TEACHER'S CHEMISTRY PROJECT

INQUIRY-BASED SCIENCE EDUCATION

IMPACT AND EVALUATION REPORT

TEACHERS ACADEMY FOUNDATION

DOW®

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EXECUTIVE SUMMARY

Advances in technology provide students with easily accessible information, accelerated learning practices, and fun ways to apply what they learn. This way, it allows students to discover new topics and understand the complex concepts of STEM education in depth. By using technology inside and outside the classroom, students can gain the 21st century technology skills needed for their future careers. With all of these developments and globalization driving digital transformation, teachers have an important role to play in providing the skills necessary for students to succeed in their careers in the future. Through engaging and educational content, teachers can spark students' curiosity and help them develop a holistic understanding of subject matters in science and math, especially in STEM education.

The Inquiry-based Science Education Program was developed in consideration of the needs of the age in mind. The program essentially aims to enable students to approach problems from an interdisciplinary perspective, under a holistic approach to education, under the guidance of teachers, and to acquire the necessary knowledge and skills through the inquiry method.

A total of 415 teachers completed the educational program. Participating teachers evaluated the educational program within the framework of criteria such as content, structure, outcomes, planning and organization. Teachers completing the program filled out a survey consisting of 15 questions to give their opinions on various aspects of the program. For purposes of monitoring and evaluating education processes, 293 persons participated in the survey. Participating teachers expressed a high level of satisfaction by giving the educational program a score of 9.3 out of 10. While more than half of the participants in the educational program were female teachers, about 30% of the participants were male. The participants, consisting of teachers working across 70 different provinces of Turkey, were primarily teachers from the fields of Chemistry and Sciences. 70% of teachers who participated in the educational program and completed the evaluation survey reported having in-depth STEM knowledge, while 67% reported gaining new perspectives on laboratory practices in chemistry/science teaching following their participation in the educational program. Teachers indicated that they had initially had reservations / prejudices about STEM education. After completing the Inquiry-based Science Education, participants emphasized that they recognized that the experience-centered STEM approach had positive effects on students' academic success and critical thinking skills. In addition, the participating teachers indicated that they had acquired important knowledge and skills by completing the educational program, especially in the area of teaching / classroom practices, and that the training had made a significant contribution to their professional development. Finally, the participating teachers expressed their expectations and suggestions for the design and planning of the educational program for the coming periods. The teachers' suggestions for the future design of the educational program focus on feedback on planning and organization. In this sense, the common opinion of the participants is that the number of synchronous sessions should be increased and the training should be spread out over more days.

At Teachers Academy Foundation, we are pleased that the Inquiry-based Science Education program, which focuses on the role of technology in achieving new levels of teacher productivity, is creating new learning spaces for students through teachers, and we hope that the social impact of the education program will spread to broader masses in the future.

ABOUT THE PROGRAM

Under the in-service training protocol between the Teachers Academy Foundation and the Ministry of National Education, Science and Chemistry teachers were involved in training through the Ministry's management information system MEBBİS. Participants followed the educational content on the Teachers Academy Foundation's distance learning platform, eKampüs. The training consists of synchronous (synchronous/live) and asynchronous (asynchronous/non-live) sessions. The first module of the educational program, which starts asynchronously, serves as a preparatory stage. In general, the focus is on basic concepts around distance learning and orientation for online education. In the second module, which continues asynchronously, the 5E learning Method and STEM education were discussed. The synchronous session, which lasted 3 hours the following day, reinforced asynchronous content through participant interaction and emphasized 21st century skills and the integration of technology into education. Laboratory practices and inquiry-based science practices were included in synchronous and asynchronous sessions, which continued at the same pace. Participating teachers who attended all synchronous sessions, viewed the asynchronous content, and completed their assignments received their certificates through MEBBİS, the Ministry of National Education's school management information system.

THEORY OF CHANGE DESIGN

The theory of change is a theoretical model that helps articulate the goals of a program or project. Basically, it is a roadmap that helps organizations understand whether they have selected the right activities to achieve the set goals and what tools they can use to measure the impact of the program (Carinin & Derine, 2017). The components that make up the theory of change of the Inquiry-based Science Education Program are as follows:

- Social impact goals
- Outcomes
- Project Outputs
- Events
- Resources

Figure 1 provides information on the theory of change design of the Inquiry-based Science Education Program. Each component of the theory of change is discussed in detail.

Social Impact Goals	Outcomes	Program Outputs	Events	Resources
This Educational Program aims at; Equipping Chemistry and Science teachers with holistic teaching practices. Making teachers create an experience-based classroom experience by understanding the relationship between 21st century skills and STEM education, Raising awareness about the integration of technology into education.	**Through this educational program,** Teachers developed knowledge and skill sets related to the inquiry-based teaching practices. Teachers learned what Web2.0 tools they can use in Chemistry and Science lessons. They gained an awareness of student-centered classroom practices.	**At the end of the Educational Program,** With 415 teachers completing the educational program, they developed a deep understanding of the inquiry-based approach to science education. Approximately 10,000 students were reached by participating teachers.	**Under the Educational Program** A total of 6 hours of synchronous sessions were held. A total of 3 hours of asynchronous sessions were held. During the educational program, applications such as experiments, simulations, and animations were also included to support inquiry-based science education.	**Human Resources** Teachers Academy Foundation Central Team . Teachers Academy Foundation Expert Trainers Teachers Academy Foundation Part-Time Trainers Ministry of Education Technical Resources ·eKampüs ·MEBBİS ·Various Web 2.0 Tools

