in the literature review.

Within the scope of Robotic and Coding training, positive changes in the cognitive and affective behaviors of the participants were found in experimental studies with open-source microcontrollers such as Arduino (Buluş Kırıkkaya & Başaran, 2019). Similarly to this study, Yenice (2003) investigated the effect of computer-assisted science teaching method applied to 8th grade primary school students on the science and computer attitudes of students. According to the results of the study, it was determined that computer assisted science teaching positively affected students' attitudes towards science and computer. The results obtained thus support the findings of this study. In accordance with this study, the use of computer based technology support in physics laboratory applications has improved the attitudes of the participants towards communication technologies (Arakliotis, Nikolos, & Kalligeros, 2016; Buluş Kırıkkaya & Başaran, 2019; Çömek & Avcı, 2016; Günbatar & Karalar, 2018; Merino, Ruiz, Fernandez, & Gil, 2016; Numanoğlu & Keser, 2017; Oluk & Korkmaz, 2018; Sohn, 2014). It has been seen that activities based on coding in science courses improve students' skills and achievement (Çömek & Avcı, 2016). It can be said that the use of technology support in the direct implementation process in laboratories and science courses has a positive effect on the attitudes, skills and success development in the light of the relevant literature findings and the results obtained in the study. In the same way, it was seen that the programming self-efficacy perception scores and programming performance of the participants were improved in the studies conducted for

programming and coding with different sample groups similar to the self-efficacy results of this study (Altun & Mazman, 2013; Aşkar & Davenport, 2009; Davidson, Larzon, & Ljunggren, 2010; Günbatar & Karalar, 2018; Kasalak, 2017; Mallik & Rajguru, 2018; Ramalingam, LaBelle, & Wiedenbeck, 2004). Indirectly, it can be said that there are positive contributions to attitudes and self-efficacy in technology-supported researches in similar science education with this study. When self-efficacy is evaluated within the context of affective behaviors, it is common for similar findings with other attitudes. Research by Govender and Govender (2009) and Stewart (2012) found a high correlation between technology self-efficacy and attitudes towards technology. Govender and Govender (2009) have identified the link between teachers' self-efficacy perceptions of information and communication technology use and the educational integration of information and communication technologies. A descriptive study was conducted with 1237 teachers. Findings show that teachers have a high perception of self-efficacy in terms of information and communication technologies, they have a positive impact on their attitudes toward technology and their integration into the educational process. Stewart (2012) found that teachers' technology integration was a significant relationship between their self-efficacy and their interest in educational technologies. Likewise, Kayaduman, Sırakaya, and Seferoğlu (2011) investigated the feasibility of the FATIH project and examined the technological infrastructure in education. According to their findings, teachers were found to be inadequate to use technology in education. It has been discovered that this inadequacy is directly related to technology self-efficacy perceptions. As a result of the studies, it seems that teachers need to have a high self-efficacy perception in order to integrate technology into the education process. Therefore, it seems that for effective technology integration in education, there is a need for more effective applications of teachers' self-efficacy perceptions of information technologies. According to the results of the literature and the findings of this study, it can be said that there is a positive correlation between interest in technology and self-efficacy. When the results in the literature are related to the results of this study, it can be said that the analytical chemistry experiments supported by Arduino have developed the self-efficacy of the pre-service teachers and reached the goal of the this study.

At the end of the study, interviews were conducted to support and validate quantitative data. At the end of the study, when the common opinions on the interviews of pre-service teachers are examined; pre-service teachers have reached consensus on common positive views such as “to provide ease of calculation”, “easier to draw”, “more instructive”, “easier to use”, “allow systematic work”, “correct measurement” “Making it easy to use”, “convenience of purchasing”, “possibility to do more than one experiment with one device”, “making the lessons pleasant”, “being a multifunctional and widespread resource”. However, it has been stated that the use of Arduino is difficult, and the connection and use of ports with computers should be learned. Similarly, according to Marangoz (2013), the primary science teachers’ thoughts towards computer-based teaching were examined. According to findings, it was revealed that all the teachers who participated in the research had a positive opinion on the application. At the same time, it has been determined that computer assisted instruction should be used more effectively and teacher education is needed in this direction. In the same study conducted by İnel, Evrekli, and Balım (2011), pre-service

