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# Developing the attitude scale for Arduino use in courses

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**Abstract.** The purpose of this study was to develop a Likert-type scale to determine the attitudes of teachers and preservice teachers towards using Arduino in their courses. Arduino is one of the leading robotic vehicles in education. There is much data about how attitudes shape behaviors. The positive attitude of the teachers about the usefulness of Arduino in the educational context is a facilitating component for them to use it more effectively. In the process of developing the scale, the Likert scale development process consisting of 8 steps determined by Anderson was followed. The draft test was applied to a total 312 teachers who are working in 11 different disciplines and participated in Arduino courses. The data obtained as a result of the Kaiser-Meyer-Olkin (KMO) and Bartlett tests were determined to be suitable for factor analysis. As a result of the factor analysis, a scale with a single factor, consisting of 21 items and with a value of .919 Cronbach's Alpha, was obtained.

**Keywords:** Arduino, attitude scale, STEAM education, interdisciplinary approach

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## INTRODUCTION

While the fast development of sciences and technology also causes the produced knowledge to grow multiplicatively, said fast produced knowledge is shared and consumed at the same speed. This fast process conceives the multi-dimensional and complex research areas. It could be said that the birth of these multi-dimensional areas is conceived from defining the daily life problems, consisting of components that cannot be restricted with skills particular to only one discipline and that are regarding multiple areas simultaneously (Yildiz, 2017). To be able to produce solutions for these multi-dimensional problems that require multi-disciplinary skills to be used collectively, people need to have multi-dimensional thinking skills to integrate different disciplines.

The traditional teaching approach is proceeding while delivering the one-discipline-specific skills to its courses without mentioning any relation to other subjects. During this process, particular problems that can only be solved by the said discipline's knowledge, skills and experiences are created and solved. This approach might seem right in the context of a single subject. However, when students are faced with problems requiring knowledge in multiple areas, they have to integrate their experiences they gained at independent courses. It is assumed that this integration process takes place automatically (Yildirim, 1996). It is often seen that individuals, who succeed in school courses, experience difficulties, and failures when faced with daily life problems. Therefore, the efficiency of teaching in schools focusing on a single discipline needs to be questioned.

The same pattern is seen in the questions requiring an interdisciplinary approach on the PISA (Programme for International Student Assessment) exam, which is held once every three years by OECD (Organization for Economic Co-operation and Development). When exam results are examined, it is clear that learners who are taught with a single-discipline-focused approach are underachieved when in need of interdisciplinary skills.

In conclusion, the need and the necessity of an interdisciplinary approach are undoubted. The interdisciplinary approach can be easily defined as, to integrate knowledge, skill, and experience regarding multiple subjects. Mainly, a daily life problem is discussed and other disciplines' knowledge and experiences are expected to integrate purposefully to solve the problem. Additionally, the process improves the high-level thinking skills of learners such as problem-solving, critical thinking, analysis and synthesis (Yildiz, 2017).

Despite the interdisciplinary approach being based on purposeful integration, not every subject can be integrated. An evaluation was done by the National Research Council (1990) to determine subjects suitable for integration. The evaluation was dealt with problem-solving processes and scientific approaches then science, mathematics, and technology subjects were determined as most suitable. The STEAM approach, lately becoming popular, also uses these subjects as a base and aims to integrate these subjects. From this point of view, the STEAM approach seems to showcase a natural development.

Although the STEAM might, fundamentally, seem like the integration of science, technology, engineering, arts, and mathematics, it is seeking to be improved with adding other components. Because STEAM education consists of every feature of the interdisciplinary approach, it encourages gaining 21st-century skills to learners. Today, a lot of different methods and techniques are used for STEAM education and new generation pieces of equipment are started to be produced, supporting these new methods and techniques. Education has started to shape by solving daily life problems with new generation pieces of equipment like robotics sets, microcontrollers, block-based coding tools, virtual and augmented reality software, 3D pens, and 3D printers.

When studies of robots and robotics used for education are analyzed, it is noted that such practices increase the motivation and improve the problem-solving skills of students and prepare the theoretical foundation for STEM education. (Beer, Chiel ve Drushel,. 1999; Nourbakhsh, Crowley, Bhave vd., 2004; Robinson, 2005; Rogers ve Portsmore, 2004). Ucgul and Cagiltay (2014), and Somyurek (2015) worked with students attending to robot camps and concluded the students took pleasure in developing projects to solve daily life problems, had increased motivations, experienced experimental learning and gained high-level thinking skills. Benitti (2012) and Altin and Pedaste (2013) also emphasize that the use of robotics in education improves students' problem solving, logic and scientific inquiry skills.