Figure 1: Inquiry-based Science Education Theory of Change Design

The Inquiry-based Science Education basically aims to develop a student-centered holistic teaching practice by enabling teachers working in Science and Chemistry fields to gain an understanding of 21st century skills and STEM education. Participants who complete this educational program will have developed a basic understanding of the following development areas:

- The relevance of topics learned in science classes to real life and how they can be related,
- The importance of observation and experimentation in continuing the learning process,
- Science concerns all people and is necessary for all,
- The link between STEM and 21st century skills,
- How design processes are used in STEM education,
- How to integrate STEM into the classroom,
- How student-centered learning is accomplished with the 5E learning method,
- How to create a lesson plan appropriate for the STEM approach,
- The importance of using animation in education,
- What safety precautions must be observed in the laboratory,
- The importance of laboratory applications in science education and
- that there are several approaches to laboratory applications in science education and how to use them

Under the Inquiry-based Science Education Project, a total of 415 teachers completed their training. A total of 320 teachers participated in the educational evaluation survey. Approximately 10,000 students were reached by participating teachers .

As part of the educational program, a training flow of a total of 6 days was performed asynchronously and synchronously. During the educational program, applications such as experiments, simulations, and animations were included to support inquiry-based science education.

[1] The following procedure was used to calculate the number of students reached: 77% of participating teachers are elementary school teachers. In Turkey, there are an average of 22 students in a classroom at the elementary school level. The number of students in secondary education per each classroom is 25 in Turkey. In calculating the number of students, it is assumed that a subject matter teacher teaches in three classrooms.

Subject matter	Content
Introduction to the Inquiry-based Science Education Theory	- Where is chemistry in all this? - Real Life Examples: Chemistry in the Kitchen
What is STEM?	- What is STEM? - 5E Learning Method
STEM Education and its Features	- The Relationship between STEM and 21st Century Skills - Engineering Design Processes - STEM Lesson Plan
Use of Technology in Lessons	- Using Animation and Simulation in Lessons
Laboratory Applications	- Safety Precautions in the Laboratory - Different Approaches in Laboratory Applications - Surface Tension - Soap Bubble Experiment
Inquiry-based Teaching Practices	- Purposes of Using Laboratory in Chemistry/Science Teaching - Close Ended Experiments - Open Ended Experiments - Hypothesis Testing Experiments - Argumentation in Science Education

Table 1: Subject and Content Details of the Inquiry-based Science Education Program

It is possible to split the resources used in the pedagogical design and implementation processes of the Inquiry-based Science Education program into two groups, i.e. human and technical resources. In this context, the referenced human resources can be listed as follows:

- Teachers Academy Foundation Central Team
- Teachers Academy Foundation Expert Trainers
- Teachers Academy Foundation Part-Time Trainers
- Ministry of Education

The technical resources used in the design and implementation processes of the educational program are as follows:

- eKampüs
- MEBBİS
- Various Web 2.0 Tools

DEMOGRAPHIC INFORMATION

Gender Distribution

Approximately 70% of the Inquiry-based Science Education participants are female teachers. The proportion of male participants was measured at 28%. The proportion of participants who did not answer this question was calculated as 4%. In terms of gender distribution, there is a parallelism between the 2020 and 2021 data [2]. The chart showing the gender distribution of participants for 2021 is shown below.

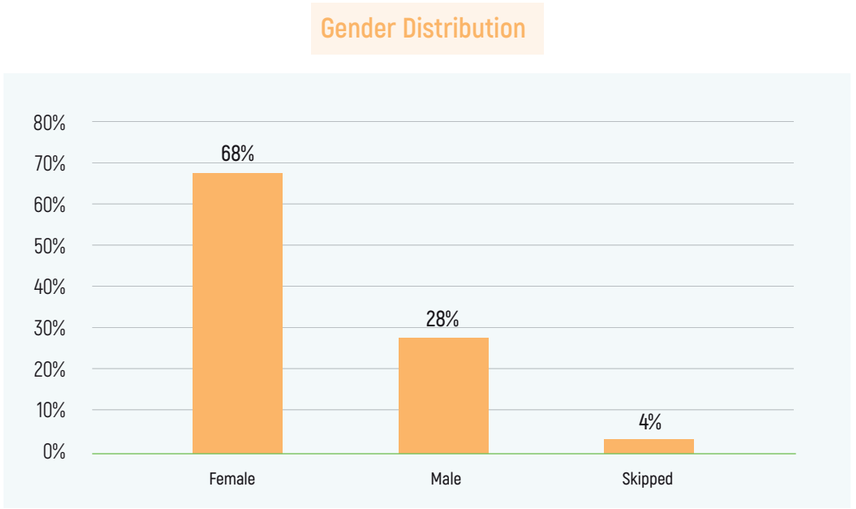


Chart 1: Gender Distribution

[2] For the Impact and Evaluation Report 2020, please see: https://www.orav.org.tr/i/assets//pdf/degerlendirme-raporlari/OgretmeninKimyasiEgitimProgramiEtkiRaporu_2020.pdf

Subject Area

The majority of participants are Science and Chemistry teachers, who are also the target group of the project. 4% of the participants who completed the training and were included in the evaluation study were teachers who were in the "Other" category. Under the other category, there are school administrators and PE teachers. The chart showing the subject matter distribution of participants is shown below.