science teachers' opinions towards the use of educational technology in science courses were researched. According to this, it was determined that the pre-science teachers participating in the research had a positive opinion about the integration of educational technology into the course contents. Moreover, it has been determined that pre-service science teachers do not see themselves adequately in terms of technology. Kirkscey (2012) has conducted a study on technology integration in secondary education. In a study with 27 teachers in Texas, teachers indicated that technology made education more permanent and effective. At the same time, they stated that the teacher reduced the burden. When the relevant literature is examined, it is seen that the pre-service teachers have generally expressed favorable views on technology integration. Obtained findings support the result of this study.

Arslan (2018) stated that the use of Arduino as an educational tool may have difficulties. The articles reviewed by Arslan in the literature, showed that the use of Arduino for students who first used Arduino was more difficult than expected and had difficulty in project work (Arslan, 2018). During the interviews conducted in order to support quantitative data, the students stated that they had difficulty in using Arduino in the beginning and that they could use them easily as time passed. They stated that they had difficulties only with port connections and that they had difficulties with library support from time to time. In this study, the students in the experimental group had to use the computer more effectively than the control group. During the activities with Arduino, the students learned the computer setups in the computer environment, they controlled the objects by programming, they learned the coding, they transferred the numerical data obtained from arduino platform to excel format, they graphed, they analyzed and they interpreted the graphics. Besides, students in the experimental group have become accustomed to the arduino computer program. Students in the control group did not receive direct information communication technology support. The students in the control group collected the data in the activities directly by taking notes with paper-pen. Only the students in the control group carried out the warm-up activities they did in the first four weeks. Students in the working groups in the class were asked to write reports in MS Word software in a common template. The students sent their reports to the instructor of the laboratory course via e-mail. For this reason, a development in information technologies self-efficacy was observed in both experimental and control groups. This development can be said to be more in the experimental group. In the interviews conducted with the experimental group for the purpose of verification, the students stated that arduino technology provides easy calculation, easy graphing, data is stored in a concrete and reliable manner; it is used in experiments easily and has a functional and interesting structure. These opinions of the students support the information self-efficacy. For this reason, there may be some more development in the students' self-efficacy in the interactive analytical chemistry laboratory in arduino. For this reason, Altun and Mazman (2013) stated that because of their low self-efficacy perceptions to develop self-efficacy in science teacher sand pre-service science teachers, designing the content from simple to complex, from the outset to the beginning, could have a positive effect on shaping self-efficacy perceptions. According to the opinions of the students, it can be said that the proposal of Altun and Mazman (2013) has been confirmed.

Conclusions

As a result it is concluded that the Arduino microcontroller, which is developed for teaching programming and coding, can be used in analytical chemistry experiments and the participants' self-efficacy regarding information technologies can be improved. As is known, the Arduino microcontroller is commonly used in computer programming, physical laboratory activities and robotic studies, but its' use in chemistry is limited. It is understood that Arduino can be used in chemistry experiments. However, when using this technology, first of all, it should be started from easy activities and the degree of difficulty of activities should be increased as time progresses. Students in the chemistry area who are not accustomed to programming language are forced to use Arduino technology and cannot learn the programming and coding processes. Therefore, students participate to course with low motivation and reluctance. In order to eliminate this negative attitude, students should be encouraged to start the process by designing activities that increase motivation and motivation in the first weeks. At the end of the learning process designed with the principle of easy to hard, it is understood that the students will have high motivation and reach the goals.

Implications

• The development of technology infrastructure should be provided in educational environments according to the opinions of pre-service teachers.

• Pre-service teachers seem to feel inadequate in terms of technology. In this context, teachers should be informed about technology and encouraged to integrate education. At the same time, studies on the use of technological devices in educational environments should be supported.

• As a result of the study, the time savings in the views of pre-service teachers are mentioned. According to this finding, teachers need to incorporate technology into the teaching process in order to use the teaching process efficiently and actively.

• As a result of the implementation, pre-service teachers have indicated that the use of Arduino is more instructive and interesting. Therefore, the teaching process should be enriched with different teaching methods and techniques.

