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Research Paper

Development and Evaluation of Unplugged Algorithmic Thinking Activities Training Program for In-Service Primary School Teachers

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ABSTRACT

The aim of this study is to evaluate a professional development program applied to primary school teachers for unplugged algorithmic thinking activities and to improve it based on this evaluation. In this context, data were collected for the improvement of the program by consulting the opinions of the teachers. The professional development program was implemented in 3 different groups, respectively and improved in each group. Teachers' opinions were collected for each group in line with the Kirkpatrick Level 1 assessment approach. The reactions and likes of the teachers participating in the training courses towards the training program are included. In this way, it is aimed that the data obtained will guide the development of the training program. The measurement tool consists of 6 parts and includes closed-ended questions designed for the purposes of evaluating the educators, course components, implementation, physical environment, and teaching materials. The Kruskal-Wallis non-parametric test was used as an analysis method to determine whether there was a significant difference between the groups. In the study, the components in which significant differences emerged between the groups in the scores given by the participants were discovered, and the training program was improved after the first and second trainings in line with these findings.

INTRODUCTION

Computer technologies have changed the way we do business, learning methods, trade, collaboration, and entertainment methods in every field in today's world. During the 20th century, developments in science, technology and economic life naturally affected the way we deliver and implement education methods. In order to be successful in the business world and to keep up with the developments, it is emphasized in many sources that the employees with interpersonal skills are preferred in order to adapt to the changing conditions while creating the human resources of the institutions (Ananiadou & Claro, 2009; National Research Council, 2013). Interpersonal skills, or 21st century skills, are a growing list since they first emerged (Dede, 2010; Voogt & Roblin, 2012). These skills are actually always necessary for people, and those who have them seem to be more successful in education and business life than those who do not (Ananiadou & Claro, 2009; Martin, 2018). In order to increase the level of social welfare and peace, it is necessary to systematically equip all students with these skills (Kivunja, 2014; OECD, 2018; Saavedra & Opfer, 2012).

The skills mentioned in the 21st century are generally called problem solving, working collaboratively with others, being technology literate enough to achieve their goals, using interdisciplinary knowledge, and taking initiative (Finegold & Notabartolo, 2010). These skills are metacognitive skills and they are too complex to be taught to students by direct instruction or self-study methods and take time to develop (Kivunja, 2014; Luna Scott, 2015). Opportunities should be created for students to acquire these skills. For example, activities and learning environments should be developed where they can practice the skills. Students will be ready for life with these skills they have developed by dealing with activities created with real-life problems throughout their school life, and they will be individuals who are highly adaptable to changing conditions by transferring these skills to different problems in different contexts (Lombardi, 2007).

The constructivist learning approach, which is applied in order to provide students with 21st century skills in the formal education system, has different methods according to the teaching context and content (Moylan, 2008; Ah-Nam & Osman, 2017). One of these methods is Computational Thinking activities (Voskoglou & Buckley, 2012; Tabesh, 2017). In the implementation of Computational Thinking activities, students' use of the processing power of computers while solving the problems they may encounter in their daily or professional lives. It encourages them to integrate technology naturally into the problem-solving process and the work based on interdisciplinary cooperation. Computational Thinking activities provide opportunities for students to engage and test their problem-solving skills.

The concept of Computational Thinking is still very new in the literature and there is almost no direct valid and reliable evidence that planned activities have positive effects on students' academic success or 21st century skills in the short and long term. However, decades of experience of problem-based learning approach studies, on which Computational Thinking activities are based, gives clues about its effects on learning outcomes. These benefits can be listed as the developing problem solving skills, developing learning strategies, recognizing information systems methods and tools that can be used in solving problems, recognizing the limitations of information systems tools in solving problems, scaling problems that can be solved with information tools, and applying the process to other fields (Dolmans, Loyens, Marcq & Gijbels, 2016 ; Norman & Schmidt, 1992; Schmidt, Rotgans & Yew, 2011; Vernon & Blake, 1993).

When considered as educational outputs, Computer Thinking activities can be considered as a platform for students to gain 21st century skills in the short and medium term. In the past, developing effective and efficient algorithms for solving a problem, testing and debugging them, making improvements to make them more efficient was considered the task of only computer science experts. In today's world, the widespread use of information technologies in all areas of life has burdened not only computer science experts but also those working in all fields of science with the responsibility of producing effective and efficient solutions to problems by using computer technologies (Shute, Sun & Asbell-Clarke, 2017). Therefore, computational thinking skills that prioritize the problem solving process by making use of the computing power of computers are seen as skills that should be possessed by everyone.

Purpose of the study

It is an inevitable reality for today's societies living in the age of information and communication technologies that it is necessary to use information processing methods and tools while operating the problem solving processes. It is thought that teaching the skills to use the processes that solve the problems they encounter in an effective and efficient way with the help of computers will be more effective in the formal education system. In this context, in line with the goal of preparing professional development programs for primary school teachers on computational thinking, which is set out as the 2023 education vision (MEB, 2018) of the Ministry of National Education of the Republic of Turkey, the aim of this study is to develop a professional development program targeting teaching methods and techniques that help teaching computational thinking skills with unplugged activities, and to make improvements on the program by evaluating teacher opinions.

