Pirpiroğlu-Gencer, İ., Mirici, S. & Selvi, M. (2023). A science education workshop associated with a science center exhibition: Language of Rings on Tree Trunks. *International Online Journal of Education and Teaching (IOJET), 10*(2). 848-877.

Received : 19.12.2022
Revised version received : 24.02.2023
Accepted : 20.02.2023

A SCIENCE EDUCATION WORKSHOP ASSOCIATED WITH A SCIENCE CENTER EXHIBITION: LANGUAGE OF RINGS ON TREE TRUNKS

Research article

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Abstract

Science centers are the environments established as a result of big investments and great efforts, and aim to increase the scientific literacy level of the society. Alongside their captivating exhibits, these centers include a variety of workshops that can provide more specialized outcomes, particularly on learning. Especially science education workshops are the most ideal places to contribute to science education. In this research carried out within the scope of BILMER Research Project (Project No: 114K646, supported by TUBITAK 1001 Program), a science education workshop titled "Language of Rings on Tree Trunks" was developed in the field of biology, based on inquiry and including scientific research and scientific process skills. In this context, the developed workshop was applied to 66 teachers from five different branches and 4 science center trainers. The data of the research were collected through a preliminary evaluation form, a workshop evaluation form, field notes, video and audio recordings of the event. In the study, which includes the case study design of the qualitative research approach, the data obtained were subjected to content analysis. Based on the evaluation and reflections, a science education workshop teaching directory that can be used in schools within the scope of science center or science center-school cooperation has been developed.

Keywords: Science center, science education workshops, professional development, rings of a trunk

1. Introduction

Schools which are defined as places that offer planned and structured learning opportunities may not be sufficient alone in science education in today's conditions. There is a need for instrumental environments outside of schools where students can experience science at first hand. Out-of-school learning environments have an increasing importance in science education and the number of researches on these environments is increasing. Out-of-school learning, which takes its philosophical foundations from thinkers such as Comenius, Dewey, Froebel, Locke, Pestalozzi, Rousseau, has begun to find a place for itself as the educational practices of the late 19th and 20th centuries (Okur-Berberoğlu & Uygun, 2013). Among the out-of-school learning environments, science centers, which generally offer informal or non-formal learning environments, are the most striking environments, the most convenient environments for learning by having fun and bringing science and society together.

Science centers, as non-profit institutions, have important influence for society, individuals, economy and politics (Garnett, 2002). Science centers, which offer lifelong learning opportunities (Toronto Declaration, 2008), provide an environment for visitors of all ages to learn while having fun (Weitze, 2003). Thousands of small, medium and large science centers play an important role in meeting children, young people, adults, families, teachers or school groups with science and technology. Science centers occupy an extraordinary place in the field of informal learning and also become strategic centers that bring together schools, research centers, universities and scientists (Lipardi, 2013).

Thanks to exhibitions, workshops, scientific shows, planetariums, various and rich activities and opportunities of science centers, visitors can learn about science, understand science and its processes, develop scientific literacy, develop scientific process skills, motivate to learn science, increase their interests and attitudes towards science, and promote a career in science. such as problem solving, creativity, innovation, development of skills such as critical thinking and decision making, development of an inquiring mind, self-efficacy, first-hand experience and the opportunity to explore the natural world (Anderson, Lucas, Ginns & Dierking, 2000; ASTC, 2011a, European Network of Science Centers and Museums [Ecsite], 2008; DeWitt & Storksdieck, 2008; Falk & Needham, 2011; Pilo, Mantero & Marasco, 2011; Şentürk & Özdemir, 2014; Ostlund, 1992; Rillero, 1998; Toronto Declaration, 2008 ; National Research Council [NRC], 1996; 2007; 2009) in many areas of cognitive, affective, and psychomotor skills. It contributes to the development of the bee. In addition, via the rich learning opportunities it offers, it has the potential to appeal and motivate students with different learning styles.

Studies in the related literature try to reveal the benefits of students spending time in science centers and receiving short or long-term education. Surely, schools can provide “more learning per unit of time” (Storksdieck, 2006), but informal learning environments such as science centers provide opportunities for positive emotional and social experiences (Anderson, Kisiel & Storksdieck, 2006). Moreno (2009) pointed out that students learn the difficult subjects that they have difficulty in understanding more efficiently in the science center and that their scientific discussion skills develop in this process. Ostlund (1992) defined science centers as an important and powerful tool that enables the development of scientific process skills.

Compared to formal education institutions, science centers with a more innovative and entrepreneurial structure (Quistgaard & Hojland, 2010), complrise exhibitions where visitors can touch and try away from formalities, enjoy science shows that surprise and excite them, attend workshops aiming to provide rich material sources. It has the potential to contribute to learning with its many elements. Successful exhibition units, which entertain and educate the visitors at the same time and provide internal motivation, attract the attention of the visitors, make them curious and surprise them; competence and self-confidence; it offers something that they need to strive to achieve, to understand; it gives a feeling of controlling something, changing it in the direction they want; it offers games and entertainment and provides a social communication environment with interaction between people (Lederman, 2007). Although exhibits are the most attractive element of science centers, this does not guarantee that visitors always learn something from that exhibition.

Science centers cover workshops that appeal to different age groups and aim at different gains in many different fields and contents, especially science education workshops, robotics and coding, mathematics, wood shaping, painting and artistic workshops. Science center workshops are an important way to provide in-depth science education in the science center. It offers participants the opportunity to explore, experience and learn a science topic in depth. It can be said that science education workshops are the components that serve the mission of science centers to create an understandable, accessible, feasible perception of science and to encourage doing science. Science education workshops are a type of educationally structured activity, especially where instructors spend one-on-one time with students. Workshops are one of the most common types of activities in science centers and have a very important place in the sustainability of science centers (Köseoğlu, Mirici & Pirpiroğlu-Gencer, 2019; PILOTs Project, 2008-2010). Since it is known that science centers are mostly visited by school groups (Falk, Storksdieck & Dierking, 2007; Rennie & McClafferty, 1996), more specialized outcomes can be provided to participants, especially these groups, with well-structured training programs compared to other science center components (ASTC, 1996; Grinell, 2002). However, in the literature, comprehensive information about the contents of the workshops held in the science center, application and evaluation information, the roles and competencies of the trainers and the development process is not available.

It is aimed to increase the number of small and large-scale science centers rapidly in Turkey (BTYK, 2016; TÜBİTAK, 2023). In order for these centers to carry out their duties in science-society communication in a healthy way, it is clear that the need for teachers who have received adequate and appropriate training and who can organize field trips effectively and efficiently will increase. In this context, the BİLMER Project was carried out in order to introduce a professional development model for teachers and trainers to increase the effectiveness of science centers in science-society communication and science education and to examine the effectiveness of their programs. “BİLMER Project: A Teacher and Trainer Professional Development Model for Increasing the Effectiveness of Science Centers in Science-Society Communication and Science Education” with the code 114K646, supported within the scope of TÜBİTAK-SOBAG 1001 program, was carried out. In the project, various scientific researches were carried out for 36 months in order to develop a professional development model that reveals the characteristics and basic components of an effective professional development program in the trainings to be given to secondary and high school science teachers, pre-service teachers and science center trainers (guides) on out-of-school learning. With the BİLMER project, a needs analysis study was conducted for the first time in Turkey in order to scientifically research the profile and needs of the instructors working in science museums and science centers and to offer solutions to the increasing number of science centers and their needs.