Arduino microcontroller is the leading robotic piece of equipment in education because it is affordable and easily accessible, it can be coded easily with block-based tools and its plentiful sensor options provide the opportunity to work on the data based on real-life and the real problems. Arduino is an open-source microcontroller. It is one of the most preferred microcontrollers because of its simple programming interface and easy operation. As a result of its built-in bootloader program, it can be programmed without the need for an external programmer. It is possible to observe the result of programming with the same card immediately and to interfere in an instant if needed.

What can be done with Arduino?

- Robotic systems can be designed to interact with the environment.
- Reactions like light, sound, movement can be produced using the analog and digital outputs.
- Data can be imported from an environment with the help of analog and digital inputs and other sensors (heat, light, humidity, distance, smoke).
- The received data can be interpreted by the microcontroller.
- It can produce outputs with various purposes like light, sound, movement depending on the received data from the environment.
- Any text and visuals can be shown by connecting any screen.

In addition to its professional coding interface, it can be coded easily, enjoyably and fast with block-based tools like Scratch for Arduino, mBlock, tinkercad/circuits, ArduinoBlocks for the novice coders. Using the block-based coding, users can write any software by drag and drop. Through the software programmed, real data can be read from sensors connected to Arduino and appropriate feedback can be given by processing the data. For instance, a parking sensor like in cars can be effortlessly put together using a distance sensor and a buzzer.

Undoubtedly, involving such a powerful tool for education will have positive contributions to students' motivation and learning. However, teachers, who are supposed to involve Arduino in their courses cannot be overlooked as another component, because its involvement and efficiency in courses will be teachers' responsibility. Regarding this, teachers' attitude in bringing in the Arduino to their courses becomes crucial. There are much data showing that attitudes shape behaviors (Tezbasaran, 1997; Tavsancil, 2010). Teachers' having positive attitudes on this tool as a useful one, in the context of education, is accepted as a facilitating component to its efficient usage.

Attitude is defined as a learned tendency to react positively or negatively to particular objects, situations, institutions, concepts or other people (Tezbasaran, 1997). The attitude, which cannot be measured directly, is tried to be deduced from the observable behaviors of the individual and has a directing effect on the individual's behaviors. Observable behaviors are accepted to be caused by the attitude that led to them; therefore, attitudes can cause positive or negative behaviors (Tavsancil, 2010; Arkonac, 2001). For these reasons, it is expected to obtain information about one's behavior by measuring attitudes. With a similar take, it is possible to create intended change in one's behavior by changing attitudes. This shows that measuring attitudes gain importance. Attitude scales are used for detecting persons' particular attitudes and values (Ozguven, 1998) and most methods used in attitude scales assume people's attitudes can be measured through the thoughts on the subject of the attitude and beliefs (Arkonac,2001).

At last, it is seen that teachers' attitude towards the use of Arduino in the courses is quite significant, for them to bring Arduino to their courses. Therefore, an attitude scale for Arduino use in courses has been developed in this study.

## METHODS

The main purpose of this study is to develop a scale to determine teachers' and preservice teachers' attitudes towards the use of Arduino in courses. For this purpose, the following scale development process determined by Anderson (1988) was followed.

The eight steps to serve to develop an Anderson (1988) Likert scale might be summarized as follows:

1. Any positive or negative substances considered to be relevant to the attitude should be written,
2. The items should be pre-evaluated by the field experts,
3. Items not approved by experts need to be removed from the scale.
4. The rest of the items need to be randomly ordered.
5. The established trial test needs to be applied to the subject group, who was selected from the target audience and was at least five times the number of items of the scale.
6. For each attitude item, item analysis should be performed to determine the relationship between the scores obtained from the whole scale.
7. Items that are not statistically significant at the end of item analysis should be removed from the scale.
8. Likert attitude scale is finalized.

### Formulation of Items of Evaluation the Draft

To reveal teachers' opinions on Arduino use in courses, fifty-one teachers from different subjects, trained on Arduino were asked open-ended questions to explain "their opinions on Arduino use in courses generally" and "their opinions on Arduino use in their subject specifically". The answers' were analyzed and a draft of thirty-six items that could be an indication of attitudes toward the Arduino use in courses was established. In the process of writing the items, every item was taken care of to be simple, understandable and to contain only one judicial expression.

