Journal of STEAM Education
Journal of Science, Technology, Engineering, Mathematics and Art Education
2021, July. (Issue: 2, Volume: 4)

STEM BASIC KNOWLEDGE TEST DEVELOPMENT STUDY FOR PRE-SERVICE TEACHERS

Özlem GÖKÇE TEKIN[1], İsmail ŞAN[2]

Article History

Received: 1 Dec. 2020

Received in revised form:

28 Dec. 2021

Accepted: 16 July 2021

Published: 30 July 2021

ABSTRACT

The purpose of this study is to develop a valid and reliable test to measure pre-service teachers' levels of STEM Basic Knowledge. Data was obtained from a total of 148 students studying in the departments of Science Education, Mathematics Teaching and Computer Education and Instructional Technology in the 2017-2018 school years. Eight characteristics were determined to be tested in this direction by examining the aims, features, benefits and the way of implementation of STEM (Science, Technology, Engineering and Mathematics) education. 40 questions related to these features were prepared. As a result of analyzes made after the application of the test to the pre-service teachers, some items were removed from the test and a test of 28 items was obtained. It was determined that the reliability coefficient of this test was 0.84, the average difficulty was 0.61, and the average discrimination was 0.49. A valid and reliable STEM Basic Knowledge Test (STEMBKT) that tests the determined gains of STEM has been obtained.

Keywords: STEM, Basic Knowledge Test, Pre-service Teachers

[1] Doctoral Student, İnönü University, Institute of Educational Sciences, ogokcetekin@gmail.com, 0000-0002-4436-3060

[2]Assistant Professor, İnönü University, Faculty of Education, ismail.san@inonu.edu.tr, 0000-0003-0780-0169

Gökçe-Tekin, Ö. & Şan, İ. (2021). STEM basic knowledge test development study for pre-service teachers. *Journal of STEAM Education, 4*(2), 118-127.

INTRODUCTION

The development of countries is directly related to their progress in science and technology. A good education is the basis of this development. Considered as an innovative approach in education, STEM is based on the idea of educating students in an interdisciplinary and practiced manner in four disciplines (science, technology, engineering and mathematics) (Suprapto, 2016). Rather than addressing the four disciplines separately, STEM integrates them into a learning approach based on real-world applications (Hom, 2014).

STEM education has a great interest in recent years. It is for the desire of countries to achieve certain goals in order not to fall behind in science and technology. According to the National Research Council of America (2011), the STEM education approach has three main goals; to raise individuals who make their career in STEM fields, to spread the workforce and to increase participation in STEM fields and to raise individuals with STEM literacy

When the international literature is examined, it is seen that STEM education has started to be implemented in schools. Under the title of "Engineering and Design Skills" in the 2018 Science Curriculum, STEM education was emphasized by including the integration of science with technology, engineering and mathematics (Ministry of National Education [MEB], 2018). In addition, it is clearly seen that STEM disciplines will be integrated and included in the lessons by including the subject area of "Science and Engineering Applications" under the unit of "Applied Science" at all levels from grade 4 to 8.

It is strategically important to train human resources who are experts in the fields of Science, Technology, Engineering and Mathematics (STEM) in order to maintain Turkey's competitive power on international scale. Reforms regarding STEM education will play an important role in Turkey's economic competitiveness (Corlu, and Capraro Capraro, 2014). Based on this importance, MEB prepared a report about STEM in June 2016. The purpose of this STEM Education Report is; to improve the dynamic education system according to the needs, to educate a generation that produces and designs (MEB, 2016). According to the report, things to do are; establishing STEM education centers, cooperation between STEM education centers and universities, training teachers in STEM fields, updating curricula regarding STEM education and preparing necessary course materials.