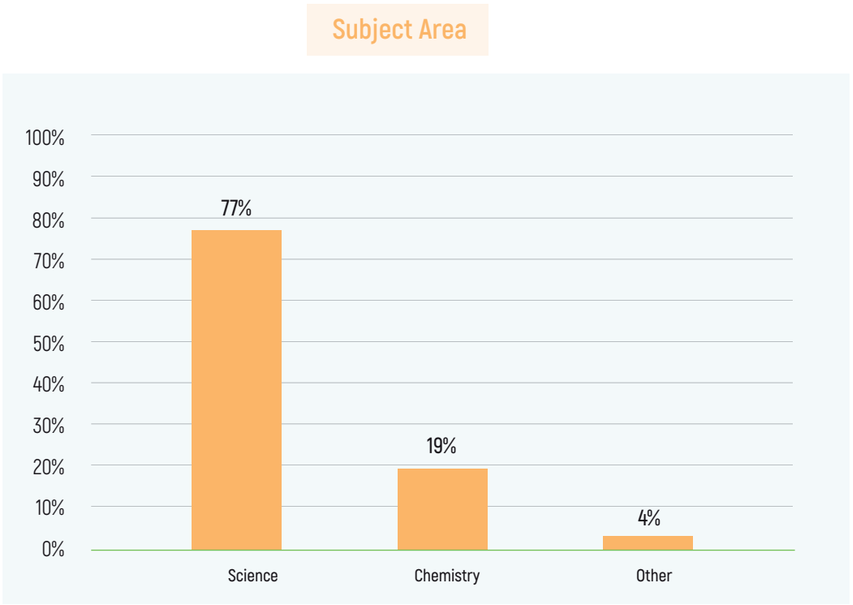


Chart 2: Distribution of Subject Area

Place of Duty

Teachers working in 70 different provinces of Turkey participated in the Inquiry-based Science Education. Participants' locations were analyzed according to the Turkish Statistical Regional Units classification, which is a classification of the Turkish Statistical Institute (TÜİK).[3].

[3] Regional statistical units are established by the Turkish Statistical Institute (TÜİK) within the framework of the harmonization laws of the European Union in order to create a region of neighboring provinces that are similar in economic, social and geographical terms, to produce region-based statistics, to conduct socio-economic analysis and to develop regional policies for society.

Within this classification, Turkey is divided into 12 regions composed of neighboring provinces. While the proportion of teachers participating in the inquiry-based science education from the Mediterranean region was 17%, it was 3% for teachers in the Northeast Anatolia region. While the proportion of teachers from the Aegean region was 13%, the proportion of teachers from Middle East Anatolia was 6%. Considering the population density of Turkey's statistical regional units, it can be said that there is a participating population that represents the whole country. The distribution of locations of participating teachers by regional statistical units is shown in the following chart.

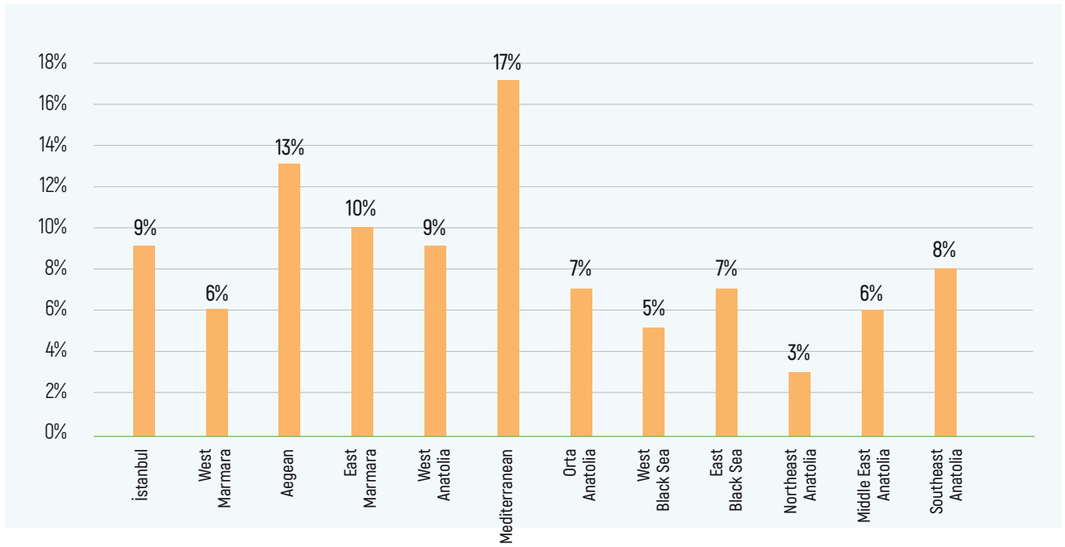


Chart 3: Place of Duty by Statistical Regional Units

Years of Professional Experience

When the teachers who completed the inquiry-based science education and participated in the evaluation survey study are examined in terms of their professional service time, it appears that teachers who have worked "6-10 years" make up the majority of participants at 31%. This is followed by teachers with 5 years or less of work experience at 20%.