Literature Review

Algorithmic thinking is preferred at times as the Turkish equivalent of the term "computational thinking" which was first introduced by Wing (2006). The definitions of these concepts and their difference from problem solving processes have not been fully revealed in the literature yet. As the concept "computational thinking" has taken its place as "Algorithmic thinking skills" in the 2023 vision document of the Ministry of National Education, which is the basis for the creation of this study, the term originally "Computational Thinking" will be referred to as "Algorithmic Thinking" in this study.

Algorithmic Thinking skills are defined as the application of students' problem solving processes on computing devices by writing algorithms and programming codes to solve computer programming problems. The term algorithm is the description of the way of doing an operation with sequential and finite steps, and it should ensure the complete implementation of the solution of a problem by anyone, whether they have prior knowledge of the subject or not. Today, the usage context of the word is mostly the listing of the process steps that solve the problem in the shortest way without error, before writing the computer program code. An algorithm that solves a problem in informatics is actually the end product of a long process such as understanding the problem, developing solution hypotheses, testing and debugging, and is an activity where problem solving skills and processes are used intensively. Therefore, a systematic design and development is necessary in teaching algorithm development skills to students.

In order to create an algorithmic thinking training program, the following questions should be answered first; “What do the concept have sub-components?” and “What content should be taught under the name of algorithmic thinking training course?”. Although there is no consensus among researchers on the concept of algorithmic thinking skills, content and training programs have begun to be designed to teach these skills in studies. The College Board and the National Science Foundation (NSF), which are pioneers in this field, have developed 7 areas that can be used as a basis for designing algorithmic thinking skills training programs (http://www.csprinciples.org/);

1. Informatics is a problem-solving/creative activity done by humans
2. Only the necessary concepts are focused on to solve the problem.
3. It allows raw and organized data to create knowledge that works for people.
4. Algorithms are one of the solution tools for the problems solved by informatics.
5. Programming that creates information products is a problem-solving/creative process.
6. Computer systems and computer networks use informatics approaches to solve problems in different areas of life.
7. Informatics brings innovative solutions to problems in other fields of science.

In the preparation of Algorithmic Thinking training programs, it was emphasized that the contents covering the above seven areas should be developed in accordance with students at every grade level.

The application of informatics concepts in the Algorithmic Thinking training program should be done within the problem solving process. In the training programs developed for Algorithmic Thinking, it is recommended that the following topics be included in the training content (Hsu, Chang, & Hung, 2018; Yadav, Stephenson & Hong, 2017):

1. Recognizing patterns in objects and abstraction
2. Systematic processing of information
3. Representing information with symbol systems
4. Work flow control with algorithmic marking system
5. Separation of problems into sub-problem components
6. Setting up circular processes
7. Control structures
8. Efficiency and performance limitations
9. Error detection and debugging

In Algorithmic Thinking trainings, content and training should be planned by using both problem solving processes and the basic concepts of computer science. The list above suggests content areas that should be in a typical Algorithmic Thinking training. The answer to the question of what should be taught in algorithmic thinking training, that is, what should be the content, should be chosen in a balanced way from the activities of both computer science and problem solving process.
In Algorithmic Thinking training programs, content preparation and the components that make up the concept should be emphasized in order in each activity. These components and their definitions are given in Table 1 below.

Table 1. Components in Teaching Algorithmic Thinking Skills (Curzon, Dorling, Ng, Selby, & Woollard, 2014)

Component	Definition
Decomposition	Presenting real-life problems and exploring their sub-problems and relationships.
Pattern Recognition	Recognizing and revealing repetitive structures, similarities, differences in a problem or in an ongoing work flow.
Abstraction	Reducing complexity by reducing unnecessary details with the results obtained as a result of pattern recognition.
Writing Algorithm	Writing sequential and finite number of command steps that give the desired solution for the problem.
Debugging / Evaluation	Testing the suitability of the developed algorithm for the purpose. For this, first of all, it is necessary to check the functional accuracy of the algorithm and to decide whether the performance of the algorithm is good enough. Finally, making a judgment about whether the solution developed with the algorithm meets the desired solution in the problem is the evaluation of the algorithm.
Iteration	Keeping design logs describing the work and operations and results during the algorithm design and development processes. Carrying out a new algorithm development process for the same problem situation by taking lessons from the previous process.
Generalization	Identifying similarities between problem situations, processes, solutions and data sets, applying a solution or part of a solution to similar problems by changing it, and using the knowledge and skills gained while developing an algorithm for one problem while developing an algorithm for another problem.

In teaching algorithmic thinking skills, besides what to teach in the content, how and where to teach is also important. While the subject of how to teach is related to teaching methods and tactics, the subject of where to teach can be considered as the arrangement of the teaching environment. When the literature is examined, it is seen that Algorithmic Thinking skills are mainly carried out with problem-based learning activities. Hsu, Chang, and Hung (2018) examined 93 studies on teaching algorithmic thinking skills in terms of teaching strategies and methods, and found that 72% of the trainings were done with problem-based learning in these studies. Algorithmic thinking is one of the skills gained by practicing in problem-based activities, so it is a natural result that the basic teaching strategy is problem-based learning.