In the field investigation and needs analysis studies carried out within the scope of the project, although the most ambitious and organized activities of our science centers in our country are workshops, designing workshops, determining suitability for student level, prioritizing scientific literacy, integrating the nature of science, history of science and scientific process skills with concepts, It has been determined that they need support in applying appropriate teaching strategies, methods and techniques and evaluating workshops (Köseoğlu, 2018). A similar situation is included in the report published within the scope of PILOT Project (2012). Accordingly, it was determined that the trainers regularly held workshops and science shows at a very high rate, but still wanted to receive training on workshop design and application examples.

There are exhibitions that deal with the age determination of trees in various science centers in our country and around the world, such as METU Society and Science Center, Konya Science Center, and Kayseri Science Center. Within the scope of the BİLMER Project, it has been determined that such exhibitions do not attract the attention of the visitors, the participants spare a very short time to examine the exhibition, and in general, they leave the exhibition without asking any questions to the trainers, in line with the interviews and observations in many field studies, including the researchers, and the data obtained from the field notes. . However, these lines on trees have many ecological meanings. From this point of view, a need has arisen to develop a science education workshop that can provide knowledge and experience on many ecosystem-biodiversity-sustainability issues, which trainers can use before or after the exhibition visit, and that teachers can use in the classroom.

There are some factors that reduce the learning potential that science centers can offer, such as visitors do not examine the exhibitions in-depth or their questioning skills are not at a sufficient level (Gutwill & Allen, 2009), visitors in the younger age group do not read the labels or the labels are not suitable for their age level (Hakverdi Can, 2013), the visit time is short, and often the visitors do not prioritize learning (Gilbert & Stocklmayer, 2001; Rennie & Williams, 2006), visitors giving up on examining the devices due to the difficulties they experience while using them (Yaşar, 2014), and visitors' experiences (Falk & Dierking, 2016). At this point, workshops that provide more customized outputs compared to other science center components such as increasing information about exhibitions and shows, serving more depth and exploration time (ASTC, 1996) gain importance. The aspect of education programs in science centers to support or complement exhibition visits is often not considered. Therefore, designing workshops that include detailed examination of exhibitions or different concepts related to the exhibition can be a factor that increases learning. Kanlı and Yavaş (2021) demonstrated the positive effects of workshops modeling exhibitions developed within the scope of the BİLMER Project on students' learning and attitudes.

The main research subject of this study is to develop science education workshop that can be used in schools to increase the effectiveness of science centers in science-society communication shops of science centers and school-science center cooperation and integration in schools, which reflect the basic characteristics and basic components of the trainer and teacher professional development programs. In this context, considering the basic characteristics of the workshops in line with the needs obtained from the field studies, the science education workshop associated with the exhibition is finalized in the light of the data obtained from the applications within the scope of the BİLMER Project, and teaching directories are created to guide those who develop content on this subject.

1.1. Purpose of the Research

Just like in the entire world, science centers in Turkey mostly have exhibitions related to the field of physics, but the exhibitions of biology and chemistry are very limited. Similarly, although there are science workshops in a wide variety of fields, science education workshops in biology are generally very limited. Therefore, activities related to the field of biology to be held in science centers are important. In this research, the lack of workshop examples in the field of biology determined within the scope of the BİLMER Project needs analysis of science center instructors and teachers, who can contribute to the opportunities offered by the science center, to the science education, the professional development need for the workshop, the integration of the school-science center and the workshop teaching directory associated with the science center exhibition. The aim of this research is to examine the opinions of the science center instructors and teachers about the biology field science education workshop called "Language of Rings on Tree Trunks" and to make a brief introduction of the activity. The research questions to be answered within the scope of the research are as follows:

- What are the contributions of the science education workshop “Language of the Rings in a Tree Trunk” to the professional development of science center instructors and teachers?
- What are the possible student achievements of the science education workshop "Language of the Rings in a Tree Trunk"?
- What are the difficulties in the practice of science education workshop, “Language of the Rings in a Tree Trunk”?
- How is the applicibility of the science education workshop “Language of the Rings in the Tree Trunk” in the classroom or science center?

1.2. Aim and Importance

The purpose of this research is to develop an example of a science education workshop associated with the science center exhibition in the field of biology, which can be used in schools, especially in science centers. It is important for the usability of the workshop to present the workshop sample to be developed in line with the needs in the field, to try it in workshops hosted by science centers and within the scope of two separate professional development programs attended by science center trainers and teachers, and to finalize the workshop in line with the opinions received. The teaching approaches of the developed workshop are integrated, far from only concept teaching perspective, questioning skills, nature of science, scientific process skills, etc. that is, the creation of a teaching directory based on the development of scientific literacy understanding will be a guide for researchers who will conduct new research on the needs in this field.

2. Method

In this study, the "case study (case study)" design (Creswell, 2016), one of the qualitative research approaches, was used. According to Fraenkel, Wallen and Hyun (2012), within the scope of the case study; a project, an event, an event, a situation created by one or more individuals can be examined in depth. The subject, whose boundaries are determined with the case study design, is investigated in detail in its own environment (Yin, 2014). The science education workshop associated with the exhibitions in the field of biology, which was desired to be developed in this research, was evaluated as a "situation".

2.1. Study group

In the study, the participants were selected via quota sampling (Baştürk & Taştepe, 2013), a non-random selection method among volunteer teachers and trainers who applied to the workshops held for the purpose of developing the BİLMER professional development program and determining its effectiveness, in line with criteria such as different branches, gender, school and school type, education level, professional experience, availability of a science center in the province.

Information about the workshops and the participants are given in Table 1.

Table 1. *Information about the* workshops *and the participants*

Title of the Wokshop	**Events**	**Participants**
Science Education Workshop of "Language of Rings on Tree Trunks"	1. Science Center- School cooperation Professional Decvelopment Practices Course; Physics-Chemistry- Biology Teachers (Total 36 hours) 2. Kayseri Science Center & Trainers-Science Teachers' Course (Total 24 hours)	1. Phsics (n=14), Chemistry (n=11), Biology (n=11) Teachers (n=36) 2. Science (n=22), Chemistry (n=2), Biology (n=2), Classroom (n=4) Teachers (N=30), Kayseri Science Center Trainers (n=4)

2.2. Data Collection

Within the scope of the professional development practices of the BİLMER Project, a large number and variety of activities have been developed that are aimed at increasing the cooperation of the school science center and to be effective in the science center and classroom practices. Event types vary, such as science workshops, science shows and desktop versions. Evaluations of the activities varied according to the variety of data collection tools, the number of repetitions, the duration and subject of the teaching practices, and the place where the application was made (science centre, school, course, etc.). Each activity developed within the scope of the project has been evaluated in its own context. It was given importance to collect data with event-specific evaluation tools. Data collection was carried out in workshops where workshops were implemented.