The chart showing the distribution of participants by professional service time is presented below.

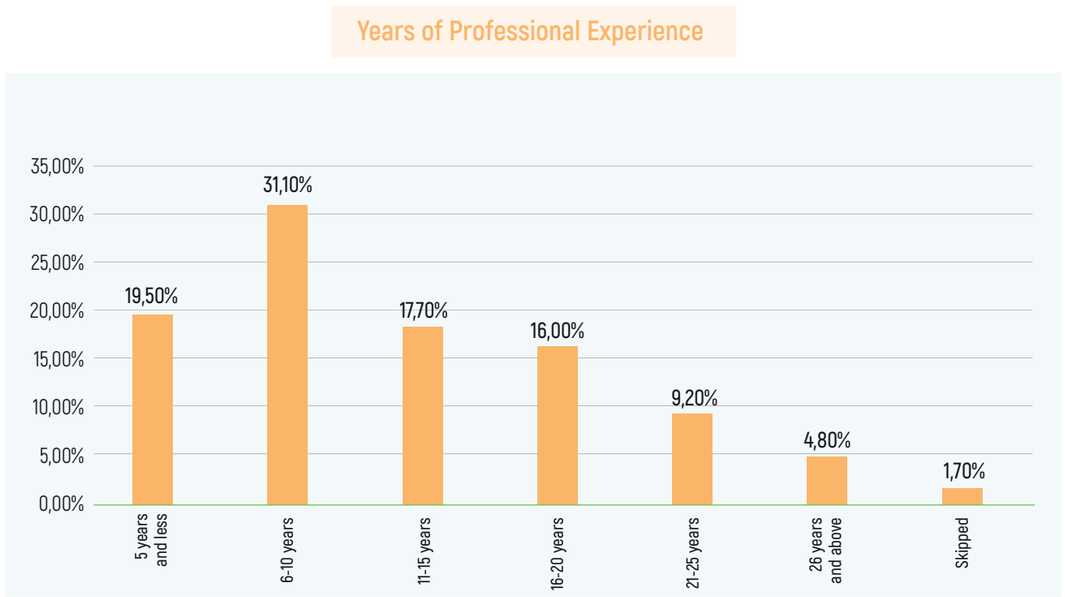


Chart 4: Years of Professional Experience

The Evaluation of the Education Program

Teachers involved in the Inquiry-based Science Education evaluated the program on various aspects such as content, structure, planning and organization, learning environment, and teacher competence. In this part of the report there are evaluations about the trainers, the learning environment, the content and the structure of the training.

Evaluations of Trainers

The average scores in this section, in which participating teachers rated trainers in categories such as "mastery of subject matter, presentation skills, time management, encouraging participation, and mentoring in social learning groups," are very positive.

The percentage distribution of responses to the items in this section of the Education Evaluation Form is shown in the chart below.

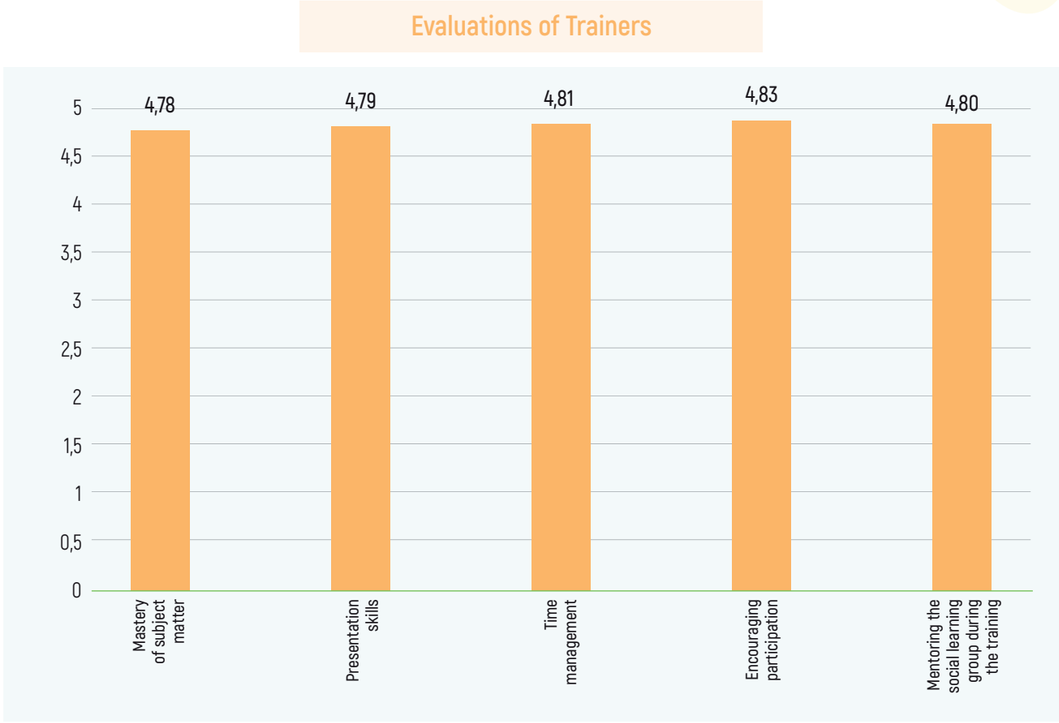


Chart 5: Evaluations of Trainers

Assessment of the Learning Environment

Since 2020, many Teachers Academy Foundation educational programs have been organized online. Training is delivered on eKampüs, the Teachers Academy Foundation's distance learning platform. The results of the "Teacher Preferences for Access to Professional and Personal Development" completed by the Teachers Academy Foundation in summer 2021 show that online professional and personal development courses provide teachers with autonomous work skills, while removing time, place, and finance barriers in accessing professional and personal development courses[4].