Problem-based learning is a teaching approach developed at the McMaster University medical school in Canada. Medicine is an applied science field and every patient faced by physicians is a problem that needs to be solved from the diagnosis stage to the treatment stage. The starting point of the problem-based learning strategy is a curriculum and strategy designed on the fact that medical students who receive traditional medicine education make a lot of professional mistakes in the first 3 years after graduation and do not feel professionally ready in the field (Savery, 2006). The basic approach in problem-based learning is to model all the concepts and principles in the curriculum and to model the paths followed by a physician from diagnosis to treatment on a patient, and to give students practical opportunities to solve problems in real cases, instead of making students memorize all the concepts and principles in the curriculum. The evaluation studies conducted to understand the effectiveness of the problem-based learning strategy in medical education compared the student group that received medical education based on problem-based teaching strategies to the student group who did not. It was determined that it made fewer diagnostic errors in the first 3 years of the profession, their professional self-confidence was higher, they improved themselves by taking more vocational training, and the patient satisfaction in this group was higher (Vernon & Blake, 1993; Dochy, Segers, Van den Bossche & Gijbels, 2003).

Researchers working in the field of education have also explained problem-based learning strategies with the constructivist learning philosophy (Hmelo-Silver, 2004; Savery & Duffy, 1995). While trying to find solutions to ill-structured real-life problems presented to learners in problem-based learning environments, many activities are carried out and learners make countless decisions. In order to teach the problem solving process effectively and efficiently, Savery and Duffy (1995) collect the activities to be followed in 8 groups and state that the activities should be applied in the learning environment in this order. These activities are:

1. Relate all learning activities around a problem: In problem-based learning activities, an ill-structured real life problem is presented to learners and they are expected to operate the solution process of this problem. Not all students can access the same common solution to the problem. What is important here is that students follow a similar problem-solving process and practice their skills. The problem presented to students also gives them a purpose and direction. All learning activities applied by students are created around the solution of the problem.
2. Encourage students to take ownership of the problem: In order for students to deal with the problem, it must be related to the life they live, the place or the situation they are in. The problem is a situation that disturbs students in any part of their lives. There are two ways to get this type of problem for teaching; to learn what the student is curious about and develop problems on these, or to give students the most relevant problems in terms of their location. In order for the presented problem to be embraced by the students, the problem must be meaningful and cognitively challenging.
3. Design realistic tasks: The problem-solving processes of students are to be placed in tasks similar to the difficulties faced by a scientist or specialist dealing with that problem as a profession. The aim here is to provide students with an analogy of the process that a scientist uses when solving problems. These analogies may contain more or less detail depending on the student's level.
4. Design the learning environment: It is the design of the environment where the tools, information resources, communication methods and tools are necessary for students to solve problems. In problem-based learning method, information technologies are used a lot to support students' work and cognitive processes, so technology integration into teaching is a natural result of running the problem-solving process. The learning environment should be equipped to challenge learners' thinking and provide appropriate support.
5. Make learners own the process that develops the solution: In addition to owning the problem, the learners are expected to take ownership of the process they use to solve the problem. Keeping a diary, writing reports, and writing reflection reports about the problem-solving process being worked on shows their progress on the problem-solving process.
6. Encourage testing of alternative ideas: During problem solving, it is necessary to consider different ideas and solutions in the process of defining the problem and reaching the planned solution. A well-structured problem presented at the beginning of the learning activity cannot have a single definition and solution, so it is necessary to choose the most effective and efficient one among the developed solutions. This requires the development and testing of alternative ideas about the problem and its solution.
7. Encourage them to reflect on the amount of content learned and the learning process: As with any teaching method, the aim of problem-based learning is to gain learners knowledge and skills about the content taught and the learning process. The way to understand where learners are in the learning process is to encourage them to write reflections.

Computer literacy or programming training courses has always been conducted using a computer and its related software. Courses that address algorithmic thinking skills and computer programming are traditionally taught using computer hardware and script editors that allow programming the hardware. In addition to block-based algorithm creation and testing tools such as Scratch, Alice, LOGO, AppInventor, MS code, which teach computer programming to beginner level learners, algorithmic thinking training is provided with tools that require coding such as C#, C++, Python, and Java for advanced learners (Hsu, Chang & Hung, 2018). In order to use these tools in teaching, technological hardware infrastructure, teachers equipped with teaching programming skills, and appropriate curriculum are required. However, studies on technology integration in the literature indicate that schools and teachers, especially at primary school level, do not have the equipment and competencies to teach algorithmic thinking skills using programming tools (Bey & Bensebaa, 2011; Curzon, McOwan, Plant & Meagher, 2014; Ozcinar, 2018).

Algorithmic thinking skill training program is an indispensable training for teaching programming in computer science and includes the ability to identify the problem, see patterns within the problem, simplify the problem, write scripts, test, and debug. It is a method that emphasizes that, when it is considered as a problem-solving process, it is possible to gain students' problem-solving skills with information technologies. In order to teach these skills to all students in primary education, it is possible to teach algorithmic thinking skills with unplugged methods that do not require the use computer labs, programming tools, or long-term training.

Unplugged algorithmic thinking skills training program is to teach students the content topics related to creating algorithms using paper, chalk or simple materials in the classroom environment with activity-based training. Algorithmic thinking is an indispensable field skill for computer science (Futschek, 2006), but computer use is not essential for teaching it (Shelton, 2016; Wong & Jiang, 2018; Jagušt, Krzic, Gledec, Grgić & Bojic, 2018). In teaching algorithms for basic topics such as data, variables, loops and logical comparison, and basic computer science problems such as data sorting and data searching, algorithmic thinking training can be done with drama-based activities by using materials such as cardboard, book, ruler, cloth, without using a computer. An example of these trainings is Computer Science Unplugged (www.csunplugged.org), which teaches primary school students the algorithms mentioned through unplugged activities.

