An Investigation of the Cognitive Awareness of Science Teacher Candidates on Sensors

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Abstract
The present study has been developed in order to inquire the cognitive awareness of the 2nd grade-level students of the Science Teaching program on "sensors", which has an important place in the development of the robotic and automation systems. In the study, the method of case study, which is one of the qualitative research motifs, was used. As the data collection tool of the study, the semi-structured interview form composed of open-ended questions, which was prepared by the author of the study, was employed. A great majority of the students stated that sensors were devices sensing the physical changes in the environment in place of human beings. In addition, they also stated that sensors were used in today's technology for the purposes of imaging, control and protection. It was determined within the scope of the study that, although the students knew about the types of sensors, they couldn't realize the other sensors they encountered in their environment in their daily lives.

Keywords: Sensors, Cognitive Awareness, Science Teacher Candidates

Introduction

Technology is in every field of our lives today, and it facilitates our lives. With the use of technology increasing day by day, robotic systems and automation systems are in a rapid process of development as well. The objective of these systems is to increase the interaction with the environment and to create robots that can run on their own. In order to be able to produce systems in line with the stated purposes, it is necessary to make use of sensors. Knowing about the characteristics of sensors as well as their purposes of use ensures that these purposes are achieved more rapidly.

In the 21st century, it has become highly important to train individuals who can easily adapt to the rapid developments in technology and use the information technologies in an efficient way. Thus, it is necessary to include the coding education in the educational system in order to develop the skills related to the information technologies.

It seems that many countries have already included the coding education in their curricula in order to improve the computer programming and coding skills of students. As for Turkey, the Ministry of National Education made the decision to add the "Computer Technologies and Software" to the educational programs in the educational year of 2012-2013. Thus, the subjects related to algorithm and programming were included in the curricula. Students began to be given programming education at the basic level beginning in the 5th grade-level. As an academic skill, coding is considered a part of logical reasoning and is accepted as one of the skills called "the 21st century skills" today (Sayın & Seferoğlu, 2016). As for the age interval for the coding education, it has been decided to apply it on all age groups beginning at the 1st grade-level as of today. The importance of the coding education has been emphasized by

means of the changes made in this process, and it has been found out that giving the coding education at every level of education beginning at early ages is necessary. The coding education is known to be started as early as at 5 years old abroad (Saygıner & Tüzün, 2017). Besides, previous studies have addressed the importance of the coding education at early ages and it has been stated that it could provide positive contributions in terms of the development of students (Özçınar et al., 2016; Demirer & Sak, 2008).

Today, use of physical robots, 'do it yourself' kits and sets, virtual robot programming environments and robot programming software is rather common in programming teaching (Numanoğlu & Keser 2017). The robots frequently used in the science and technology courses are used in programming education as well. While robots teach students the basic concepts of engineering and technology by means of entertaining, educational and cooperative activities, they also improve their building, design and programming skills (Fidan & Yalçın, 2012). Students make the robots move in physical environment by means of robot programming software and by using the electronic circuit components. The circuit components most commonly used in robotic programming are the sensors.

The devices sensing the physical changes in the environment in place of human beings are called sensors. Sensors are the systems sensing and measuring the physical changes such as temperature, pressure, sound, distance, etc. and transforming them into electric signals (Yüksel, 2006). According to Wilson, a sensor is a device turning a physical phenomenon into an electric signal. Therefore, sensors represent a part of the interface between the physical world and the electrical devices. Sensors are used to measure various physical features such as temperature, force, pressure, flow, position, light intensity, etc. Fraden defines a sensor as a device that generally receives a signal or a stimulus and transforms it into an electric signal compatible with electronic circuits. In short, sensors connect the physical environment and electronic devices to each other and assume the role of a bridge in this regard.

As a result of the rapid advance in technology, there are many types of sensors today. Most commonly known types of sensors are the optical, thermal, pressure, electronic, chemical and biological sensors. In robotic and automation systems, touch, speed, inclination, acceleration, position, force, sound and image sensors are preferred (Işık, 2013; Fraden, 2010).