[4] For details, please refer to:
https://www.orav.org.tr/i/assets//pdf/degerlendirme-raporlari/Gelisim_Egitimleri_Tercih_arastirma_rapor_.pdf

At this point, teacher evaluations of online education and the learning environment specific to the Inquiry-based Science Education corroborate the research findings. For example, participants gave the statement "I find online training very useful" a score of 4.54 out of 5. Similarly, they awarded the statement "I had no technical problems in eKampüs during my training" 4.45 out of 5 points, which showed that the learning environment was suitable for the work. Participating teachers' ratings of the learning environment are shown in the chart below.

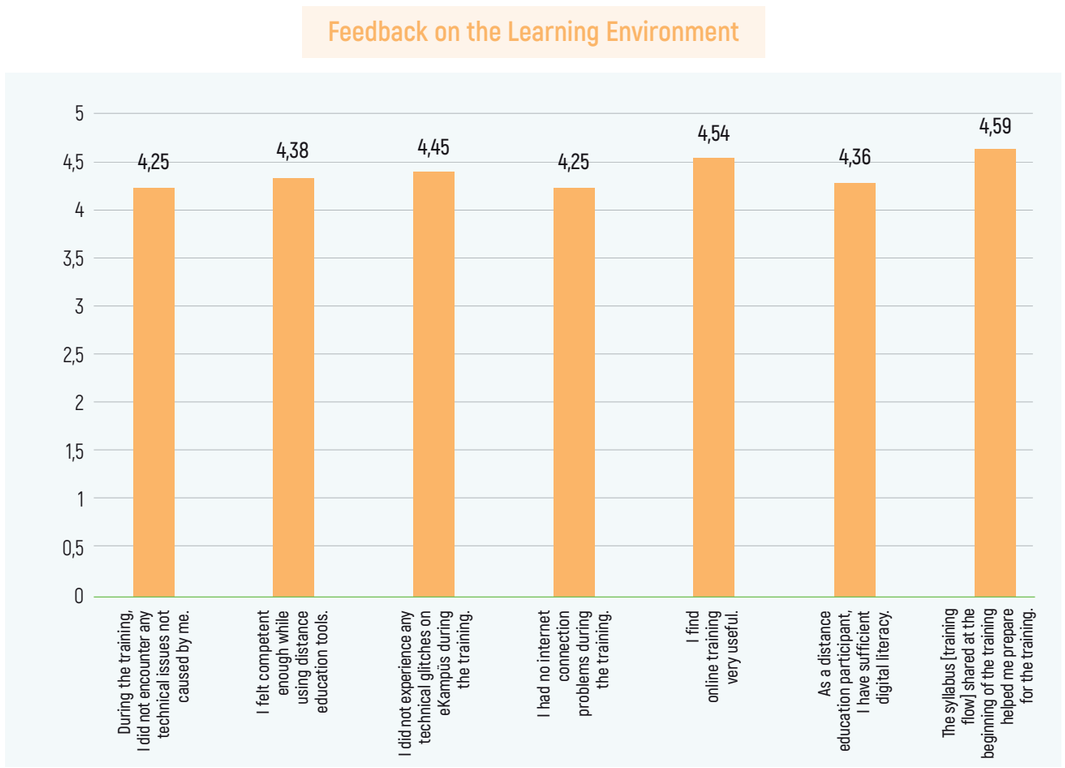


Chart 6: Assessments of the Learning Environment

Training Overall Evaluation

Finally, participating teachers evaluated the educational program within the framework of criteria such as content, structure, planning and organization. Teachers indicated that they found the educational content interesting, that the educational content was understandable, and therefore they were willing to share the training with other colleagues. The general evaluation of the educational program is shown in the following chart.