The fact that computer science is indispensable for all professions necessitates the ability to write one's own program rather than using application programs in order to use computers more effectively in the professions of the future, and to offer a method that will teach all students problem-solving skills effectively and efficiently. Therefore, algorithmic thinking skills are included in the 2023 Vision document of the Republic of Turkey Ministry of National Education as the goal of teaching algorithmic thinking skills to primary school students with unplugged activities. However, studies on the development and evaluation of professional development programs for teachers who will teach algorithmic thinking skills to students are still very limited in the literature. Current studies mostly try to understand the effects of unplugged algorithmic thinking activities on the educational outcomes of students (Brackmann et. al, 2017; Conde et. al, 2017; Looi et. al, 2018; Tuparova, 2019). When the studies are examined, it is seen that the theoretical approach of the developed education programs and the development processes in terms of teaching strategy/method are not clear. The aim of this study is to evaluate the development process and implementation of unplugged algorithmic thinking skills training activities developed as a professional development program for elementary school teachers. The developed program was implemented three times as training course, and each time, reaction of teachers to the program components were measured and their opinions were collected. In this framework, in the teacher training program, which was developed with a focus on teaching algorithmic thinking skills; the research question " *Is there a significant difference between the responses of the participants to survey on the training program components in the training courses*?" guides this study.

Developing a training program is an iterative process in which the developed program is implemented, corrections are made and reapplied. The deficiencies learned and the corrections made during each implementation are a lesson for the next implementation and make the program more effective and efficient. In addition, when the whole application is evaluated totally, strategy and method suggestions can be developed for the planning and development of the curriculum in teaching the knowledge and skills that are the subject of instruction (Demirel, 1992). This article is a study of producing professional development program that teaches algorithmic thinking skills in an unplugged environment intended for primary school teachers. The development and implementation of the program will contribute to the development of strategies and principles in order to develop and implement the more effective and efficient similar programs.

METHOD

Algorithmic Thinking is a high-level thinking skill that can be defined as systematically applying problem solving processes, reaching the most efficient solution, and expressing this solution in steps that everyone can understand, without exception. It is a known fact that individuals apply and refine their problem-solving skills by solving the problems they encounter throughout their lives and develop a problem-solving strategy suitable for them, by doing so they can acquire this skills. However, if these skills are experienced individually by everyone without going through a formation, it is not an efficient learning process, moreover, it causes loss of resources and labor. With the thought that one of the most appropriate methods of systematically gaining Algorithmic Thinking skills to a society is activity-based training at primary school age, in which these skills can be applied, a training program and its content were organized for primary school teachers in order to carry through the goal of providing Algorithmic Thinking trainings to them, which is also included in the 2023 vision document of the Turkish Ministry of National Education.

Training Program Development and Implementation

The process of developing the Algorithmic Thinking curriculum includes literature review, consultation with expert academics in computer engineering and primary school teaching, and the review of the resulting framework program by relevant academics. The sections and brief explanations of the training program, which consists of 13 sections and 34 activities, are below.

Chapter 1 What is Algorithmic Thinking: It is the part where the basic concepts and definitions are included and that explains the components of algorithmic thinking, how algorithmic thinking is taught and how it is evaluated.
Chapter 2 Sequential and Finite Steps: This is the part where it is explained with 4 activities that the algorithm consists of sequential and finite steps and that these steps should be clear enough to be understood by everyone without exception.
Chapter 3 What is Data: It is the part, with 9 activities, that explains how computers detect and label real-life objects and how error control is done,
Chapter 4 Data Organization: It is the part, with 3 activities, that explains why and how data is organized for easier processing.
Chapter 5 What is Data Entry: It is the section that describes what features of the data are checked when data is entered into the computer and what the entered data is?
Chapter 6 What is a Variable: It is the part, with 3 activities, that explains the changes in the values held by the elements used in calculations in algorithms.
Chapter 7 Comparison Structures: It is the part, with 3 activities, that explains how to compare the values of data in algorithms.
Chapter 8 Loop Structure: It is the part, with 2 activities, that explains how to write repetitive operations in algorithms simply.
Chapter 9 Nested Loop Structure: It is the part, with 3 activities, that explains how to write repetitive loop structures in algorithms simply.
Chapter 10 Search Algorithms: It is the part, with 2 activities, that explains how to find the desired data in a series of data with sequential and unordered search,
Chapter 11 Sorting Algorithms: It is the part, with 4 activities, that describes ordering a set of data from smallest to largest.
Chapter 12 Activity Preparation Guide: It is the part that tells primary school teachers how to prepare their own algorithmic thinking activities.
Chapter 13 Activity Evaluation: It is the part that explains how the prepared activities will be evaluated.

All activities in the training program start with a real-life problem and proceed in sequence by addressing the components of algorithmic thinking required to solve this problem.

One of the difficulties encountered while developing the activities is the preparation of activities that will explain the algorithm topics at a level that primary school students can understand and by making real-life simulations. The training program includes the basic approach of acquiring in-class activities and algorithm concepts without using a computer, operating the systematic process while solving algorithm problems, and evaluating the activities. Particular attention was paid to the use of materials such as paper, cardboard, scissors, glue, books, rulers, which are both economical and easily accessible to teachers and students in the school and classroom as educational materials.