All of this workshop activity, which was held as part of the implementation workshops, was video-recorded, voice recorders were placed on the desks of all groups, and field notes were taken in all processes. Opinions about the event were collected with two separate data collection tools. Participants first stopped the "Preliminary Information Form" before the workshop and the "Workshop Evaluation Form" right after the workshop.

Before the workshop, the participants were given a Preliminary Information Form including the founders showing whether they are trainers or teachers, including their branch. The questions in the Preliminary Information Form are as follows:

1. Can you explain with examples what you know about age determination methods in different living things?
2. What information do you think can be obtained from tree rings and how?
3. Do you know of any achievements in the curriculum about age determination in trees? If so, can you explain?
4. Do you talk about age determination in trees in your course? Do you do any activities related to age determination in trees in your lesson? Please explain.

The questions in the "Workshop Evaluation Form", in which the opinions of the participants were taken after the workshop, are as follows:

1. Is the workshop suitable pedagogically (age, level, compatibility with achievements, etc.) to be applied in science centers/classrooms? Explain?
2. Were there things you didn't know before but learned in this workshop? What are they?
3. What are the strengths of the workshop that you find strong? Please explain.
4. What are the weak points of the workshop? Please explain
5. What do you think could be the student achievements in the workshop?
6. Are the student worksheets used in the workshop sufficient? If not, what are your suggestions?
7. Do you think this workshop includes all the steps of the scientific research method? In what ways do you think this will contribute to your students?
8. Would you consider using this workshop in your lesson/science centre? Can you explain why?
9. Apart from these, if there are things you would like to add about the workshop (suggestion, criticism, improvement, etc.) can you write?

2.3. Data Analysis

The analysis and reporting of the data collected within the scope of qualitative research is a difficult process even if the researcher is experienced, and it is one of the most difficult stages (Yıldırım & Şimşek, 2011). Because, although the analysis of qualitative data generally seems to be given by quoting the data obtained from the collected data, this process was quite complex and requires systematic work (Ekiz, 2009). Content analysis was used in the analysis of the data obtained regarding the practices within the scope of both workshops.

In content analysis, (i) organizing and preparing data for analysis, (ii) reading all the data and considering the meaning under the information, (iii) clustering similar topics by making a list of all topics, (iv) shortening the topics as codes, (v) reviewing all the data. Checking whether a new code has emerged by passing it along, (vi) creating descriptions of categories or themes for analysis, (vii) advancing how the description and themes will be represented, (viii) interpreting the data were followed (Creswell, 2014).

In the analyzes, science center trainers “E” (n=4), science teachers “FB” (n=22), physics teachers “F” (n=14), chemistry teachers “K” (n=13), biology teachers “B” (n=13) and classroom teachers were coded as “S” (n=4).

2.4. Validity and Reliability Study for Qualitative Data

In order to ensure the reliability of the significance and codes to be obtained from the data, the codes were coded by two independent researchers and the codes were compared. Krippendorff Alpha statistics were used to determine the agreement between the coders (Krippendoff, 1995). The Krippendorff Alpha reliability coefficient was calculated over 0.80 and it was determined that there was a high level of agreement between the coders (Bıkmaz-Bilgen & Doğan, 2017).

2.5. Ethical Consent of the Research

This research was carried out within the scope of the project coded 114K646 “BİLMER Project: A Teacher and Trainer Professional Development Model for Increasing the Efficiency of Science Centers in Science-Society Communication and Science Education" supported within the scope of TÜBİTAK-SOBAG 1001 program and all permissions were obtained.

2.6. Application Process of Science Education Workshop

The development of the workshop was based on the themes of science society communication and its importance, nature of science and science teaching and teaching and practices in science centers in the education modules of the BİLMER professional development program.

The aim of developing the workshop is to develop an example of a science education workshop associated with this exhibition, based on the "climate log" exhibition, which is located in various science centers in our country and around the world, such as METU Society and Science Center, Konya Science Center, and Kayseri Science Center, which deals with the issues of age determination of trees.

Picture 1. Konya Science Center Exhibition Setup

The aim of the workshop is to determine the history of forest fires in relation to the past, to determine the rate of erosion that occurred in the past, to determine the rate of erosion in the past, to climatic changes in the past, volcanic events. This is how avalanche events can be interpreted in ecological information such as the dating of earthquakes, dating archaeological remains, the places where the tree branches, the tree's access to light or food. In the workshop, the participants have the experience of observing, obtaining data, interpreting the data and drawing conclusions, as in the scientific research process, by using a scientific method like scientists working on dendrochnology, which is the method of dating with tree rings. It will also be possible for them to create a creative scenario in which they can use the information they learned in the workshop and to draw within the scope of the scenario given to them. At the last stage, they are asked to prepare a research report that includes all they have learned.

The workshop was based on the inquiry-research teaching approach. Although there are differences in the models developed for teaching with an inquiry-research approach, it is basically based on Piaget's learning theories developed by Myron Atkin and Robert Karplus and based on the first learning cycle (1962), (1) exploration, (2) concept development, and (3) A 3-stage learning (3E) model, which includes the concept learning cycle, was used. The event takes a total of 60 minutes. Briefly, if the processing of the content is to be conveyed, firstly, if the workshop is handled in the science center, the relevant exhibition is visited in order to draw the attention of the participants to the subject, otherwise various examples are examined in the workshop environment.

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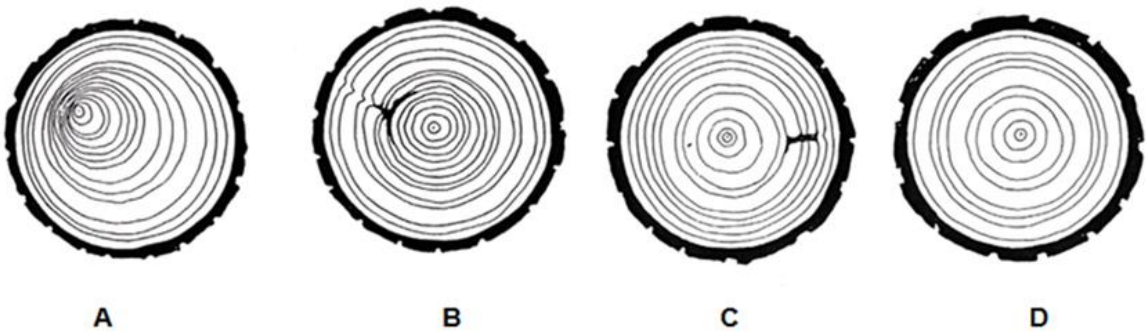
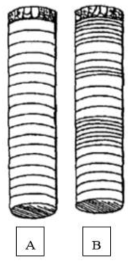
Picture 2. Examining the Exhibition of "Climate Log" in the Kayseri Science Center