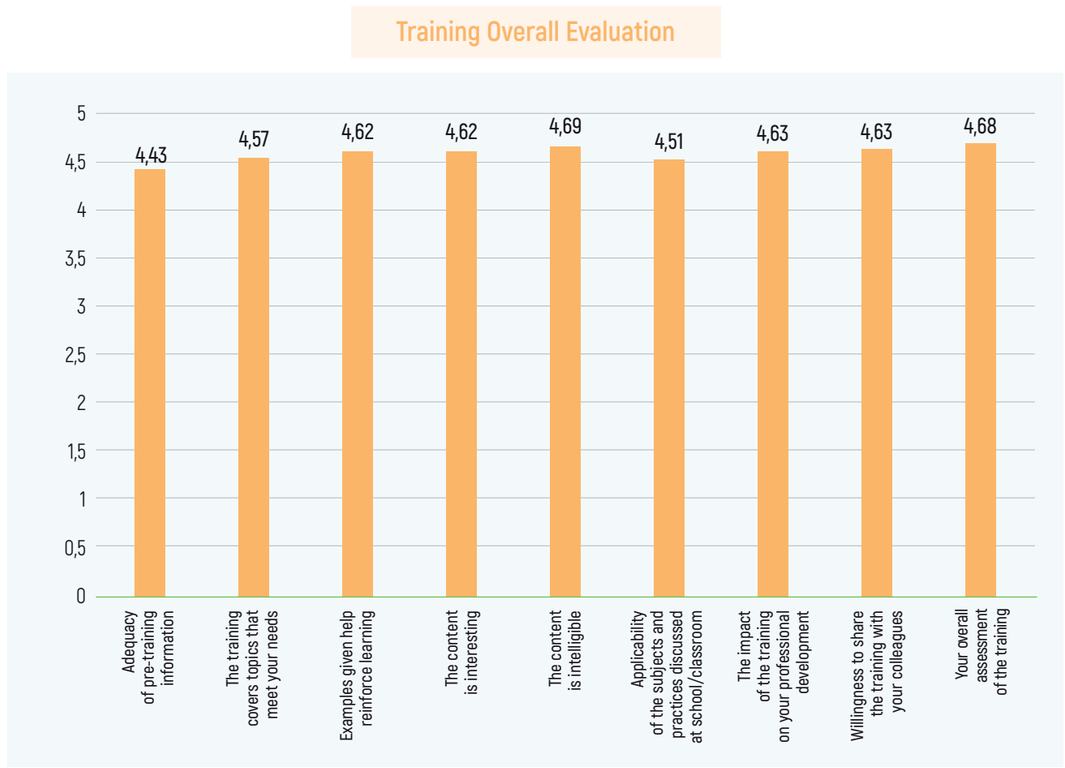


Chart 7: Training Overall Evaluation

Under the monitoring and evaluation studies of the Inquiry-based Science Education, participating teachers were asked an open-ended question about what they found most useful in education to obtain more comprehensive data on education.

The data obtained were analyzed with the MAXDicto module of MAXQDA. In this regard, if we look at the evaluations of the participating teachers about the trainers, the teachers emphasized that the trainers had impressive mastery of their specialty field, had effective communication and presentation skills, and were well equipped to manage an effective learning process. The qualitative data table created based on the responses of the participating teachers is shown below.

Theme	Category	Code	Participant Statements
Feedback on Training	Feedback on Trainers	Communication Skills	"Besides all the new things we learned, our teachers were so energetic and pleasant that I thought for my own part I should pay a little more attention in class. Thank you."
		Mastery of Subject Matter	"I learned a lot about different approaches, methods, and practices to use in classroom activities, both from our trainers and from my participating colleagues."
		Managing the Learning Process	"I had the opportunity to meet valuable trainers and both of our trainers imparted their knowledge with full motivation. I always thank my teachers for guiding the learning process."
	Feedback on the Educational Structure	Applicability	"I learned about new practices and new techniques. I realized how easy STEM applications that I thought would be difficult could actually be implemented and applied."
	Feedback on the Educational Content	Transferability to the Classroom Environment	"Remembering the subjects I learned in school and learning to use techniques in a classroom environment has given me new ideas."

Table 2: Feedback on Training

The Effect of Education on Teachers

To understand the impact of the Inquiry-based Science Education on teachers, both qualitative and quantitative analyses were conducted. Responses to open-ended questions were analyzed using the computer-assisted qualitative software program MAXQDA. Quantitative scales such as educational attainment were analyzed using spreadsheet programs such as SPSS and Excel.

Firstly, participating teachers were asked an open-ended question, "What can this training change about you? For example, what will you do differently after this training?" Participating teachers' responses to this question were analyzed using MAXQDA's MAXDicto and Visual Tools modules. The effect of education on teachers was examined in two categories, "Classroom Practices" and "Teaching Practices." The codes of these categories are shared in the concept map given below.

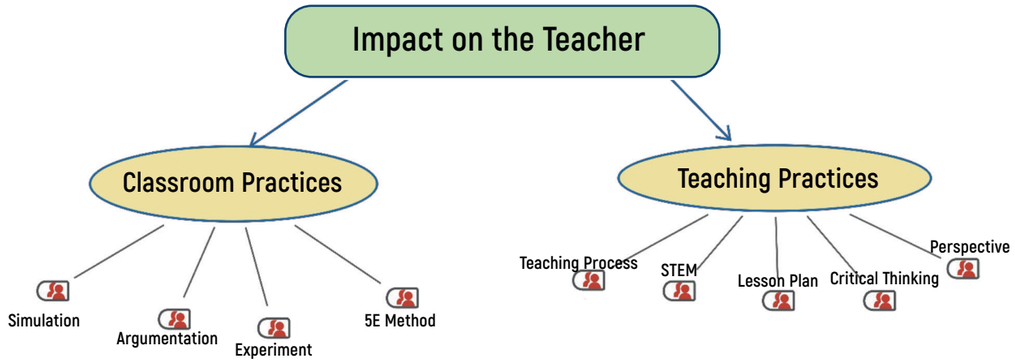


Figure 2: The Impact of the Education Program on the Teacher

When the codes in Figure 1 are examined individually, the progress made by teachers with regards to classroom practices aligns with educational achievements. Participating teachers indicated that the gains they made in the educational program included easy-to-use practices in a classroom environment. In fact, a participant with 16-20 years of professional experience of teaching science, expressed the impact of the training on their professional development in the following words:

"It helped me design and manage the activities and experiments that I could use in my classes. I think the training helped me to challenge myself for a lasting and student-centered education. I think it contributed to my professional development. I would also like to point out that I applied many things in my lessons before the end of the training. Like the fruit basket."