The training program was implemented on 3 different teacher groups over a period of 3 months. Each course lasted for 5 working days, and after each course, data for evaluation of training program were collected from the participants and evaluated, improvements were made on the activities and content in the program according to the evaluation results. After improvements, the program was applied to the new participant group. The order of implementation of the activities was the same as the order of the chapters in the content. Some activities were held in the classroom, while some activities were implemented in the garden. During activities, the active participation of the teachers was ensured and as many participants as possible contributed to the activities.
In each course of the training program, two academicians who are experts in their fields, were assigned and the program was taught by a total of 4 academicians. Different academicians took part in each course. The academics assigned in the program are experts in the field of computer and instructional technologies, and they are competent and experienced in teaching educational technologies and programming to teacher candidates.

Study Group (Participants)

Each course of the training program was carried out by two trainers who are experts in their fields. In each course, the participants were selected from the primary school teachers working in schools affiliated to the Ministry of National Education with a snowball sampling approach by the Ministry of National Education's General Directorate of Innovation and Educational Technologies. In the formation of the groups, it was taken into account that the participants had a postgraduate education and were teachers who used technology effectively in their classes since the study was a program evaluation study.

The first training course was applied as a total of 30 hours in 5 days between 2-6 September 2019 at the Ministry of National Education Ankara In-Service Training Institute. A total of 22 primary school teachers, 15 women (%68) and 7 men (%32), were participated in the course. The average professional experience of the group is 17.6 years, the highest professional experience is 25 years, the lowest professional experience is 5 years.

The second course was carried out between 30 September and 4 October at the Ministry of National Education Ankara In-Service Training Institute for 30 hours in a week. 21 primary school teachers participated in this course. 15 (71%) of the participating teachers are female and 6 (29%) of them are male. The average professional experience of the group is 17.1 years.

The third course was carried out in Aksaray In-Service training center between 14-18 October 2019. A total of 22 people, 11 female (50%) and 11 male (50%) participants, attended the course. The average professional experience of the group is 16.3 years. For all courses, the average teaching experience of the participants ranged from 16.6 years to 18.6 years for women and between 14 and 19.7 years for men. Table 2 below shows the distribution of the participants by gender and education, and Table 3 shows the average teaching experience of the participants in years in each courses.

Table 2. Distribution of teachers participating in each training course by gender

	Female		Male		Total	
	N	%	N	%	N	%
First Training Course	15	%68	7	%32	22	%100
Second Training Course	15	%71	6	%29	21	%100
Third Training Course	11	%50	11	%50	22	%100
Total	41	%100	24	%100	65	%100

In the light of the information in Table 2, it was determined that there was no significant difference in terms of gender distribution in the groups with the chi-square analysis performed separately for each group and on the total number of participants.

Table 3. Average of professional experience of participants

	Female (year)	Male (year)	Average (year)
First Training Course	16,6	19,7	17,6
Second Training Course	18,1	15,8	17,1
Third Training Course	18,6	14	16,3

As can be seen in Table 3, the average teaching experience of the participants in all three training courses is over 15 years. This shows that the teachers participating in the trainings are senior educators. Whether there was a difference in experience among the participant groups was analyzed with the Kruskal-Wallis test. According to the test results, it was determined that all three groups were not different from each other in terms of professional experience.

Data Collection Tools

Kirkpatrick Level 1 evaluation approach was adopted for the evaluation of all three course of the Algorithmic Thinking Training Program. The approach, which is one of the most frequently used methods in the evaluation of educational programs, has 4 levels, but “Level 1 – Reaction” can be used to evaluate teachers' reactions to the components of the training program or their level of appreciation due to time and resource constraints (Kirkpatrick & Kirkpatrick, 2006).

Level 1 is generally an evaluation to measure participants' response to a training program. The results of evaluation provide feedback in order to reveal the flaws or deficiencies of the program and to make improvements for the next trials. Feedback was received from the participating teachers with the measurement tool developed as a questionnaire in the Algorithmic Thinking Teacher Training Program. The measurement tool basically consists of 6 parts; Each of the first 5 sections are 5-point Likert answer scale with closed-ended questions, and the 6th section is the open-ended section where the qualitative opinions of the participants are collected. Items on the Likert scale were evaluated in five points: 1 - Strongly Disagree, 2 - Disagree, 3- Neither agree nor disagree, 4 - Agree and 5 - Strongly Agree. The titles and explanations of the 5 sections are as follows:

Educator: In this section, opinions about the educators in the training program were collected. Feedback was collected about the work that the educators should do during the training, such as the mastery of the subject, the method of communication, and the use of the material.

Components of the Course: In this section, statements about the objectives and difficulty level of the curriculum content were included and the extent to which the participants agreed with these statements was measured.

Implementation: During the implementation of the training program, the application was measured with statements about planning, support of educator, and motivational support.

Physical Environment: There are statements that measure how suitable the physical environment in which the training program is held is suitable for the participants.

Instructional Technologies / Materials: Statements measuring how appropriate the educational materials used for education are included.

The answers given to the survey questions were used as feedback in the implementation of the next training program and evaluated as formal feedback for the improvement of both the training content and the training program.