For example, a discussion environment is created by asking questions such as how to determine the age of humans, why they are needed, and how to know the age of other living things. Then they are asked how the age of trees is calculated. The visuals on the science center exhibitions or the information sheets developed within the scope of this workshop, and the samples taken with the increment auger to be used in the workshop before, or the age ring samples on the tree trunk in pre-cut form are examined. The reasons why the rings are in the middle or on the edge, the reasons for black marks and clefts, the reasons for the differences in the distance between the rings, the thin and thick rings, the slits, the scars, the crustal region, phloem, xylem, cambium, on the examples and the information sheet of which Picture 3 is a part. and core regions and branches are introduced through visuals. They are asked and discussed whether the shapes they see here (such as clefts, thick and thin rings, scars) have any meaning. The meanings of the rings and the differences and why it is important to know them are evaluated..



Picture 3. Images of Rings in a Tree Trunk

It is explained that the method of dating with tree rings is called Dendrochnology. It is shared that the traces seen in the rings of the trees provide information about natural events such as forest fires, erosion, climate changes, volcanic events, earthquakes in the past. Afterwards, the "How Do We Find Out the Age of Living Trees?" was prepared for the students. Work on the worksheet titled "(1)". Here, the participants form research questions and hypotheses based on the meanings they deduced from the images. For example, “A” is for the image “It is a fast-growing ------------ years old tree.” and for image “B” “A tree that grows fast in the first 6 years, slow-growing in the next 7 years, -------- growing in the next 4 years is a ----------year-old tree.” The fast and slow growth conditions of trees such as trees and their age are evaluated.



Picture 4. A Short Part in a Worksheet

For scenarioization, “Can you write the life story of this tree (second image) based on the information you have collected (such as its age, difficulties, and climatic conditions)? While writing this story, were there any other things you wondered about the life of the tree? Can you write the questions you are curious about? Question 1-------------. What do you think could be the answer to your questions? Hypothesis 1-----------.” Answers are sought and hypotheses are formed.

Participants, who learn about age determination from tree rings and the meanings of the rings, now go to the application stage. The sample is taken with a tool called an increment auger. Evaluation and comments are made on the sample taken.

Picture 5. Age Determination with Increment Auger and Examples (Bilmer Inservice Education Course)

After taking the samples with the increment auger and making the necessary examinations, it is returned to the workshop environment. “How Do We Find Out the Age of Living Trees? (2)” is filled in the worksheet. Information is given on the growth relationship between the diameter and age of the tree trunk. They are asked to calculate the age of the trees they see around them, based on the knowledge that, in general, most trees grow an average of 2.5 cm each year, except for very slow or very fast-growing trees. When calculating the age of the tree in tropical climates, it is reported that the age is calculated by measuring 1.5 m from the ground. Based on this information, the people participating in the workshop are asked to calculate the age of the trees they see around them, just like a dendrologist. They are asked to conduct a research in accordance with the format given to them and to prepare a brief report. After the activity, it is requested to re-examine the exhibition setups in the science center.

3. Findings and Discussions

In this section, the data obtained through the "Preliminary Information Evaluation Form" and the "Workshop Evaluation Form" were analyzed in line with the stages of coding the data, finding the themes, organizing the codes and themes, defining and interpreting the findings. Analysis results are presented depending on the order of the sub-problems.

3.1. Findings Regarding the First Sub-Problem

The first sub-problem addressed in the research is "What are the contributions of the "Language of the Rings in the Tree Trunk" science education workshop to the professional development of science center instructors and teachers? is in the form. 66 teachers from five different branches participating in the workshop filled the Preliminary Information Form. Instructors were excluded from the evaluation because there was an exhibition mechanism related to age determination in trees in the science center they are affiliated with and preliminary interviews were made while designing the workshop within the scope of the research. The reason for the preliminary knowledge determination study is to determine whether the knowledge of the participants changes after the workshop application. The analysis table prepared according to the data obtained from the Preliminary Information Evaluation Forum is given below. Sample expressions representing the codes are also presented in Table 2.

Table 2. *Data Aanalysis of Preliminary Information Form*

Theme	Categories	Participants and Frequency of Responses	Sample Statements
Age Determination Method in Different Living Beings	**Ring numbers in trees**	FB: 7, F: 2, K: 1, B: 5, S: 1 (N=16)	*"Counting light and dark rings in trees." (FB 1)* *"Via tree rings." (B 2)* *"Counting summer rings in trees."(FB 2)* *"Via C-14 in trees." (K 1)*
	Tooth Development in Horses	FB: 1, F: -, K: -, B: 1, S: - (N=2)	*"Examining the development of teeth in horses is different in periods." (FB 1)* *"Via teeth of a horses." (B 1)*
	Antler Structure of Deers	FB: 1, F: - , K: - B: 2, S: - (N=3)	*"Via antler of deers." (FB 4)*
	Rings on the Turtle's Shell	FB: 1, F: -, K: - B: -, S: 1 (N=2)	*"Via number of hexagons on a turtle shell." (FB 1)* *"Via turtle shell." (S 2)*
	Number of Teeth in Living Beings	FB: 5, F: 2, K:2, B: 4, S: 1(N=14)	*"Counting teeth of living beings." (FB 4)* *"Number of teeth in cattle." (K 3)*
	Carbon-14 Method	FB: 1, F: 2, K: 5 B: 4, S: - (N=12)	*"All are done via C-14 method." (K 4)* *"Age determinations can be made using the carbon isotope." (K 3)* *"Via Carbon-14" (B 3)*

When the Pre-knowledge Form applied before the workshop was evaluated, it was seen that participants had partial knowledge on the subject of age determination of living things in terms of science and biology teachers, while other subject teachers did not have sufficient knowledge. Similarly, it was observed that teachers other than three science teachers and two biology teachers were not knowledgeable about what information could be obtained from tree age rings. Participants stated that this subject was not included in the curriculum and that they did not perform any activities related to the workshop topic. Overall, it was revealed that the participants had very limited knowledge and experience on this subject.

Immediately after the workshop, all participants filled out the Workshop Evaluation Form. Based on the data obtained from the Workshop Evaluation Form, the theme of "Professional Development Effects: Gains" was determined. Three categories were created within the scope of the relevant theme. The categories, sub-categories, and frequencies of the answers given by the participants are summarized in Table 3.