The thirty-one question trial test in the form of a five-point Likert scale is established for preliminary study. For each item on the scale, the following grading is asked to be done: "1: Strongly disagree", "2: Disagree", "3: Neither agree nor disagree", "4: Agree", "5: Strongly agree". The highest score could be taken was 155 and the lowest score was 31. The draft scale was applied to 312 teachers who were trained in Arduino and have been working at 11 different subjects.

## Participants

Participants were selected from teachers and preservice teachers trained in Arduino, who are already the target audience for the scale. The data for the scale was gathered from 312 teachers from different cities of Turkey who have been working at 11 different subjects (Physics, Chemistry, Biology, Mathematics, Sciences, Primary School Teachers, Information Technologies, Technology and Design, Literature and Counseling). When the experiences of teachers were reviewed, 62 (%20) of them had 1 to 5 years of experience, 81 (%26) had 6 to 10 years, 62 (%20) had 11 to 15 years and 107 (%34) had +15 years of experience in their subjects. The age distribution of teachers varied between 21 and 62.

## Analysis of Data

Following the application of the preliminary study, the data was transferred to the computer environment. Primarily, an outlier analysis was done for the obtained data. The analysis revealed 10 participants had outlier values and these 10 data were decided to be put aside consequently.

After the outlier analysis, a missing value analysis was performed for the items not answered. This analysis showed the missing data did not have a significant distribution, and rather it was random. Consequently, the missing data was decided to be exchanged with mean values. At the next step, item - scale scores correlation was examined to execute if each of the items in the scale served for the overall purpose of the scale. With this correlation, the compatibility of each item with the whole scale was examined and it was found appropriate to remove 4 items (m3, m7, m20, m21) whose value was below 0.20 (Tavşancıl, 2010).

For this purpose, it is planned to carry out factor analysis, which aims to explain related variables with fewer and unrelated conceptual structures (Büyüköztürk 2007). However, firstly, Kaiser-Meyer-Olkin (KMO) and Bartlett tests were performed to determine whether the data obtained were suitable for factor analysis.

**Table 1.** *KMO and Bartlett tests results of the scale*

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin (KMO) Sample Suitability Value | | ,901 |
| Bartlett's Sphericity Test | Proximate Chi-Square Test (X2) | 3609,763 |
| | Degree of Freedom (df) | 210 |
| | Level of Significance (Sig.) | ,000 |

When the test results given in Table 1 were examined, the KMO value showing the consistency between the samples and the scale was calculated as .901. The chi-square value obtained by the Bartlett sphericity test was significant at .00 level and the data were considered suitable for factor analysis. (Kalaycı, 2010; Tavşancıl, 2010; Büyüköztürk, 2007; Leech, Barrett and Morgan, 2005).

# RESULTS

In order to reveal the factor structure of the scale, Exploratory Factor Analysis (EFA) was applied to the data. The variance that was determined with this analysis might have resulted higher because it includes the error variance (Kline, 2013) yet Thompson (1992) emphasizes the results improve as reliability increases. AFA was considered appropriate due to the high reliability coefficient in the study. In the process of EFA, Principal Component Analysis was used. Moreover, because the factors were considered to be completely independent of each other, Promax was used as one of the rotation methods of oblique rotation. Factor loads of the items were important data in factor analysis and it was acceptable to have these values above 0,30 (Buyukozturk, 2007). For this reason, the items with a load of 0,30 or more were considered in the factor analysis. As a result of the analysis, 6 items (m8, m9, m10, m25, m28 and m30) with two very close loads in factors were excluded from the scale.

Factors and factor loads for the remaining items are given in Table 2. When Table 2 is examined, it is seen that 4 factors emerge and factor loads of items related to each factor are 0,359 or more. According to this data, it is observed that items m13, m1, m14, m12, m2, m11, m15, m26, m27 are included in 1st factor; items m19, m22, m4, m23, m17 are included in 2nd factor; items m18, m5, m16, m31 are included in 3rd factor and items m6, m24, m29 are included in 4th factor.

**Table 2.** *Factors and factor loads of the items*

| Factor 1 | | Factor 2 | | Factor 3 | | Factor 4 | |
|---|---|---|---|---|---|---|---|
| **Item** | **Factor Load** | **Item** | **Factor Load** | **Item** | **Factor Load** | **Item** | **Factor Load** |
| m13 | ,958 | m19 | ,889 | m18 | ,943 | m6 | ,943 |
| m1 | ,874 | m22 | ,887 | m5 | ,850 | m24 | ,935 |
| m14 | ,817 | m4 | ,597 | m16 | ,609 | m29 | ,359 |
| m12 | ,794 | m23 | ,525 | m31 | ,454 | | |
| m2 | ,773 | m17 | ,359 | | | | |
| m11 | ,771 | | | | | | |
| m15 | ,612 | | | | | | |
| m26 | ,479 | | | | | | |
| m27 | ,431 | | | | | | |

However, it is difficult to say that this analysis has made a definite distinction between factors. Therefore, it was decided to examine the eigenvalues and explained variance. The eigenvalues and explained variance of the scale are given in Table 3.