Review of Literature

Sensors are used today in a wide range of applications in various fields including health, automotive, robots, rockets, machines, etc. (Kretschmar & Welsby). In literature, there are a number of studies in the field of health that aim to control the patients and the doctors. In the study conducted by Dener (2018), the locations of the doctors in a hospital were determined by means of wireless sensors. Coşar et al. (2012) stated in their study that people with Alzheimer's disease frequently leave their home for taking a walk and cannot return since they forget the route they have followed. They gave information about mobile navigation devices that could be used for people with Alzheimer's disease. The existence and use of such applications in mobile smart phones were investigated and their advantages and disadvantages were determined in their study.

Studies concerning the use of sensors in security systems can be found in the literature concerning the automotive industry. Çavaş et al. (2012) controlled the ignition system of automobiles by means of fingerprint sensor. In other words, they developed a personal security system by making use of the biometric features of people. Sağıroğlu and Özkaya (2006) created an identification system by means of the automated fingerprint recognition system. Thus, identification could be carried out based on the image of fingerprint in a trouble-free, reliable, rapid and automated way.

When the studies concerning the use of sensors in robotic coding have been examined, it has been found out that Turhan (2016) drew the environment map for a wheeled mobile robot with a limited mobility by using a random tree structure algorithm and by means of a laser distance detecting sensor. When the literature has been reviewed for the studies concerning the use of robotic coding in science teaching, it has been found out that Şenol (2012) collected the

opinions of students concerning the experimental activities carried out with the support of the robot technology in the 'science and technology' course in order to make use of technological innovations. In addition, the same study investigated the effects of the experimental activities on the scientific process skills of students and their motivation for the science and technology course. Özer (2019), on the other hand, investigated the effects of the use of robots in the coding education on the access, motivation and problem-solving skills of the middle school students. Numanoğlu and Keser (2017) investigated the usability of the mBot-STEM Education Robot Kit platform produced and developed by 'Makeblock' in programming teaching. Using the MakeBlock programming medium, they developed model applications including the basic programming concepts and carried out trials on the mBot-Robot Kit and Tağci (2019) investigated the effects of the coding education on primary school students.

Aim of the Study

As a result of the rapid changes and developments in technology, all countries carry out works for making use of technology in their educational system today, and therefore the coding education seems to have risen to prominence. Coding education has begun to take part, in a very rapid way, primarily at the preschool and primary school levels of education. The electronic circuit components most commonly used in coding education, especially in robotic programming, are the sensors.

Within this context, the present study has been conducted in order to determine the cognitive awareness of the 2nd grade-level students studying in the Science Teaching program on sensors, which are of importance for robotic systems in today's rapidly developing technology.

It is considered that the science teacher candidates having an adequate level of knowledge on sensors will easily be able to help their students in coding education when they start to perform their profession. Therefore, the rationale of the study is to inquire the cognitive level of the students concerning "sensors", which have an important place in robotic systems and the coding education. In order to ensure the solution of the defined problem, the sub-problems stated below have been investigated within the scope of the study.

1. What is the cognitive knowledge of the students studying at the Department of Science Teaching about the functions of sensors or their definition of task?
2. What is the knowledge of the students studying at the Department of Science Teaching about the purposes of use of sensors?
3. What is the knowledge of the students studying at the Department of Science Teaching about the application fields of sensors?
4. What is the awareness level of the students studying at the Department of Science Teaching concerning the sensors they encounter in their daily lives?

Method

The method of case study, which is a qualitative research motif, was used in the present study. In the case study method, the author collects detailed and deep data concerning the subject and tries to directly learn about the individual perceptions, experiences and viewpoints of the participants, and to understand and explain the existing situation (Patton, 2014). The most prominent feature of a case study is that "it is a study focusing on and deeply investigating a current phenomenon, event, situation, individual and group" (Ekiz, 2009; Yıldırım & Şimşek, 2016).

The Sample

As the sample selection method of the present study, the criterion sampling, which is a purposeful sampling method, was employed. In this sampling method, a case meeting a previously determined set of criteria is addressed. The criterion or criteria taken as the basis can be created by the author (Yıldırım & Şimşek, 2016).