Table 3. Frequencies of the Categories, Sub-categories, and Answers related to the "Language of Rings on Tree Trunks" Science Education Workshop's "Professional Development Effects: Gains" Theme

Theme	Kategori	Alt Kategori	Katılımcıların Branşları ve Cevapların Frekansları
Effects on Professionsl Developmen: Attainments	**Conceptual and Pedagogical knowledge/ Skills/ Experience**	➢ Contribution to Scientific Process Skills	FB: 14, F: 7, K: 5, B: 9, S: 2 E: 2 (N=39)
		➢ Conducting a Scientific Research	FB: 10, F: 5, K: 5, B: 7, S: 1 E: 1 (N=29)
		➢ Age Determination Method in Trees	FB: 17, F: 8, K: 6, B: 4, S: 2, E:2 (N=38)
		➢ Ecological Information on Tree Age Rings	FB: 19, F: 10, K: 8, B: 5, S: 4, E:2 (N=48)
		➢ Age Determination Methods in Living Things	FB: 13, F: 7, K: 7,B: 6, S: 4, E: 2 (N=39)
		➢ Using Increment Auger	FB: 15, F: 10, K: 10,B: 9, S: 4, E: 4 (N=52)
		➢ Ecology-Biodiversity-Sustainability Relationship	FB: 9, F: 5, K: 4, B: 6, S: 2, E: (N=30)
		➢ Involving the Connection of Science to Everyday Life in Teaching	FB: 7, F: 3, K: 4, B: 6, S: 1, E: 1 (N=22)
		➢ Importance of Scripting	FB: 7, F: 4, K: 5, B: 4, S: 3, E: (N=23)
	Sensory Reflections Towards Teaching	➢ Developing Self-confidence towards Teaching	FB: 9, F: 1, K: 3, B: 8, S: 2, E: 2 (N=25)
		➢ Developing Motivation/Willingness towards Teaching	FB: 14, F: 2, K: 4, B: 9, S: 4, E: 4 (N=37)
	Workshops associated with exhibitions	➢ Impact on Permanent Learning	FB: 19, F: 9, K: 10, B: 10, S: 3 E: 3 (N=54)

When examining the contributions of the participants of the study to their professional development, three separate categories emerged. In the first category, it was determined that science center educators and teachers acquired "conceptual and pedagogical knowledge, skills, and experiences" for their professional development. 56% of the participants stated that they gained scientific process skills. Some of the expressions that exemplify these gains are as follows: FB 20: *Observing, making inferences from observations, and turning them into results are actually very important. This activity really contributes to interpreting what you observed. It was very enjoyable for all of us to try to deduce results from both real examples and examples on worksheets.* B6: *Conducting a scientific research, the examples on worksheets, and examining the exhibition were all great experiences. I really liked it. We discussed the hypothesis, observation, inference, and possible results, and the discussion environment was very productive.* E2: *I always asked at the beginning of the exhibition what it means to you. Then I would explain. Maybe I can use more scientific process terms. For example, what can I say about the hypothesis, what did you observe, what did you deduce? I can question a little more.*

Regarding scientific research, 41% of the participants stated that they gained various gains. Some of the example statements are as follows: FB 13: "It provided a small research experience. We tried to deduce meaning from our observations. First, we took a sample, examined it, and wrote a report. Then we just measured and reported the tree trunks. It was a nice and informative activity." K 13: "It was a demonstration-type research process. I think the information and research process created a good awareness in everyone."

One of the main knowledge gains for the participants is conceptual knowledge related to the topic. For example, 69% of the participants reported that they gained various insights into ecological information carried by the age rings of trees. Some sample statements are as follows: F9: "So, this interesting crack means that the tree couldn't get nutrients near the ring and it sprouted a branch from here, and this mark was made by the wind, etc. We learned some great information about nature." K9: "We learned new things about how information about past events such as earthquakes, floods, and famines was obtained." B8: "It was great to learn that we can see the traces of an ecological history that goes back thousands of years. Even trees that are only 40 years old today are bigger than me and we learned what they have seen."

One of the knowledges and skill gains for the participants is the use of an increment borer. Regarding the use of the increment borer as both knowledge and skill, 54% of the participants reported that they gained insight. For example: F8: *I learned and tried the use of an increment borer for the first time. I learned that we can also determine the age of trees simply by measuring them.* E1*: It was a topic we always talked about, but it still gave us a sense of awareness and practical knowledge and skills.* B6: *It was a very useful activity. We learned a lot and I am even thinking about implementing it in my class. I will even bring my students to the science center.*

The workshop has declared that 43% of the participants achieved the basic attainment goals of the workshop, which included ecology-ecosystem-biodiversity, sustainability, and their interaction with each other. Sample statements are as follows: FB 21: The example of the oldest pine tree was very striking. For instance, I am thinking of giving the example of the richest olive tree in our country in the class. Rainfall, drought, pests, buildings, and roads are actually constructed without considering the environment and ecological balance in education, and we can see their traces. It is a very simple but profound activity. F 12: The things in the examples were very impressive, for instance, three years of normal growth, then there was a drought, and I don't know a fire later. So the effect on growth was very striking. It is the same for every living thing. Biodiversity is actually very important. It makes you question yourself. B 7: I think the topic was productive. The concepts discussed, such as the importance of ecological relationships, ecological relationships on living things and sustainability, species diversity, were very useful.

The workshop topic is a subject that is directly related to nature. 31% of the participants liked this situation very much, and especially emphasized that including the connection between science and everyday life in the teaching process contributed to their own teaching. Sample statements are as follows: S 2: We actually see science and what science says simply. We can raise awareness of the place and importance of science in daily life for children with these types of easy but separately considered activities. E 1: All our exhibitions are already for making everyone love and understand science. I understood this better today with this example. Actually, when you look at the subject from the perspective of the science hat, it becomes deeper, more meaningful, and more useful. The good aspect is the selection of an example situation from within life.

One of the activities within the workshop is presenting the content with a scenario. Participants were presented with tree age ring examples, and they were asked to create a story about the ecological effects on the life of the tree based on this example. Then, they were expected to determine research questions and hypotheses in this story. 33% of the participants stated that they acquired new gains regarding the effects of scenario-based teaching. Sample statements: K1: *It was very nice to make up stories about what they saw in the trees. It requires using their creativity and knowledge. It was a good example.* S2: *I am a primary school teacher, and this is a good example for teaching with these types of scenarios for elementary school students. It can be applied to students by adding a coloring activity to the tree scenario*. FB 9: *Instead of theoretical knowledge, putting yourself in the role of a researcher, even with a worksheet or simply measuring from any visual or tree outside, putting it in the role of a researcher is very effective. It draws you into the situation. It is really an important point in teaching.*

It has been determined that science center educators and teachers who participated in the workshop gained confidence in teaching (36%) and motivation and willingness to teach (53%). Sample statements are as follows: E2: *Our participation was very good. I think I can apply it to different age groups by reviewing it a bit. I have no concern about being able to practice when I gain experience.* B13: *I think the worksheets and applications are very informative and everything is understandable. It gave me the confidence to easily apply it.* FB21: *I think everyone had fun, learned, and discussed, so it was enjoyable. These observations motivate me to have my students know what I know even if it's not in the curriculum.* S1: *I am eager to apply what I learned in the classroom. E 4: We also talked with friends. We want to practice as a workshop.*