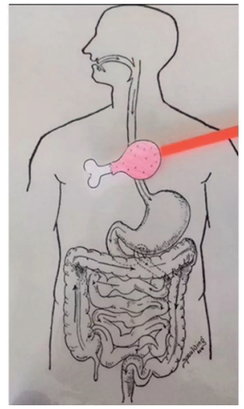
In addition, teachers who had a number of bias and reservations about STEM prior to attending the training indicated that this training had freed them from such bias and reservations. In fact, one participant teaching chemistry stated that the Inquiry-based Science Education allowed individual biases toward STEM to dissolve and provided an experiential perspective in place of traditional teaching approaches in the following words:

"STEM was something I was very biased toward. I saw myself more as an exam-oriented teacher thinking about how to motivate students to solve more tests. I believe they will be more successful in exams as their interpretive skills improve after experiencing hands-on learning with STEM."

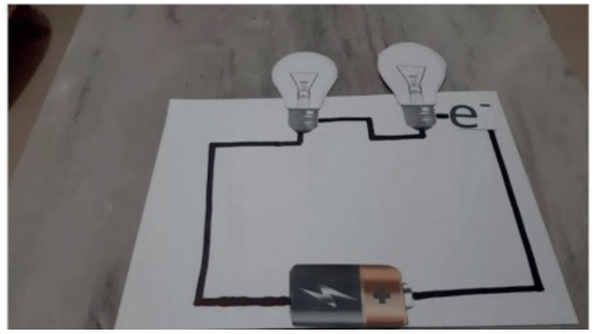
Finally, the teachers involved in the Inquiry-based Science Education indicated that the educational structure and content had a positive impact on their personal and professional development alike. Again, a participating science teacher expressed their assessment of the training course as follows:

"All the interactive practices in the education program kept me in the moment even though I was so tired. It was all very enjoyable. They were very well prepared, helping us brush up on our knowledge and bone upon our knowledge in general about teaching. The active participation of the participants in the training, the use of different methods and the music are a lot of fun."

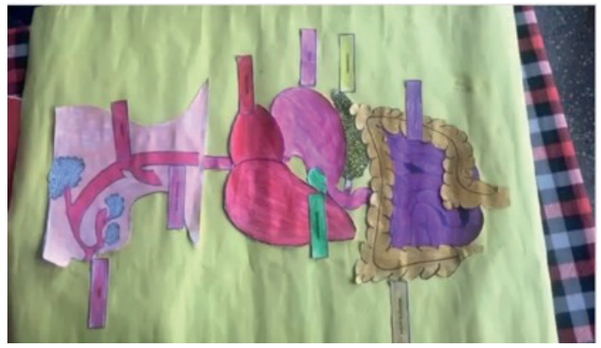
Another technique that participating teachers mentioned often in their evaluations of the educational program was stop-motion. You can view the stop-motion work done as part of the project using the QR codes below



Picture 1: Examples from Stop Motion Application 1



Picture 2: Examples from Stop Motion Application 2



Picture 3: Examples from Stop Motion Application 3

Learning Outcomes

A scale was used to understand the learning outcomes of the Inquiry-based Science Education and the participating teachers' evaluations of educational achievements. The data for the attainments queried in the 5-point Likert-type are shown in the following chart.