In the selection of the sample to take part in the present study, being a 2nd grade-level student of the science teaching department who have taken the course of 'Technological Applications of Science' was determined as the basic criterion. Based on this basic criterion, the target population of the study comprised the 2nd grade-level students studying in the Science Teaching program in the Faculty of Education in Kırıkkale University in the academic

year of 2019-2020, and the sample of the study comprised 17 students meeting this condition. Within this framework, the criteria such as participating in the study on a voluntary basis and easy access to the author were taken into consideration in selecting the teacher candidates. Consequently, the participating group was composed of 17 female students.

Data Collection Tools and the Analysis of the Data

The semi-structured interview form used as the data collection tool has been prepared by the author. The interview form, which is composed of open-ended questions, allows the author to address the phenomenon she chooses with a flexible and open-ended approach (Yıldırım & Şimşek, 2016). In the study, an interview form composed of 5 open-ended questions was used in order to determine the cognitive levels and awareness of the 2nd grade-level students studying at the Science Teaching program concerning sensors. By means of the first question, the functions, i.e. the task definition, of sensors is inquired. The purpose of the second question is to determine the purposes of use of sensors. The third question inquires what the fields of application of sensors are in today's technology. In the fourth question, an example case is presented and, based on it,the students are asked what types of sensors they could use. Lastly, they are asked what types of sensors they encounter in their daily lives.

In order to be able to carry out the grouping before conducting an analysis on the data obtained by means of the interview form comprising open ended questions, which was developed by the author, the interview form containing the answers of the students was coded by the author. The identities of the students interviewed kept secret, and each was given a number to that end. (For instance, they were numbered in the form of K1, K2, and so on, since all of them were female students – 'K' standing for the Turkish word 'Kız', meaning 'Girl').

The findings were obtained by means of the descriptive analysis method. In descriptive analysis, the purpose is to organize the collected data based on the themes defined by the questions, to correlate them, to interpret them and to present them to the reader. Depending on the themes formed, some data may be left outside. The organized data is supported with direct quotations where deemed necessary (Yıldırım & Şimşek, 2016).

In qualitative studies, ensuring the validity and reliability is of importance in terms of the quality of the study. In the present study, the author first coded the data independently, and then she received the expert opinion. That coding was carried out sometimes by means of a word, sometimes by means of a sentence, and sometimes by means of data comprising a paragraph. In order to ensure the reliability of the study, the codes of two authors were compared in order to verify whether the codes given under the conceptual category at the end of the analysis represent the conceptual categories matching up with each other. The reliability of the qualitative data of the study was calculated by using the formula "Reliability = Consensus / [Consensus + Dissensus] x 100" developed by Miles and Huberman (1994). For the reliability of the results of the study, the consensus among the experts was calculated as 86 %.

Findings

By means of the descriptive analysis carried out by the author, the following data was obtained.

How would you define the sensors we encounter around us?

By means of the first question, the students' knowledge about the functions or task definition of sensors was inquired.

Table 1 The Analysis Results 'Correct - Partially Correct - Incorrect – Empty' Concerning the Definition of Sensors

	f Correct	f Partially correct	f Incorrect	f Empty
Definition of a sensor	10	6	1	-

According to the findings given in Table 1, 10 of the students defined the concept of sensor correctly, 6 partially correctly and 1 incorrectly. It was determined that only 3 of the students defining the concept of sensor correctly explained it by stating both the functions of the sensors and the physical changes that take place. It was also determined that 14 students defining the concept of sensor in a correct

or partially correct way explained what physical changes are sensed by sensors by giving examples.

The excerpts from the students' answers concerning the task definition of sensors are given below.

1. K1: Sensors are the devices sensing the physical changes in the environment (such as heat, temperature, sound and humidity) on behalf of us.
2. K3: A sensor is a tool we use in almost each area of our lives that has certain characteristics and responds (gives warning) when such characteristics come about or occur. We encounter them everywhere from escalators to the remote controls in our houses. They have various types such as magnetic, optical, biological, chemical, etc.
3. K5: Sensors are devices sensing physical events in the environment on behalf of us. Sensors assume the role of a bridge connecting the physical environment and electronic devices to each other. They are used in sensing the magnitudes such as sound, pressure, temperature, acceleration, torque and moment.
4. K8: Sensors are the devices sensing the changing factors in the environment (such as heat, temperature and distance) on behalf of us. They assume the role of a bridge between physical environments and electronic devices.