Akgündüz et al. (2015) have prepared STEM Turkey Report. In the report, it was stated that the lack of knowledge, skills and experience of STEM teachers, to provide education in these fields is a deficiency. In the literature, there are various scale development studies on STEM education in which teachers and pre-service teachers are determined as participants. Corlu, et al. (2015) developed a scale to investigate pre-service teachers' levels of mental readiness towards STEM education and their attitudes towards the nature and holistic teaching of mathematics and science teaching. Taş et al. (2016) adapted the Scale of Teacher Competence and Attitudes Towards STEM into Turkish. Hacıömeroğlu and Bulut (2016) adapted the integrated STEM teaching orientation scale into Turkish for pre-service teachers. Buyruk and Korkmaz (2016) developed a scale to determine the STEM basic knowledge levels of pre-service teachers studying in Computer, Mathematics and Science Teaching departments. Çevik (2017) developed a scale to determine the STEM awareness levels of science, technology, engineering

and mathematics (STEM) teachers (mathematics, physics, chemistry, biology and information technologies) working in high schools. In these studies on STEM education, mostly attitude and awareness were measured. There is no study that tests the pre-service teachers' basic knowledge levels about STEM education according to the features, goals and benefits of STEM. The absence of such a test in the literature makes it necessary to develop a test for this measurement. As a matter of fact, it is important to determine whether pre-service teachers who will be implementers of STEM in the future have the basic knowledge level of STEM. From this point of view, it is thought that the valid and reliable STEM Basic Knowledge Test will make an important contribution to the field.

Purpose of the research

The aim of this study is to develop the STEM Basic Knowledge Test to determine the basic knowledge levels of pre-service teachers for STEM education. For this purpose, validity and reliability studies of the test have been performed.

METHOD

This section includes information about the participants of the study, the development of the data collection tool, and the data analysis process. The steps of the STEM Basic Knowledge Test development and the participant information are below.

Participants

Data was collected in April in the 2017-2018 school year. Participants of the research comprised of 148 senior students studying in the departments of Science Education, Mathematics Teaching and Computer Education and Instructional Technology at İnönü University Faculty of Education. Volunteerism has been taken as a basis in terms of participation.

Data Collection Tool Development Process

In this study, it was tried to develop a valid and reliable test for pre-service teachers. Test form was used as data collection tool to determine STEM basic knowledge of pre-service teachers. In the process of developing this test, national and international studies on STEM education were examined and a literature review was conducted.

The three main goals of STEM education approach are; "To educate individuals who make their careers in STEM fields, to spread the workforce in STEM fields, to increase participation in these fields and to educate individuals with STEM literacy". These goals serve the purpose of higher education (to train students according to the science policy of Turkey by their interests, skills and abilities and to train them according to the high level and manpower needs of the society at various levels).

These goals of STEM also serve the goal of National Education: "to develop the interest, competencies and abilities of all members of the Turkish nation, to prepare them for life by

providing with the necessary knowledge, skills and behaviors and gaining the habit of working together and to ensure that they have a profession make them happy and contribute to the happiness of the society."

Considering the goals of STEM, eight characteristics (gains) of STEM were determined. These gains examined the aims, features, benefits and the way of implementation of STEM (Science, Technology, Engineering and Mathematics) education. According to Bloom's taxonomy, an essay form with a total of 40 items including 17 items from the knowledge level and 23 items from the understanding level was prepared. In order to develop an item pool, the literature has been reviewed (Maryland State Department of Education, 2012; Morrison, 2006; Suprapto, 2016; Hom, 2014; Bragow, Gragow and Smith, 1995; Gutherie, Wigfield and VonSecker, 2000; Hurley, 2001; Dierdorp, Bakker, van Maanen, and Eijkelhof, 2014; Sanders, 2008; Dillon, & Dillon, 1988; Fulkerson & Banilower, 2014). And the Public Personnel Selection Exam questions, which include educational sciences questions related to the aims, characteristics, benefits and implementation of STEM education were examined. A multiple choice "STEM Basic Knowledge Test (STEMBKT)" consisting of 40 items was prepared. Test items consist of 4 options, 1 of which is correct answer, 3 of which are distracting.

To ensure the content validity of the STEMBKT, a table of specifications has been prepared. In this table, it is stated which cognitive level the tested characteristics of STEM are related to. The table of specifications of the STEMBKT is given in Table 1.