One of the needs identified under the BILMER project and desired to be developed is the development of workshop activities associated with exhibitions aimed at increasing the effectiveness of the exhibitions. In this research, an example of a workshop associated with the climate log exhibit was developed. 77% of the participants stated that attending such workshops had an impact on their permanent learning and that such workshops would provide permanent learning. For example: F8: *I don't think the exhibition alone is attention-grabbing. On the first day, I also walked past it and thought I knew something about it. But when I went to the workshop, I understood how important the information it contained actually was. I think exhibitions can be supported with such workshops. Physics topics are very suitable, for example, it should definitely be included.* E2: *I think the connection between the exhibition and the workshop was really well thought out. It can be applied, attention-grabbing, and permanent. And if they take those sticks with them when they leave, they will never forget.* B 6: *Yes, you look and examine the exhibition, but learning and experiencing in-depth by entering the workshop is much more effective and permanent. It contributed to our learning by doing and experiencing, just like children.*

3.2. Findings the Second Sub-Problem The second sub-problem of the research is what possible student gains can be achieved through science education workshops. The information obtained by analyzing the responses of 66 teachers from different branches and 4 science center educators who participated in the research is presented in Table 4, which includes the themes, categories, and sub-categories obtained and the frequencies of participant responses.

Table 4. “Language of Rings on the Tree Trunk” Possible Student Gains of Science Education Workshop Theme Categories, Sub-Categories, and Frequencies of Participant Responses from Different Branches.

Theme	Category	Sub-Category	Participant Branches and Frequency of Responses
Possible Student Learning Outcomes in the Workshop	**Knowledge/Skill /Experience**	➢ Conceptual Learning	FB: 19, F: 11, K: 10, B: 12, S: 3, E: 3, (N=59)
		➢ Permanent Learning	FB: 18, F: 11, K: 10, B: 11, S: 3, E: 4, (N=57)
		➢ Ecology-Ecosystem-Biodiversity-Sustainability Relationship	FB: 16, F: 6, K: 4, B: 9, S: 2, E: 2 (N=39)
		➢ The Place of Science in Daily Life	FB: 19, F: 11, K: 8, B: 12, S: 3, E: 4 (N=57)
		➢ Scientific Process Skills	FB: 18, F: 6, K: 5, B: 8, S: 2, E: 3 (N=42)
		➢ Ability to Conduct Scientific Research	FB: 13, F: 8, K: 7, B: 9, S: 3, E: 3 (N=43)
		➢ Ability to Conduct Scientific Research	FB: 14, F: 5, K: 4, B: 7, S: 2, E: 2 (N=34)
		➢ Inquiry Skills	
		➢ Recognizing the Diversity of Scientific Methods	FB: 16, F: 9, K: 7, B: 10, S: 3, E: 3 (N=48)
		➢ Using the Increment Borer	FB: 20, F: 11, K: 10, B: 12, S: 3, E: 3 (N=59)

Emotional Reflections	➢	Interest/Attitude towards Nature and Environment	FB: 21, F: 12, K: 12, B: 13, S: 3 E: 4 (N=65)
	➢	Interest towards Science/Research	FB: 13, F: 8, K: 7, B: 8, S: 1, E: [illegible] (N=40)

When the opinions of science center trainers and teachers who participated in workshop applications were examined in terms of the possible gains of students, two separate categories emerged. The first category is the possible knowledge, skills, and experiences that students will gain. 84% of the participants believe that students can acquire various conceptual gains from the workshop. Sample expressions are as follows: FB6*: They learn about monument trees. They learn about how important the ecosystem is, the value of each living creature, how important the sustainability of natural resources is, and many other topics.* B3: *They gain knowledge about many subjects and concepts such as the effect of environmental conditions on the development of living creatures, ecology, biodiversity, sustainability, monument trees. They learn about dendrochronology.* B11: *They acquire knowledge and skills on many topics and concepts related to each other, such as the marks in the tree rings, the situation of wounds and pests, climate conditions such as drought, wind, sun, or storm, land conditions such as branching status, erosion, and slope, the effect of urbanization on them, and their impact on vitality and sustainability.*

According to the participants, students who attend this workshop associated with exhibits can achieve permanent learning (%81) if they attend these workshops. Sample statements: FB 20: *It was very successful. The learning cycle was designed very well. Such an activity involving scientific processes and conceptual knowledge will definitely be effective in remembering and achieving permanent learning.* S1: *Research-inquiry activity. If it is simplified a bit for children, I think it is a very permanent learning environment*.

According to 54% of the participants, along with conceptual gains, students can gain knowledge, skills, and experience related to ecology-biodiversity-sustainability relationship. Sample statements: B11: *Plants, animals, humans, microorganisms all have living diversity, they all have inseparable relationships with each other and their own cycles. They can gain new knowledge about ecological relationships.* K10: *All natural events have an effect on life. The effect of natural events on living things. So, they develop awareness about learning and relationships on many subjects such as ecology, age determination in living things, and the importance of diversity.*

According to the participants, selecting the workshop topic related to everyday life will enable students to gain knowledge (%56) about the place and importance of science in everyday life. Some sample statements are as follows: F3: *The subject is already from within life with everything. Knowing what has been experienced, why it is important, the relationship between where science stands and accessing, interpreting, drawing conclusions, and taking preventive measures from scientific information is very effective for students to see science in their lives.* B12: *An example from daily life. Trees and environmental problems can be related. With scientific methods, it can be learned how to access this information. They will realize that science is in everyday life.*

According to the participants, another benefit for students is gaining scientific process skills (56%). Here are some example statements: F3: *It's actually all about scientific processes. What is data? It's the mark on the ring. So it's not always about math or measuring. The research* *question is not always about conducting experiments. The importance of observation is crucial. It has many aspects, and I really liked it. I think it provides a different research and scientific process experience.* E4: *Actually, when we explain during the exhibition, we can emphasize the observation, data, and conclusion relationships. I think if we include these in the visitor workshop or exhibition, we can better understand scientific processes.* S1: *For children, simple visuals such as "What did you see - observation", "What did you understand - conclusion", "What do you wonder - research question", "What do you think the answer is - hypothesis relationship" can be used. Even if we don't use these concepts, the questions asked and their answers are essential for developing these skills.*

Another possible benefit for students is the potential to gain research skills (49%). Here are some participant opinions on this topic: FB6: *You are conducting research with very simple materials and a simple plot. They experience all the steps to some extent. The biggest gain for students might be this.* B10: *They realize that scientific research is not only done in laboratories. Experiencing a small research process positively affects children and provides them with experience.* E2: *It's actually a mini research experience for visitors. I think it will be successful and a good experience for the participants.*

The following are some statements from participants (%69) who believe that the workshop will have an impact on students' awareness of the diversity of scientific methods: K7: *The carbon test is a method of determining the age of a tree by measuring around it. In fact, there are different ways to obtain scientific knowledge. Learning and realizing them would be very useful.* B7: *There are many methods to learn the age of the same tree. The same is true for other living things. Science is not always about the microscope. There is also nature observation, chemical use, and laboratory work for science. So they can obtain different perspectives*. E2*: Finding the age of the same tree with several different methods is a different experience. Science works like this, actually. I think it is an important awareness.*

Another important gain that students will acquire, according to participants, is questioning skills (%49). Some example statements are as follows: F 14: They will try to question and reach what they know and don't know while seeing a lot of tracks and ring widths. They will experience critical and analytical thinking processes. Thus, their questioning skills will develop. B 4: They will learn why it is important to know the ages of living things and how to do it. They will interpret what they see in the rings of the tree and question it to reach a conclusion. In the end, they will have learned thinking skills.