They have different types such as pressure sensors, thermal sensors, optical sensors, magnetic sensors, electronic sensors, biological sensors and chemical sensors.

Table 2 The Frequencies and Percentages of the Physical Changes in the Environment Given as Examples While Defining the Sensors

Physical Changes	f	%
Temperature	10	58.8
Sound	6	35.3
Heat	5	29.4
Light	4	23.5
Pressure	4	23.5
Distance	3	17.6

The examples of the physical changes occurring in the environment given by students while they were explaining the concept of sensor are given in Table 2. The most common example of the occurring physical changes given while explaining sensors was determined to be temperature with 58.8 %, and the least common one to be distance with 3 %. In addition, there are also codes that were not included in Table 2 since their frequency value was below 3, which are acceleration, moment and magnetic field.

What are the Purposes of use of Sensors in the Industrial Processes?

By means of the second question, it is aimed to determine the students' cognitive knowledge about the purposes of use of sensors. In Table 3, the students' answers concerning the purposes of use of sensors and the frequency and percentage values belonging to those answers are given.

Table 3 The Frequency and Percentage Values Concerning the Purposes of use of Sensors

Purpose of Use of Sensors	f	%
Controlling	10	58.8
Security	8	47
Remote Control	7	41.2
Determining the Level	5	29.4
In Diagnosing the Diseases in Medicine	4	23.5
Protection	3	7.6
Imaging	3	7.6
Making Life Easier	3	7.6

While 58.8 % of the students stated the purpose of use of sensors to be controlling, 7.6 % of them stated that they are used both for protection and imaging and for making our lives easier. There are also a number of codes that were not included in Table 3 since their frequency value was below 3. These codes are 'making good use of time', 'sensing the temperature' and "sensing the smell'.

The excerpts from the students' answers concerning the purposes of use of sensors are given below.

1. K5: They are used in the field of medicine, in diagnosing certain diseases. They are used in food control.
2. K11: Sensors are used in the field of industry in

controls, in safety and for measuring the levels of the substances in boxes. They are also used in factory doors and to ensure turning things on and off without contact in laboratories. Types of sensors are used in controlling devices remotely as well.

3. K14: For security purposes (in the entrances to and exits from places such as shopping malls).
4. For controlling purposes (in factories, in remote control devices).

What are the Fields of Application of Sensors?

By means of the third question, it was aimed to determine the students' cognitive knowledge concerning the fields of application of sensors in today's technology. As can be seen in Table 4, 58.8 % of the students stated that the sensors were used both in the health sector and in the industry. According to 47 % of the students, security systems comprise another field of application by which the security of our workplaces or private areas is ensured in our daily lives. 29.4 % of the students were found to have stated that shopping malls are another field of application, due to the fact people spend a considerable part of their time in large shopping malls. In addition, although sensors are commonly used in our living spaces today, it was found out that as low as 11.7 % of the students stated the smart home systems. Likewise, the rate of the students stating that the field of military and defense constituted another field of application was also 11.7 %. There are also a number of codes that were not included in Table 4 since their frequency value was below 2. These codes are 'genetics', 'traffic' and the 'automotive sector'.

Table 4 The Frequency and Percentage Values Concerning the Fields of Application of Sensors

Fields of Application of Sensors	f	%
Field of Health	10	58.8
Industry	10	58.8
Security Systems	8	47
Shopping Malls	5	29.4
Field of Military/Defense	2	11.7
Smart Homes	2	11.7

The excerpts from the students' answers concerning the fields of application of sensors are given below.

1. K1: Since sensors make our lives easier in many fields, we encounter them everywhere. Their fields of application generally include the medicine (imaging), genetics (biosensors) and engineering (control panels in factories).
2. K8: They are used in factories, in the automotive sector, in smart homes, in places requiring security and in hospitals.
3. K15: Sensors have many fields of use:
   - They are used in the field of medicine for imaging.
   - They are used in industry.
   - They are used in the food sector in order to ensure that the products are equal.
   - They are used in shopping malls concerning the security measures.

If you were asked to establish a large aquarium facility in the province of Kırıkkale, which types of sensors would you install in this facility? Please write them by stating your purpose of using them as well.