Table 1. STEM basic knowledge test specifications table

Item No	Gains	Knowledge	Understanding	Percentage
1	Knows the STEM disciplines	6	-	15
2	Knows the goals of STEM education	5	-	12,5
3	Knows the benefits of STEM education	6	-	15
4	Comments student-teacher roles in STEM education	-	4	10
5	Comments methods and techniques in STEM education	-	8	20
6	Comments the relationship between STEM education and higher order thinking skills	-	3	7,5
7	Comments assessment and evaluation in STEM education	-	2	5
8	Comments the characteristics of learning environments suitable for STEM education	-	6	15
	Total	17	23	
	Percentage	42,5	57,5	

As seen in Table 1, three of the gains (42.5%) are at the knowledge level and five of them (57.5%) are at the understanding level. When Table 1 is examined in terms of the number of

items related to the gains, there are 17 items related to the gains in the knowledge level. And there are 23 items in the understanding level.

At least one item to test each gain is considered. A 4-option, multiple-choice trial form consisting of 43 items was prepared. Items were examined by 3 academicians, two of which were from the Curriculum and Instruction field, one from the Measurement and Evaluation field, and 4 teachers from the Science, Mathematics, Computer and Instructional Technologies and Turkish departments. The experts find it appropriate to exclude 3 items from the test. One of these items was removed because the similarity of another item. And the other two items were removed because they did not include the tested characteristics of STEM. In addition, some items were corrected both in the root of the question and in distractors, making incomprehensible questions understandable. It was decided that the test named "STEM Awareness Test", which was presented for the opinion of experts, should be named "STEM Basic Knowledge Test".

In order to determine the clarity and understandability of the items of the prepared test, a pre-application was made with 20 undergraduate students. They were studying in Science Education, Mathematics Education and Computer Education and Instructional Technology departments. The test was rearranged by making the necessary corrections in line with the feedback from the students.

Analysis of Data

STEM Basic Knowledge Test form was administered to a total of 148 students. They were studying in the 4th grade of Science Education, Mathematics Teaching and Computer Education and Instructional Technology departments of İnönü University Faculty of Education. After the application, the difficulty and discrimination indexes of each item in the test were found by analyzing the items. The limits determined by Tekin (2003: 247-252) were taken as criteria for the comment of difficulty and discrimination. Accordingly, the item difficulty index (p) ranging from zero to +1 is considered to be moderate difficulty between 0.25 and 0.75. Tekin (2003: 249) evaluates item discrimination indexes based on the following limits:

0.40 and higher: Very good item,

0.30 - 0.39: Good item (However improvements can be made),

0.20 - 0.29: An item that needs to be corrected and improved,

0.19 or less: Very weak item (Must be excluded from the test)

FINDINGS

By analyzing the STEMBKT, numerical data for each item were obtained. The scores of the pre-service teachers were listed from the highest to the lowest. 27% upper group and 27%

subgroups were determined. The scores of 7 pre-service teachers who have the same score with the score of the 40th pre-service teacher in the upper group were also included in the group. Likewise, the score of 3 pre-service teachers in the subgroup with the same score as the 40th person was added to the subgroup.

In line with the data obtained, the discrimination and item difficulty values for each item of STEMTBT are summarized in Table 2.

Table 2. Difficulty and Discrimination Indexes of the Items in the Test

Item Number	Item difficulty index	Item discrimination index	Item Number	Item difficulty index	Item discrimination index
1	0.70	0.54	21	0.50	0.35*
2	0.21	-0.04*	22	0.47	0.29*
3	0.66	0.54	23	0.66	0.37*
4	0.63	0.48	24	0.81	0.53
5	0.44	0.27*	25	0.56	0.46
6	0.74	0.31*	26	0.82	0.38*
7	0.56	0.48	27	0.72	0.63
8	0.80	0.47	28	0.51	0.29*
9	0.64	0.41	29	0.36	0.32
10	0.60	0.55	30	0.63	0.13*
11	0.67	0.52	31	0.44	0.34
12	0.66	0.59	32	0.68	0.57
13	0.41	0.38	33	0.61	0.46
14	0.70	0.56	34	0.58	0.52
15	0.76	0.49	35	0.52	0.43
16	0.20	0.16*	36	0.62	0.26*
17	0.45	0.23*	37	0.43	0.42
18	0.72	0.50	38	0.61	0.35*
19	0.82	0.53	39	0.60	0.43
20	0.32	0.32	40	0.78	0.42

* Items excluded from the test

As seen in Table 2, 24 items with a discrimination index of 0.40 and greater have very good discrimination. These 24 items were included in the test without any changes. The discrimination of the 13 items numbered 5, 6, 16, 17, 21, 22, 23, 26, 28, 30, 36 and 38 is less than 0.40. So they were excluded from the test to increase the reliability. However, items 20, 29 and 31 with a discrimination between 0.30 and 0.39 were not excluded from the test. Because it would negatively affect the content validity. The 20th item is based on the gain of "knows the goals of STEM education". And the 29th and 31st items are based on the gain of “comments methods-techniques in STEM education. The answers given to these items were examined in detail. Distractors that were not effective in distinguishing the upper group and the lower group were strengthened. The edited items were included in the test with the consensus of the experts.