DATA ANALYSIS

Since the aim of this study was to improve the developed training program, each item in the data collection tool was evaluated one by one. The data collection tool was applied again at the end of each training program in order to see the effects of the improvements made on the participants in the next application. The Kruskal-Wallis non-parametric test was used to understand whether the improvements made on the training program in line with the participant's opinions showed a significant difference between the applications. There are two reasons for choosing this test: First, the number of completed questionnaires from teachers in each education group varies between 15 and 22, and secondly, the Shapiro-Wilk test result shows that the distribution of each questionnaire item is not normal. Therefore, the effects of the program-related improvements on the opinions of the participants between the three application groups were analyzed with the Kruskal-Wallis non-parametric test.

RESULTS

In this section, the results obtained from the analysis of the assessment tools are presented.

Level 1: The Results of Evaluation Survey

In Table 4, the average of scores for the program components evaluated in each training course are presented.

Table 4. Average scores given to the Algorithmic Thinking training program components in each course

	Average Scores of First Training Course	**Average Scores of Second Training Course**	**Average Scores of Third Training Course**
Educator	4,63	4,89	4,91
Components of Course	3,93	4,13	4,27
Implementation	4,29	4,79	4,84
Physical Environment	3,89	4,37	4,11
Instructional Technologies / Materials	4,61	4,73	4,93

According to the results in Table 4, it is seen that the participants evaluated the components of all three training programs with high scores. In line with the feedback received from the teachers after each course, improvements were made about the training content, materials and application methods, and the improved program was implemented in the next course. When we look at the changes in the averages of the measured areas between the education programs, it will be seen that the average score of each education program component in the evaluation tool increases from the first course to the third course. Participants gave the highest scores to the educator of program and the instructional technologies and materials used in the program in all three courses. The average score for educators, which was 4.63 in the first training, increased to 4.89 in the second training and 4.91 in the third training, respectively. Similarly, the evaluation scores of the instructional technologies/materials used in the program increased from 4.61 in the first course to 4.73 in the second course and 4.93 in the third course, respectively. It is the least scored physical environment component among the measured curriculum components. The physical environment evaluation scores, in which the training program was applied, showed a fluctuating trend even though it was improved with the feedback from each training program. The physical environment score, which was 3.89 in the first education, became 4.37 at the end of the second education and 4.11 at the end of the third education. In line with the scores given to the components of the training program at the end of each training program, after the content and environment of the training program are reviewed at the end of each application and necessary corrections are made, it is seen that the views of the participants about the course and the program are positively affected.

Kruskal-Wallis analysis was conducted to determine whether the change in the applications in the satisfaction score of each item in the questionnaire was statistically significant. The results of the analysis, in which the components of the training program were examined one by one, are presented in Table 5.

Table 5. Comparison of the questionnaire scores related the educators in the training courses

Presentation / Communcation of Educator(s)	**Average Scores of First Training Course**	**Average Scores of Second Training Course**	**Average Scores of Third Training Course**	**P**
Topics made interesting	4,43	4,85	4,95	0,003*
My attention is focused on the lesson	4,48	4,85	4,76	0,039*
He/she was willing/enthusiastic while teaching	4,81	4,92	4,95	,343
He/she used clear and understandable language	4,48	4,92	4,86	,058
He/she summarized the key points of the lesson or discussion at the end of the lesson	4,38	4,85	4,90	,016*
He/she used good examples to illustrate important topics in the lesson	4,43	4,85	4,81	,119
He/she teaches in pace that I could follow the lessons and materials	4,57	4,77	4,95	,094
He/she organized the lessons	4,62	4,92	4,90	,079
Different views are showed respect	4,90	5,00	4,95	,397
He/she treated learners with respect	5,00	5,00	4,95	,513
Knowledge / Competence of Educator(s)				
He/she is competent in his/her field- his/her knowledge is sufficient.	4,67	4,92	4,95	,089
He/she is aware of new developments in the field.	4,71	4,85	4,90	,469
He/she answers the questions I ask about the subject in the course in detail.	4,71	4,92	4,95	,179
He/she notices what I know wrong about the subject and informs me about the correct one.	4,71	4,85	5,00	,138

*p<0,05

The educators in the training program got high scores for each implementation of training from each evaluation item. However, the improvements made at the end of the training practices, taking into account the feedback, created a statistically significant difference in three items. First of all, at the point of making the subjects interesting, attention was paid to the fact that all the problems presented in the content were real-life problems that students would encounter in life and that the problem situations started with a story. Secondly, while the training was given in the first training group, the direct instruction method was used on the conceptual dimension of the subject related to the algorithm, while in the second and third courses, the conceptual lecture was kept short and the algorithm was applied and the questions from the participants were answered and the different dimensions of the concept were explained. Finally, the points given to the item summarizing the important points of the lesson or discussion in order to make the program better have increased as a result of the improvements, creating a significant difference between the first training application and the third training application. Based on this result, it can be suggested for educators to pay attention to the completion of the lesson with the summary of the activity or content at the end of the lesson.

As course components, the participants were asked for their views on the objectives, content and difficulty level of the training program. The items in the relevant part of the questionnaire and the averages of the scores given by the participants are presented in Table 6.