The use of the increment borer, an important practice in the workshop, was evaluated by participants as a student gain (%84). An example statement is: FB6: *Just holding the increment borer is a beautiful thing in itself, a new knowledge, skill, gain.*

Along with the knowledge, skills, and experiences that students can acquire, various "affective gains" are also possible. According to participants, students who attend the workshop can gain interest, attitude, and sensitivity (%93) towards nature. Some example statements they made are as follows: S4: *I think the scenario was successful. It creates a sense of sadness in humans as well. What has happened, how have they come to this age, that is, it appeals to human emotions. It encourages interest in and good treatment of nature, even behavioral change.* E3: *A story from nature, very realistic and informative. I think it raises awareness and interest in the environment.* F5: *Their interest in nature will definitely increase.*

According to the participants, another emotional gain that students can acquire is their interest in science and research (57%). For example, in the case of student F9, when they are assigned the role of a researcher, they take ownership of the process. If you tell the child to conduct research, take measurements, write a report, and share the findings, they will do so diligently. They may not show interest if you share the research results with them, but if you ask them to do it themselves and provide assistance, they can benefit greatly. They want to be involved in scientific research. Student K3 thinks that most children believe that science is difficult, impossible, or boring. Being involved in a simple research project can show that science can be feasible, not necessarily easy, but enjoyable. It can change their tendencies and perspectives. Student E1 thinks that the overall goal of science center activities is to develop positive feelings towards science. This activity is very appropriate for that purpose.

3.3. Findings Regarding the Third Sub-Problem

The third sub-problem of the study is to identify the difficulties and challenges in implementing the science education workshop. Based on the analysis of the data obtained from the responses of the participants, the issues that they found most concerning, difficult, time-consuming, or challenging can be evaluated as the weaknesses of the workshop. The information containing the themes, categories, and subcategories obtained from the analysis of the responses of 66 teachers from different branches and 4 science center educators who participated in the study, as well as the frequencies of participant responses, are presented in Table 5.

Table 5. *"Language of Rings on Tree Trunks: Weaknesses of the Science Education Workshop: Difficulties Theme, Categories, Subcategories, and Frequencies of Responses*

Theme	Category	Sub-Category	Participant Branches and Frequency of Responses
Weaknesses of the Workshop: Difficulties	**Knowledge/Skill Requirement**	➢ Not being included in the curriculum for in-class use	FB: 10, F: 1, K: 3, B: 4, S: 1, E: - (N=19)
		➢ The necessity of theoretical knowledge for the instructor/teacher	FB: 5, F: 2, K: 2, B: 3, S: -, E: 1, (N=11)
		➢ Mastery of scientific process skills by the instructor/teacher	FB: 9, F: 2, K: 3, B: 4, S: -, E: 1 (N=19)
	Material/Equipment Requirement	➢ The need for an Auger bit	FB: 14, F: 3, K: 6, B: 8, S: -, E: 2 (N=34)
		➢ Samples of baked wood logs	FB: 6, F: 2, K: 3, B: 4, S: -, E: 2 (N=17)

Two separate categories have emerged regarding the weak points and implementation difficulties of the workshop applications for science center educators and teachers who participated in the workshop. The first category is the knowledge and skill requirements of the teachers who will perform the application. 27% of the participants evaluated the fact that the workshop is not directly related to the curriculum as the weak point of the workshop. For example, FB 21: Not directly included in the curriculum. It can be applied in 4th and 5th grades. It will be difficult for young ages. It can be in the unit of Living Things and World. Plant growth, age, the effect of seasons, and how they are affected by climate conditions can be mentioned. K 11: I think the topic was conveyed very successfully. When we were discussing in the group, everyone said they wished it was a topic in the curriculum, but the child can learn so much, not only in one topic but in many topics. Of course, it is desired to be in the curriculum for everyone. S 1: Yes, there is no direct gain related to the curriculum, but it can still be implemented. Of course, it would be better if it were a unit topic.

According to the participants, both science center educators and teachers need to have a grasp of theoretical knowledge and scientific process skills in order to be able to implement the workshop. Some of the participants (%16) believe that teachers need to have theoretical knowledge, and their views are as follows: *FB5: I think the presenters were very knowledgeable. They provided many different and new pieces of information during the discussions. The process was very engaging. It made me think whether it would have been so effective if the presenter was ordinary.* B2: *The activity looks easy when you look at it, but I don't think it's that easy to correctly identify the example taken from nature and interpret the tracks.* E4: *I think I cannot do detailed Q&A like our presenting teachers do since this is not my field. Although our target audience is students and they probably won't ask that many questions anyway. Still, it is necessary to have a good understanding of the subject first and foremost.*

According to the participants, another difficulty in implementing the workshop is the mastery of scientific process skills both by science center educators and teachers (%27). This issue has been generally emphasized due to the workshop's structure, which includes scientific process skills. Some sample statements are as follows: FB4: *It is important to be knowledgeable not only about the subject but also about scientific process skills and research reporting processes. The person who will manage all the processes from the child's ability to write research questions, hypotheses, and results must know these skills themselves first.* F13: *The worksheets are well-prepared, but knowing the scientific process is still necessary for proper guidance and instruction.* E4: *We do not carry out activities that are primarily based on research processes. Although the workshop we conducted requires simple knowledge and experience, we still need to be knowledgeable about scientific process skills.*

One of the general weaknesses or implementation difficulties of the workshop is the necessary materials and equipment, according to the participants. They think that the most important challenge to overcome for the workshop to be effective is to provide a drill bit (%49). They believe that the workshop would not be effective enough without a drill bit. Some sample statements are as follows: E2: *The most striking part is taking a sample from a tree. It was very impressive. But if we are going to do it, we need to get a drill bit.* FB14: *The best and most prominent aspect of this activity was taking a sample from a tree. I also want to do it in the classroom, but I think the drill bit is expensive.* F6: *Like all applications and experiments, material needs and limitations are always a problem for teachers. Here, a drill bit is also necessary, but the school doesn't buy it, and even if they do, where will they use it?*