As seen in Table 2, the items have different difficulty levels. The 4 items numbered 8, 19, 24, 26 with an item difficulty of 0.80 or higher were determined to be very easy items. It was determined that 11 items numbered 1, 3, 6, 11, 12, 14, 15, 18, 23, 27, 32 were quite easy. These

items are between 0.65 and 0.79 difficulty indexes. 18 items numbered 4, 5, 7, 9, 10, 13, 17, 21, 22, 25, 28, 29, 30, 31, 33, 34, 35, 37 with difficulty indexes between 0.35 and 0.64. These are medium level items. And 3 items numbered 2, 16 and 20 with difficulty indexes between 0.20 and 0.34 were determined to be quite difficult items.

The Kuder–Richardson (KR-20) formula was used to measure the reliability of the the STEMBKT. Descriptive statistics of the test are summarized in Table 3.

Table 3. Descriptive statistics for STEM basic knowledge test

Number of Items	28
KR-20 Reliability Coefficient	0.84
Item Difficulty Average	0.61
Item Discrimination Average	0.49

When Table 3 is examined, it is seen that the reliability coefficient of the test consisting of 28 items is 0.84. The average difficulty of the test is 0.61, and the average discrimination is 0.49.

According to the item analysis results, 12 items with low item difficulty and discrimination were excluded from the basic knowledge test. A valid and reliable basic knowledge test has been developed. STEMBKT consists of 28 items that tests the determined gains of STEM

CONCLUSION AND RECOMMENDATIONS

In this study, it was aimed to develop STEM Basic Knowledge Test for pre-service teachers. And for this, validity and reliability studies were performed. This test, consisting of 28 items, measures eight STEM gains. The reliability coefficient of the test was calculated as 0.84. This result indicates that the test is reliable. The average difficulty of the test was determined as 0.61, and the average discrimination was determined as 0.485. These results show that the test is moderately difficult and discriminatory.

In order for STEM to reach the desired goal in our education system, it is necessary for teachers to have the necessary equipment. Dong et al., (2020) stated that teachers with STEM education knowledge will have less difficulties in STEM teaching. As a result of their studies, the difficulties teachers will have in STEM education practices were predicted by looking at their STEM knowledge and beliefs. Kennedy et al. (2008) stated that it is important for teachers to have strong content and pedagogical knowledge about STEM education. Therefore, it is inevitable that pre-service teachers who are on the way to become teachers should have this information. The developed STEMBKT measures the gains in the knowledge and understanding dimensions of the cognitive domain level. It will make an important contribution in measuring the basic knowledge level of pre-service teachers about STEM education. Yıldırım and Türk (2018) stated in their study that teachers feel inadequate about engineering, application and science and technology knowledge. The present study has revealed a test that determines the basic knowledge level of teachers about STEM education. And it can lead to

future studies. In this direction, STEM teacher training can be directed. In addition, the scales developed in studies conducted with teachers and pre-service teachers on STEM education in the literature are mostly aimed at measuring attitude and awareness (Çorlu, et al., 2015; Taş et al., 2016; Hacıömeroğlu & Bulut, 2016; Buyruk & Korkmaz, 2016; Çevik, 2017.). There are no studies testing pre-service teachers' basic knowledge levels, characteristics, goals, benefits and so on about STEM education. With this study, this deficiency in the literature will be eliminated.

It can be said that the study has some limitations. STEM Basic Knowledge Test measures only the gains of knowledge and understanding. STEM is an approach to implement high-level thinking skills. For this reason, it may be suggested to develop different tests that examine high level gains in future studies. In addition, this study was limited to eight STEM gains (tested traits) determined by the researchers. Similar studies can be done by increasing the number of gains.

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