In the fourth question, the students were given an example case in order to determine what were the suitable types of sensors they could use in that specific case. In the example case given, the students were asked "to establish an aquarium facility in the province of Kırıkkale in Turkey". They were asked to state which sensors they would choose for the aquarium facility and which purpose the sensors they chose would fulfill. In Table 5, the frequency and percentage values concerning the sensors chosen by the students for the example case are given based on the findings obtained.

According to the findings given in Table 5, 6 students corresponding to a rate of 35.3 % stated that thermal sensors were needed in order to determine any fire that may occur in the aquarium facility, and optical sensors were needed in order to switch on and off the lights while moving among the different spaces of the facility. In addition, 6 students corresponding to a rate of 35.3 % stated that magnetic sensors such as an X-ray machine was needed to be installed at the main entrance of the aquarium facility in order to ensure the security

of the people and of the environment. 29.4 % of the students stated that pressure sensors were needed in order to keep the pressure of the water constituting the living space for the fish in the aquarium facility fixed. 5 students corresponding to a rate of 29.4 % stated that chemical sensors were needed in order to be able to control the harmful gases that may form in the water, and 3 students corresponding to a rate of 17.7 % stated that electronic sensors were needed in order to determine the level of the water.

By means of this question asked to the students, it was aimed to learn about their skills to use the knowledge. However, although the students knew about the types of sensors, they answered the question by using limited numbers of sensors in the aquarium facility when they were required to use that knowledge. Within this context, the students seem not to know when to use the knowledge and how to adapt it to new situations.

Table 5 The Frequency and Percentage Values Concerning the Example Cases Given in Relation to Sensors

Example Case /Aquarium Facility	Sensor	f	%
Fire Alarm	Thermal	6	35.3
Switching on/off the lights without contact	Optical	6	35.3
X-ray machine	Magnetic	6	35.3
Keeping the temperature of the aquarium fixed	Thermal	5	29.4
Keeping the temperature of the environment fixed	Thermal	5	29.4
Opening/closing the doors without contact	Optical	5	29.4
Keeping the pressure of the water of the aquarium fixed	Pressure	5	29.4
Checking the gases in the water	Chemical	5	29.4
Determining the level of the water	Electronic	3	17.6
Turning on/off faucets without contact	Optical	2	11.7

The excerpts from the students' answers concerning the example cases given in relation to sensors are given below.

1. K3: Almost all spaces in the aquarium facility can be equipped with sensors. I would first place thermal sensors in the aquariums in order to ensure that fish is kept in water with a suitable temperature.
2. K7: If I was asked to establish an aquarium facility, I would need optical sensors for the lighting of the spaces, pressure sensors concerning the pressure applied by the water to the aquarium, biological and chemical sensors in order to prevent the inhalation of the chemicals in the environment and to ensure the health of the fish, and thermal sensors in order to regulate the heat in the environment.
3. K8: I would place biological and chemical sensors in it in order to detect foreign substances.
4. K14: In an aquarium facility, I would use optical sensors for the entrance doors to be opened when someone comes in, for the faucets in the public toilets, and for the lights.

What are the Sensors that you Encounter Around you in your Daily Life?

Lastly, the students were asked which sensors they encountered in their daily lives in order to determine their awareness in this regard. In Table 6, the students' answers concerning the sensors they frequently encounter in their daily lives, and the frequency and percentage values belonging to those answers are given.

Table 6 The Frequency and Percentage Values Concerning the Types of Sensors Encountered in Daily Life

Types of sensors encountered in daily life	Task of the Sensor	f	%
Optical sensor	Opening/ closing doors without contact	11	64.7
Optical sensor	Turning on/off faucets without contact	10	58.8
Thermal sensor	Fire alarm	9	52.9
Thermal sensor	Fire alarm	9	52.9

Optical sensor	Switching on/off lights without contact	5	29.4
Optical sensor	Burglar alarm	4	23.5
Chemical sensor	Detection of harmful chemical gases, etc.	3	17.6
Optical sensor	Hand-dryers	2	11.7

As it can be seen when Table 6 is examined, 64.7 % of the students (11 students) stated that they wanted to use optical sensors in order to ensure that the doors are opened and closed without contact. Likewise, 10 students corresponding to a rate of 58.8 % stated that they would use optical sensors in order to ensure that the acts of turning on and off the faucets in public toilets can be performed without contact for ensuring hygiene in crowded spaces.