Table 6. Comparison of the questionnaire scores related the components of course in the training courses

Objectives / Content	**Average Scores of First Training Course**	**Average Scores of Second Training Course**	**Average Scores of Third Training Course**	**P**
Educational objectives are clearly stated at the beginning of the training.	4,55	4,54	4,86	,377
At the beginning of the training, the learners were informed about what is expected of them.	4,55	4,46	4,81	,307
Learners were informed about the learning goals they will reach at the end of the training.	4,45	4,62	4,81	,159
Difficulty Level				
Expectations at the activities were at an appropriate level	3,95	4,31	4,67	,028*
The activities are difficult enough for the learners to develop himself/herself, but easy enough to cope with.	4,05	4,38	4,62	,037*
Enough time given to learn activities	4,29	4,38	4,57	,839
I had to put in more effort than I expected to do the activities	2,90	3,15	3,10	,803
I had to work harder than ever to meet the expectations of the educators.	2,80	3,23	2,76	,705

*p<0,05

Course components were evaluated in two groups as objectives/content and difficulty level. While the participants gave high points to being informed about the course objectives and content, they stated that they were not forced in the activities and course content. When the scores of the questionnaire items in both sections in the first, second and third courses are compared, it will be seen that the evaluation scores about the objectives and content increase from the first course to the third course. It is important for the participants that the goals and expectations of the Unplugged Algorithmic Thinking training are clear and understandable since this training program was applied to a group of teachers whose area of expertise was not computer education and who had not received any training in computer programming before. At the beginning of the each training course, learning objectives and expectations of the program were explained to each group with examples. As a result, the relevant items were scored high in all three training groups, but no significant difference was found in the result of the analysis.

When the evaluation scores about the difficulty level of the subjects in the training program are examined, it will be seen that the perceived difficulty level of the program decreases from the first course to the third course. In the Kruskal-Wallis test, which was conducted to understand whether the differences were statistically significant, there was a significant difference between the trainings in the answers given by the participants to the questionnaire items in two items. The first item is that the expectations from the participants in the activities are at an appropriate level. The increase in the scores from the first education application to the third education application and the meaningfulness of these differences made the activities more understandable as a result of the changes made in the program. Secondly, there is a difference between the trainings in the item stating that the activities are difficult enough for the participant to develop himself, but easy enough to cope with. Participants in all three groups think that the time given for the activities in the program is appropriate. The last two items in this section ask the participants whether the difficulty level of the activities and the expectations of the trainers are appropriate. Finding low scores for these items indicates that the program is easy for the participants. Based on these findings, it can be concluded that the training program and the activities in it are suitable for the level of primary school teachers. In addition, the improvements made in the training program as a result of the feedback received from the participating teachers during the training course, from the first training course to the third training course, helped to increase the evaluation scores. However, although the improvements made increase the positive scores of the participants, they are not statistically significant.

The results of the questionnaire items asked to evaluate the implementation process of the training program are presented in Table 7.

Table 7. Comparison of the questionnaire scores related the process of implementation in the training course

Implementation	**Average Scores of First Training Course**	**Average Scores of Second Training Course**	**Average Scores of Third Training Course**	**p**
The flow of activities is well planned.	3,90	4,69	4,67	,003*
Topics of training were correlated with real life	4,14	4,85	4,81	,001*
When an activitiy is made, the steps of it are explained	4,52	4,69	4,95	,036*
Sufficient support was provided during activities	4,76	4,92	4,95	,330
Motivating elements were present for the learner to show maximum performance	4,48	4,85	4,90	,017*

Good examples or good models were used	4,05	4,85	4,81	,000*
Activities were implemented within reasonable time limits	4,19	4,69	4,81	,012*

*p<0,05

In Table 7, it is seen that the participants gave high scores to all items related implementation and the improvements made on the training program after first and second training course created significant differences between the participant groups. The first item which showed a significant difference in this part of the measurement tool is the planning of the flow of activities. Algorithmic thinking training course for primary school teachers is a training program planned in consultation with experts of the field. The training program was created by considering the basic principles "from simple to complex", "from easy to difficult" and "from near to far", and was developed by considering the interconnectedness of the subjects. Within each of the 13 interconnected main training topics, there are 34 activities in total, created from simple to difficult. In the first training course, the flow order for each subject was applied as theoretical information about the subject, implementation of the activity and summative discussion. However, in the feedback received from the participants at the end of first training course, it was suggested that this flow be changed to implementation of the activity, summative discussion, and short theoretical information about the subject. The flow planning of the activities created during the first training course was improved before the next training course and the score regarding the participants' views about the activity flows increased significantly.

The second item which showed a significant difference in the measurement tool is about associating the subjects with daily life. In the training program, content and examples were associated with daily life so that primary school children could understand an abstract concepts related to algorithmic thinking skills. Daily life problems were designed for the activities, at the beginning of the activities these problems were presented by being narrated and learning was carried out within the solution process of the problems. Narrations of the problems have been improved based on feedback received after the courses. Therefore, the scores given by the participating teachers increased after each application, creating a significant difference between the first and third applications.
The third item, which shows a significant difference, is about making explanations about the activities. As a result of the improvements made between the first and third courses in the parts where the algorithmic thinking activities are explained step by step, there was a significant difference between the scores. The fourth item that showed a significant difference was related to the presence of motivating elements in the program. Enriching the practical activities in the training program with motivating elements created a significant difference between the first training and the third training courses.

In the fifth item, which showed a significant difference, there was a significant difference between the groups in the opinions about the use of good examples and good models in the training program. Numerous examples have been created in the training program to embody and better understand abstract concepts. The sixth item with a significant difference is related to the duration of the activities. This item assesses whether the activities are carried out within reasonable time limits. Between the first course and the third course of the training program, there were significant differences between the views of the participant groups, since measures were taken to improve both time and quality of the implementation process of the activities. The participation of two academicians who are experts in the subject area in each course of the training program ensured that the participants were given sufficient support during the implementation of the activities. Since the scores given to this item were close to the highest score of 5 in each of three training course, there was no significant difference between them.