• The integration of technology in the training of pre-service teachers should be emphasized and related trainings should be given.

• Experiments with microprocessors can be varied and used for many different courses.

• The study can be done by choosing different experimental approaches.

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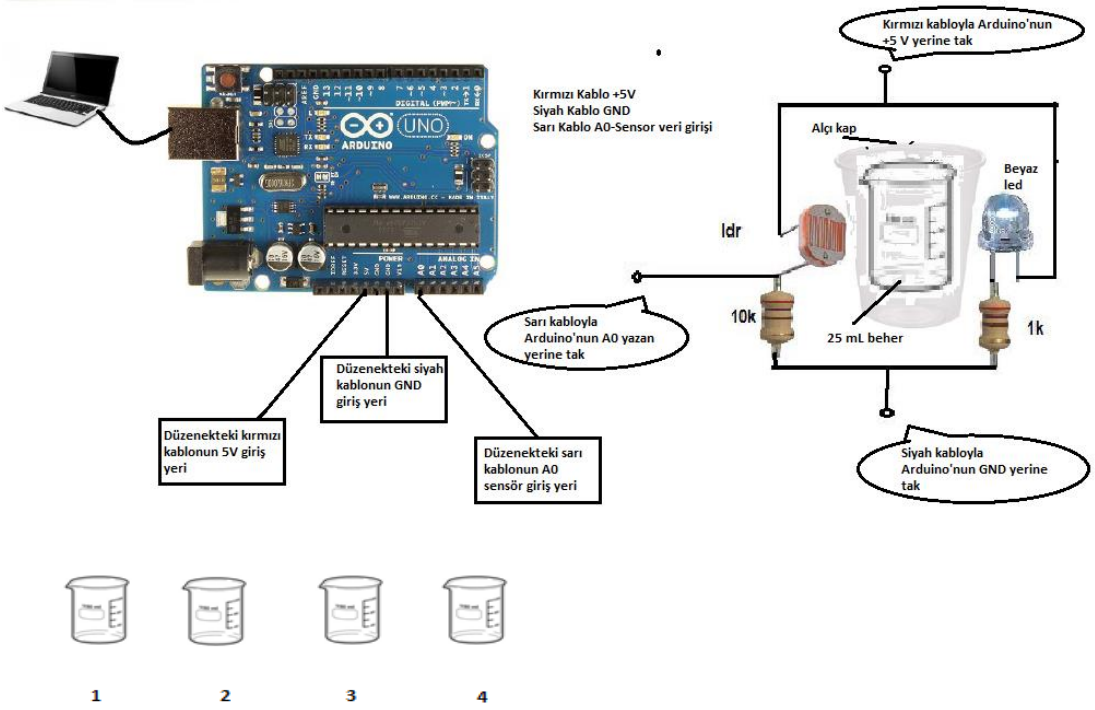
Appendix-Arduino Chemistry Experiment Test and Program Code Used in Equilibrium Constant Experiment and Colorimetric Analysis Experiment

Schematic Setup of Experiment Plan



Important Information about The Device: This device was prepared in the Colorimetry experiment. This will be used in the experiment. Here is a reminder that the preparation of the apparatus has been explained. A 25 mL plaster mold was prepared by the researcher, taking a 25 mL beaker. The LDR and White led were drilled with a drill from the outside of the plaster mold, as shown in the figure, and the connections were made. The electrical circuit is wrapped with insulated tape so that it is not affected by the solution. As you can see, the red, black and yellow colored cables are laid out on the plaster mold. During the experiment, the pre-service teachers simply placed these cables on the places shown on the Arduino Uno. Pre-service teachers are required to run the program by issuing a pre-prepared command word file. In this way, it is aimed that the process is accelerated with the ready device and that the electronic technical part of the test system is not given to the pre-service teachers and that the analytical chemistry is not taken out.

Arduino Experiment Program Code

```
void setup() {
  Serial.begin(9600);
}
void loop() {
  int sensorValue = analogRead(A0);
  float isik = sensorValue * (5.0 / 1023.0);
  Serial.println(isik);
  delay (500);
}
```