It can also be seen that 9 students corresponding to a rate of 52.9 % stated that thermal sensors needed to be used as a precautionary measure for fires that may occur in indoor spaces as a result of even a minor negligence. In addition, the students stated that X-ray machines needed to be installed in places where entrance controls take place in order to ensure the safety of the lives of people in workplaces and private spaces. Accordingly, 7 students corresponding to a rate of 41.2 % stated that they would use magnetic sensors in order to detect various objects such as metal objects, pistols and sharp objects. The excerpts from the students' answers concerning the types of sensors they encounter in their daily lives in relation to relevant examples are given below.

1. K6: The lamp we insert into the plug at home lights when the environment is dark. Optical sensor.
2. K12: Thermal sensors They are used in dormitories and shopping malls in order to prevent fires.
3. K14: By using optical sensors, ensuring that water flows from faucets without any contact.

Discussion and Conclusion

The electronic devices we encounter in our daily lives work using the robotics and automation systems. Sensors are used in order to maximize the interaction of the electronic devices taking part in our lives with their environment. Thus, people need to have a cognitive infrastructure concerning a number of electronic circuit components such as sensors in order to be able to keep up with the age of technology we live in.

The results of the present study aiming to determine the cognitive and awareness level of science students concerning "sensors", which are used in the rapidly developing technology and in their own daily lives, are presented below.

It was determined by means of the present study that the science students had a cognitive infrastructure to know that the electronic devices sensing any physical change taking place in the environment are sensors. In addition, the students stated that the physical changes that may take place can be highly diverse. It was determined that only a small number of students stated that sensors assume only a function of a bridge connecting the physical environment and the industrial electronic devices to each other. Within this context, it appears the students do not have awareness concerning the functional purpose of sensors. Accordingly, it can be concluded that the science students do not have any difficulty in explaining the purposes of the use of sensors in the industrial processes and their fields of application.

It was also found out that, although they knew about the types of sensors, the science students couldn't determine which types of sensors needed to be installed in accordance with their purpose of use in a given example case (an aquarium facility). The great majority of the students stated that they wanted to use three or four types of sensors in the aquarium facility to be newly established.

It was also determined that the science students didn't know about transducers, which convert the collected information into electrical energy. Within this context, it is necessary to put more emphasis on the working principles of all electronic devices besides the sensors.

It has been found out that the science students have developed awareness only on limited numbers of the types of sensors in spite of the fact that they encounter many types of them in their daily lives. The fingerprint sensors in laptop computers, the parking sensors in cars, and the internal and external

environment sensors in air conditioners can be given as examples for the diversity of the sensors we encounter in our daily lives. The devices measuring the blood glucose levels are biological sensors. The breathalyzers used by traffic police in breath tests are an example of chemical sensors. Controlled vehicle passage systems are commonly used in car parks or entrances to apartment buildings. Digital scales used at homes or in laboratories have pressure sensors. Magnetic sensors are used to measure the car bonnet dyes. Vacuum cleaners have also magnetic sensors checking whether the dust bag has filled up. Refrigerators have thermal sensors warning when their door is kept open too long.

Consequently, when the literature was reviewed for the studies conducted in Turkey concerning the sensors, the number of such studies was found to be quite limited. When the academic studies conducted on sensors except for the dissertation studies were reviewed, it was determined that they were primarily the studies concerning the robot design. Accordingly, it may be concluded that there is a need to conduct studies on sensors in order to improve robot designs and make them more functional. In the international literature, Druin (2009) stated that since the beginning of the twenty-first century in education, sensors have become didactic and integrated into various child-centered activities. Science educators need to include new projects in their laboratory applications that will allow the students to design sensors in a way that suits the needs and purposes of use. Thus, science laboratories should be supported more with information technologies. Instead of using ready-made sensors in STEM education applications, training should be provided for the production of new sensors to be designed and developed by the students themselves. Consequently, new studies to be conducted on sensors are considered to contribute to the literature.

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