The evaluations regarding the items in "the physical environment" title of the measurement tool are presented in Table 8.

Table 8. Comparison of the questionnaire scores related the physical environment in the training courses

The Physical Environment	**Average Scores of First Training Course**	**Average Scores of Second Training Course**	**Average Scores of Third Training Course**	**p**
Classes are appropriately sized according to the number of learners.	4,19	4,46	4,52	,491
The temperature level of the classroom environment is suitable for teaching.	4,23	4,31	4,00	,750
The light level of the classroom environment is suitable for teaching.	4,33	4,62	4,29	,605
Ventilation is provided in the classroom environment.	2,48	4,15	3,10	,007*
Refreshments are sufficient during the training.	4,23	4,31	4,67	,412

*p<0,05

In Table 8, it is seen that the item related to ventilation was scored very low by the participants during the first course. The participants stated that the ventilation in the classroom environment where the training was carried out was not sufficient. It is thought that the low scoring of this item is due to the fact that the training was held at the beginning of September, when the weather was not cool yet. Necessary measures have been taken to ventilate the classrooms to be used for the next training program, and the effect of them is seen in the results.

Participants also evaluated the materials and technologies used during the training courses on the questionnaire. Table 9 reflects the participant views on the materials and technologies used during the training courses.

Table 9. Comparison of the questionnaire scores related the instructional technologies/materials in the training courses

The Instructional Technologies/ Materials	**Average Scores of First Training Course**	**Average Scores of Second Training Course**	**Average Scores of Third Training Course**	**p**
Internet access was provided in the classroom.	4,48	4,38	4,86	,541
Our classroom had the tools and equipment that the educator could use whenever they wanted.	4,71	4,77	4,95	,488
The course materials used were sufficient to do the activities.	4,52	4,92	4,90	,136
Educators guided participants on which materials they could use about the activities.	4,76	4,85	5,00	,348

*p<0,05

In the evaluations of the participants' opinions in three groups on instructional technologies and materials, the scores they gave to the relevant questionnaire items are seen to be quite high. However, no significant difference was observed between the groups. Therefore, it can be said that the materials used during the training program are sufficient and the guidance provided by the educators on the use of the material is appropriate.

CONCLUSION AND DISCUSSION

In a world where innovative information technologies and competition for a better quality of life and environment have been a priority for nations, employees of the future professions are expected not only to be users of information technologies, but also to be solution developers to problems in their profession by using information technologies. At this point, it would be appropriate to use information technology concepts and tools in systematically teaching problem solving skills at an early age. One of the skills that can be taught to achieve this goal is the Algorithmic thinking skill. Since algorithmic thinking skill is not a part of classroom education teaching program, there is a need to develop an unplugged Algorithmic Thinking teacher education program for primary school students in order to gain this skill to all students at an early age. In line with this need, the aim of the study is to develop a professional development program that will teach primary school teachers how to gain their students algorithmic thinking skills. The methods and environments used in the teaching of algorithmic thinking skills may vary according to the opportunities available in the educational environment. A wide range of teaching environments and methods can be used from teaching algorithmic thinking with activities without computers to teaching block programming tools in a computer laboratory (Hsu, Chang, & Hung, 2018). In this study, in order to increase the participation of the students in the classroom and to be applied in schools without computer laboratories, unplugged activities and Algorithmic thinking curriculum were planned as in-service training.

Algorithmic thinking activities without computers, developed in consultation with computer science and primary education experts, were applied to classroom teachers in 3 different groups, one month apart. The training program was planned as 30 hours, 5 days a week. At the end of each training course, the opinions of the participants about the training program were taken with a questionnaire and changes were made to improve the program with the analysis of the feedback from the participants. These improvements were carried out before the application with the second and third groups. The use of circular processes in the design and development of educational programs is frequently practiced by program developers (Hunkins & Hammill, 1994). Receiving feedback from the participants after each course of the developed program and improving and re-applying the program within the framework of the recommendations make the program more effective, efficient and attractive for future applications (Frick & Reigeluth, 1999).

As a result of the improvements made in the training program, which is the subject of this study, the scores given by the participants to the evaluation questionnaire about the program increased from the first application to the third application. As a result of analysis made with the non-parametric Kruskal-Wallis test, significant differences emerged between the groups, especially in the scores given by the participants in the application of the training program. This shows that the improvements made in the program are welcomed by the participants and that the program can be used in the professional development of teachers. As a result, the content, teaching method, difficulty level, application in the classroom environment and materials of the developed training program and activities were found to be usable and applicable by the teachers.

In future studies, the effectiveness of the program on the participants in terms of learning objectives can be investigated. With studies designed with an experimental or quasi-experimental approach, the developed program can be compared with programs that provide algorithmic thinking skills with other teaching methods. The current activities in Unplugged Algorithmic Thinking Skills Curriculum have been prepared considering the primary school student level, but the effectiveness of the activities has not been tested on primary school students. For this reason, studies that investigate the effect of this program on primary school students can be designed.

Ethics and Consent: Ethics committee approval is not required since the data was collected before 2020.

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