**Table 3.** *Eigenvalues and explained variance values of the scale*

| | Initial Eigenvalues | | | Sum of Squares Rotation | | |
|---|---|---|---|---|---|---|
| **Factor** | **Total** | **Percentage of Explained Variance (%)** | **Cumulative Variance Percentage (%)** | **Total** | **Percentage of Explained Variance (%)** | **Cumulative Variance Percentage (%)** |
| 1 | 8,915 | 42,453 | 42,453 | 8,915 | 42,453 | 42,453 |
| 2 | 1,744 | 8,306 | 50,759 | 1,744 | 8,306 | 50,759 |
| 3 | 1,328 | 6,326 | 57,085 | 1,328 | 6,326 | 57,085 |
| 4 | 1,191 | 5,671 | 62,756 | 1,191 | 5,671 | 62,756 |

When eigenvalues and explained variance values in Table 3 were examined, 4 factors with eigenvalues above 1 appeared. But the scale have to be handled in one factor because of the following indicators :(Ekici, Ekici and Kara 2012; Deniz Sunbul, 2006).

- The eigenvalue of the first factor (8,915) being at least 3 times larger than the second factor,
- The eigenvalues and explained variances of the factors, except for the first one, very close to each other;

- The first factor is explaining 42.453% of the 62.756% of the total.

When Eigenvalue-Component Graphic in Figure 2, given in addition to the table, is examined, the significant decreases of eigenvalues after the first factors stand out. This situation reinforces the opinion that the scale is composed of a single factor.

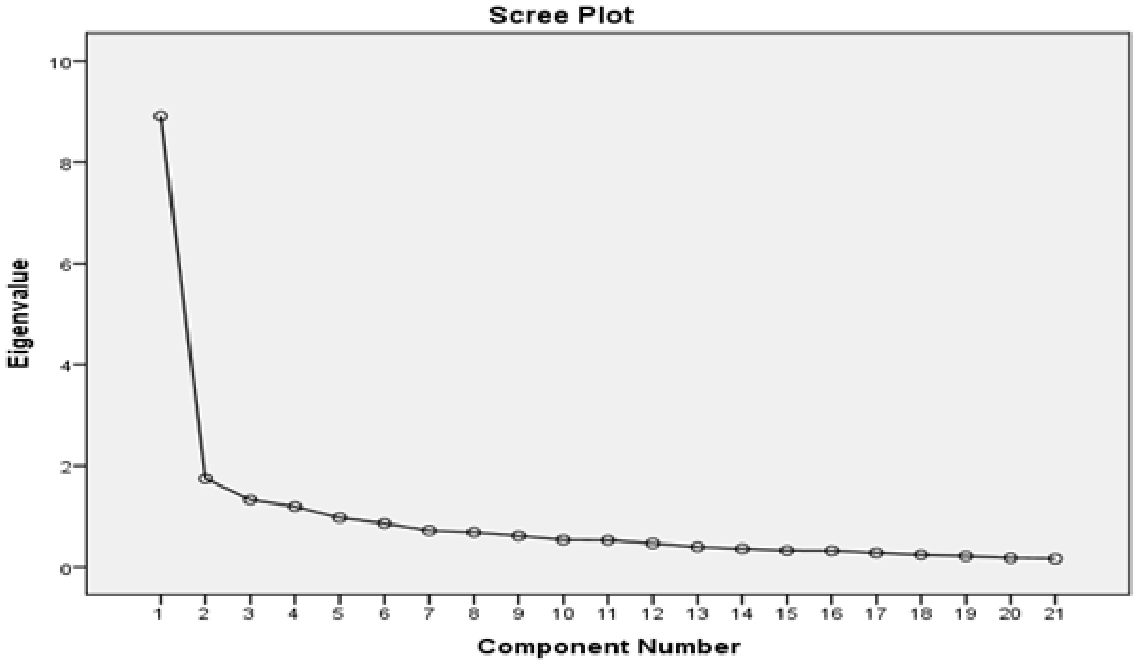


**FIGURE 1.** *Eigenvalue-Component graphic regarding the scale*

As a result of the reliability analysis done for 21 items obtained, Cronbach's Alpha value was calculated as ,919.