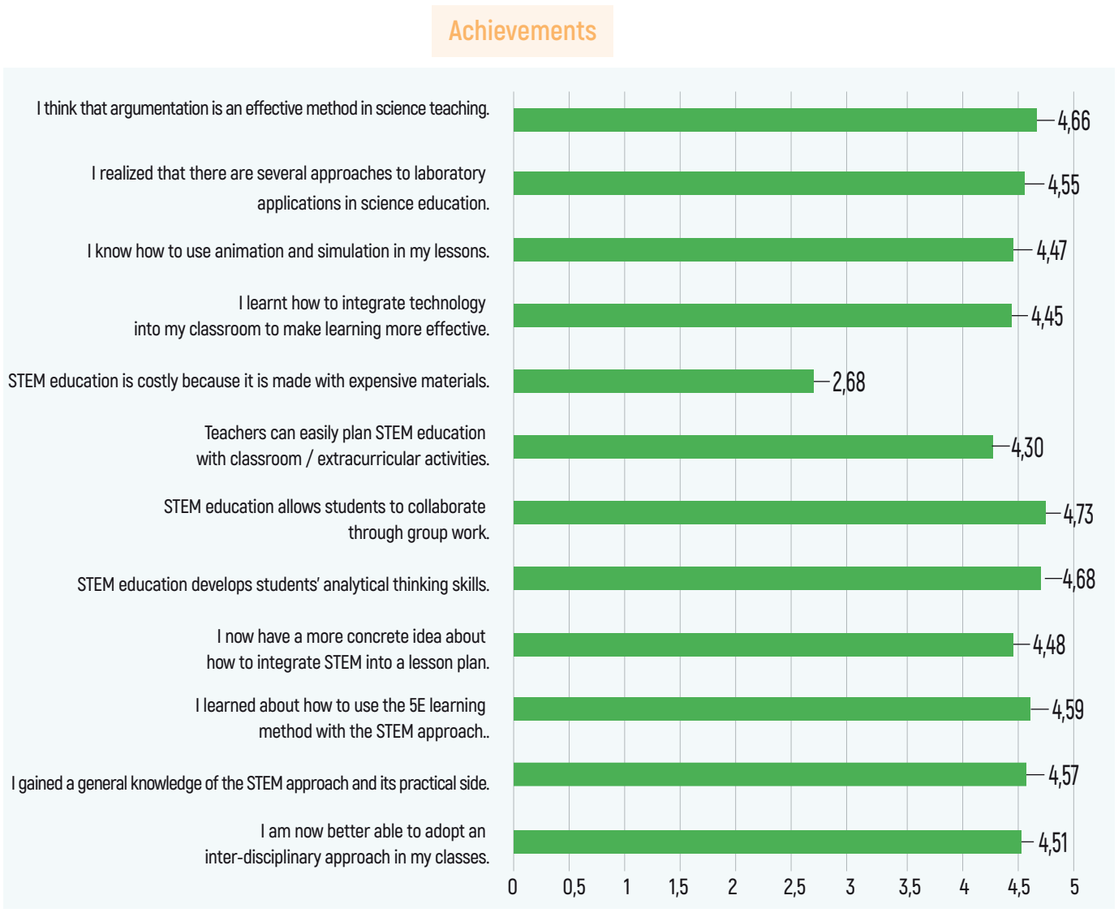


Chart 8: Learning Outcomes

Given the data in the educational attainment chart above, it can be said that the participating teachers have gained a basic understanding of STEM. The awarding of 2.68 out of 5 points for the item "STEM education incurs costs because it is done with expensive materials," which is a control statement in the scale, also confirms this assertion.

Expectations Suggestions

The open-ended question, "What would you include in this distance education program or what would you have done differently?" was asked of the teachers to find out what expectations and suggestions they had for the future design of the education program. The obtained data were analyzed using MAXQDA's MAXDicto and Visual Tools module. In accordance with the teachers' responses, the codes and participants' statements created under three basic categories: "Educational Content", "Educational Structure" and "Planning and Organization" are presented in the following table.

Category	Code	Participant Statements
Educational Content	Games	"I would add interactive simulations or games to increase engagement."
	Arduino Education	"It might be good to add Arduino to the program for next semester."
	Alternative Measuring Tools	"I think it was pretty good. In addition, there may be alternative measurement tools."
	Visual Resources	"I wish it had actual videos and more visuals."
Educational Structure	Interactive Sessions	"Having interactive sessions where teachers can take an active role."
Planning and Organization	Timing	"I would spread out the virtual sessions over more days, delivered in shorter hours instead of 3 hours." "There can be more room for classroom practices. You could have shortened the hour daily duration and increased the number of days."

Table 3: Expectations and Suggestions of Participating Teachers for Education

Participating teachers provided feedback on the adding of games to educational content to improve interaction in future versions of the program. In addition, teacher suggestions include increasing the visual elements that make up the educational content and adding current videos. The basic expectation about the structure of the training is that the sessions can be more interactive. They also indicated that they would like to attend more training to further improve themselves.

Conclusion

In a globally and digitally connected world, all students, from early education to adult learning, need new knowledge and skill sets to succeed. Given the role teachers play in adapting to and leading all of these processes of societal change and transformation, it is critical for teachers to acquire 21st century skills to successfully prepare students for their educational lives and future careers. In this context, the Inquiry-based Science Education Project, designed keeping in mind the demands of the current age, aims at interdisciplinary and in-depth learning of individuals by combining science education with experimentation again. This way, the students were supported by the participating teachers to take a holistic perspective by associating information learnt in the classroom with their daily lives. The Inquiry-based Science Education, which was conducted online in the 2020-2021 academic year as part of the COVID-19 epidemic measures, was also conducted online in the 2021-2022 academic year. As emphasized in the section of the report discussing participating teachers' evaluations of the learning environment, a well-designed online educational program was found to contribute significantly to teachers' professional development. Online professional and personal development training organized by the Teachers Academy Foundation not only benefits teachers' flexibility and versatility, but also allows teachers to build learning communities among their colleagues. In fact, the social learning groups created in our learning management system, eKampüs, specifically for the Inquiry-based Science Education Project, have opened up an area where participants can be inspired by each other and turn that inspiration into new aspirations by doing away with place-based constraints.

Participating teachers indicated that the Inquiry-based Science Education contributed to their professional development. In the analyses conducted based on the responses to the open-ended questions in the questionnaire form, it was found that the education program made significant contributions to classroom practices and instructional practices, particularly in the area of professional development. Teachers emphasized that they found the topics of science education and inquiry-based science teaching practices useful during the educational program and expressed that they would incorporate the lessons learned into the classroom environment. Teachers who completed the education program in the 2021-2022 academic year shared their expectations and suggestions for the future set-ups of the education program. The participants' demands and proposals for the next period are divided into three main categories: Content, Structure and Organizat

ion. Teachers who completed the training made suggestions to include more visuals and current videos in the educational content and to increase the number of synchronous sessions and keep the session duration short.

In light of the educational monitoring and evaluation report, necessary changes will be made to the structure of the inquiry-based science education program, taking into account the participating teachers, the opportunities provided by the learning environment, and the conditions in which we find ourselves the next semester.

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