### DISCUSSION and CONCLUSIONS

Ekici (2002) emphasizes the importance of attitude towards an activity for that activity to be successful. In their study Uredi and Uredi (2005) lay weight on scaling attitudes in order to predict the future behaviours, change attitudes or develop new attitudes. These studies show the importance of attitudes during learning process. Tavsancil (2014) describes ages 12-30 -including most of the teachers and preservice teachers who are the target audience of this study- as the critical period and states that peers, mass media and education are the three main factors forming attitudes during this period. These factors are obviously important for both while preservice teachers are being trained and professional development of novice teachers. Determining the relevant persons' attitudes are crucial to manage this process of shaping and changing attitudes. Arduino microcontroller is one of the most popular and irreplaceable tool for lately fashionable robotics coding courses (Bender & Kussman, 2012; Balogh, 2010, Sarik & Kymissis 2010). When the studies of this robotics coding tool being used in courses are examined, motivation, problem solving skills and academic success of the students seem to be affected positively. For this reason, the attitudes of persons who are going to use Arduino in their courses gain prominence but there are not any scale specifically oriented for this purpose in the literature. To serve this purpose, a scale aiming to determine teachers' and preservice teachers' attitudes towards the use of Arduino in courses was developed. With the scale developed, attitudes of teachers teaching courses other than information technologies or alike courses towards Arduino use in their courses will be determined and the process of integrating the courses in an interdisciplinary manner will be easier. During the scale development process, the eight steps determined by Anderson (1988) to develop a Likert scale has been followed. In the preliminary study conducted with 51 teachers, their opinions about the use of Arduino in courses were asked and a draft test consisting of 36 items was created. Next, some data was collected by testing 312 teachers trained in Arduino. As a result of analysis done, 15 items was decided to be excluded and the last version of scale consisting of 21 items was acquired. Through the factor analysis, it has been thought that scale consists of 4 factors, yet to decide unquestionably, eigenvalues and explained variance values of scale and factors, and Eigenvalues-Components Graph were examined. As a result of this examination, the eigenvalue of the first factor (8,915) being at least 3 times larger than the second factor's; factors' eigenvalues being values very close to each other except for the first one; the first factor explaining 42,453% of the 62,756% of the total explained variance, were indicators that the scale was consisted of a single factor. As a result, a single factor 21-item scale with ,919 Cronbach's Alpha value has been obtained.

The scale is expected to be a facilitator for interdisciplinary studies. In addition, the scale can be used to see the impact of Arduino professional development courses given by institutions and individuals, and it can be used as a guide in the development of alternative scales related to the use of similar technologies in courses.

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## The Attitude Scale for Arduino Use in Courses

*1: Strongly disagree, 2: Disagree, 3: Neither agree nor disagree, 4: Agree, 5: Strongly agree*

| **Scale Items** | | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|---|
| **1** | I would like to use Arduino in my courses. | | | | | |
| **2** | Arduino use in courses will increase students' motivation towards the course. | | | | | |
| **3** | Arduino use in courses makes students more social | | | | | |
| **4** | Arduino use in courses is suitable for different subjects (such as Mathematics, English, Turkish etc.) | | | | | |
| **5** | Arduino use in courses is suitable for students of all ages. | | | | | |
| **6** | Arduino use in courses provides learning by experience. | | | | | |
| **7** | Arduino use in courses provides learning with fun. | | | | | |
| **8** | Arduino use in courses helps students to embody abstract concepts. | | | | | |
| **9** | Arduino use in courses supports the collaboration in the classroom. | | | | | |
| **10** | Arduino use in courses improves the quality of education. | | | | | |
| **11** | Arduino use in courses increases the success of students. | | | | | |
| **12** | Arduino use in courses has educational advantages. | | | | | |
| **13** | Every subject is suitable for Arduino use. | | | | | |
| **14** | Arduino use in courses strengths classroom communication. | | | | | |
| **15** | Arduino use in courses increases the communication skills of the students. | | | | | |
| **16** | Arduino use in courses makes the content more fun. | | | | | |
| **17** | Arduino use in courses is suitable for students of all levels. | | | | | |
| **18** | Arduino use in courses may enrich the course content. | | | | | |
| **19** | Arduino should be used in lessons soon. | | | | | |
| **20** | Arduino use in courses makes it easier for students to construct information themselves. | | | | | |
| **21** | Arduino use in courses increases students' knowledge on the subjects. | | | | | |