Another need for the implementation of the workshop is the dried tree trunk samples presented as examples in the workshop (%24). Some sample statements: FB17: *I think the variety of materials in the workshop content was very successful. We need to obtain drill bits and trunk samples.* B8: *Find dried trunk samples.* E2: *We also need to get tree trunk samples.*

3.4. Findings Regarding the Fourth Sub-Problem

The fourth sub-problem of the research is about the applicability of the "Language of Rings in the Trunk of a Tree" science education workshop in the classroom or science center. 18 science, 10 chemistry, 10 biology, and 4 class teachers stated that the workshop is applicable for classroom use. All class teachers expressed that the content needs to be simplified conceptually. Regarding this sub-problem, 14 physics teachers did not respond to the question about classroom use, and 11 did not respond due to their field not being related to the subject. Similarly, 4 science center instructors were excluded from the study. Sample expressions from other participants include: FB11: *I will use it. It is an interesting, important, and easily relatable activity for students to learn scientific process skills using easily accessible materials.* FB12: *It is not included in the curriculum, but it can definitely be done within the scope of Science Applications course. In addition, it can be covered in 6th-grade natural monuments, or an application can be made.* K7: *Why not? The content is easy, materials are easy, and the worksheets are very clear. Although it is not my field, there is no obstacle that requires resources or environment when considering the school environment. I will share it with my colleagues, and I have already received the documents and presentation.* S1: *We actually talked with our friends, and we thought it could be done. Of course, we need to simplify it at our level, but there is no need to change the plot. A coloring activity can be added, and it can be scripted. So we, as class teachers, think that it is applicable.*

On the other hand, 4 science, 3 chemistry, and 3 biology teachers think that the activity is not suitable for classroom use. The reasons for this are that the activity is not directly related to the curriculum (n=5), obtaining an increment borer is difficult (n=6), the content will not be effective without an increment borer (n=2), and it is not interesting (n=3). Some example statements are: F14: *If it is done in a science center, I would like all children to participate, including my own children. It would be great if they see the exhibitions and participate in the workshop at the science center. Revision in content can be made according to the visitor profile, and this is under our control after all. I think the gains are very valuable. So, I think it is applicable*. E2: *We really liked the idea of a workshop supported by a science center exhibition. It was something we wanted to do but couldn't. The content can be revised according to the visitor profile, and this is under our control. I think the gains are very valuable, so I think it is applicable.* S4: *If there is a possibility to bring the children to a science center, the science center is more suitable; otherwise, materials are more difficult in the classroom. But it can also be done in the classroom. We can show a real tree section and get dried materials. In addition to this, we can bring a log to the class.*

In summary, most class teachers and some science, biology, and chemistry teachers believe that the "Language of Rings on Tree Trunks" workshop is applicable to the classroom environment, and it is an effective and easily accessible activity that enables students to learn scientific process skills. However, some teachers think that obtaining an increment borer is difficult, and the content is not directly related to the curriculum. They suggest that the workshop can be held at a science center where the content can be revised according to the visitor profile.

4. Discussion, Conclusions, and Recommendations

Workshops are environments in science centers where the most specialized gains, regardless of their type, can be directly presented to visitors. Workshops, where science center educators spend one-on-one time with students and are the most commonly conducted activities by science centers, have the potential to contribute to visitors' science literacy and learning through entertainment, as well as to affect the sustainability of science centers (Kabapınar & Adadan, 2019; Köseoğlu, Mirici & Pirpiroğlu-Gencer, 2019).

Considering the increasing number of science centers in Turkey and their increasing needs, a study was conducted within the scope of the BİLMER Project to determine these needs. According to the research, science center educators have a professional development need in workshop preparation and implementation, especially in the limited examples of biology-related workshops and the need for exemplary applications. Additionally, the importance of linking workshops to exhibitions has been revealed. In this context, designing workshops to increase the effectiveness of an exhibit that attracts less visitor attention is planned. The identification of the characteristic features that workshops should have (scientific content knowledge, research-based learning approaches, teaching activities that pedagogically model the exhibits in science centers, understanding the nature of science, assessment, worksheets, etc.) and developing content suitable for this, gaining competence in conceptual knowledge, pedagogical knowledge, contextual knowledge, pedagogical content knowledge, research-based science teaching, understanding of scientific knowledge and the nature of science in science center educators and teachers by testing workshops experimentally and based on evaluations and reflections, and developing theoretical understanding and education designs accordingly, is the target.

To provide an opportunity to increase practical skills and to create examples of teaching sequences specific to workshops, a science education workshop example was developed in this study by selecting a topic from nature and developing a research-based content for ecological traces carried by tree age rings. The practices of the science education workshop were carried out in two separate professional development program workshops, and the opinions of 70 participants were obtained.

According to the results obtained from the analysis of data obtained through the applications, participants have gained a wide variety of knowledge, skills, experience, and emotional gains. It was determined that the teachers and science center educators who participated in the workshop gained conceptual, pedagogical, and emotional knowledge, skills, and experience for their professional development. Participants expressed that there are conceptual gains that the workshop can offer both themselves and potentially to students. As a remarkable result, participants believe that students will gain similar gains to what they gain from the workshop. The workshop provides information on how age determination can be made in trees and different organisms, information related to various ecological situations such as erosion, drought, storms, climate change, earthquake, and healing from tree rings, and different methods such as increment borer, tree diameter, carbon-14 that can be used to determine the age depending on whether the living or non-living parts of the tree or tree species are used. New knowledge, skills, and experiences have been gained about ecology, ecosystem, biodiversity, and sustainability and the oldest trees in the world and in our country, such as the monument tree. In addition, it has been revealed that permanent learning can be provided for both participants and students.

Participants stated that there are positive effects of relating the subject to daily life in terms of pedagogy, presenting the subject with a scenario increases interest in the subject, provides different perspectives, and makes them feel like researchers due to the scenario in the workshop, and they followed the scientific processes more carefully. Participants who found the workshop useful in terms of work papers and documents expressed that it provided confidence, motivation, and willingness for them to be able to use this workshop as it is or with modifications. It was determined that one of the important results of this research is scenario building, which is quite remarkable, and participants expressed that they want to use this approach in their teaching processes. It is important to include detailed and guiding instructions, questions, and answers for practitioners, especially when designing educational workshops, and scenario building of the content is one of the important factors (Bal Cetinkaya, 2017).

The inquiry-based research method was preferred in the developed workshop. Scientific inquiry can provide a suitable learning environment/context for the development of students' understanding of the nature of science, the methods and processes that lead to the development of scientific knowledge, and the development of scientific process skills. Due to its effectiveness in science education, the inquiry-based approach also has a significant place in the professional development of individuals working in teacher and out-of-school learning environments (Astor-Jack, McCallie & Balcerzak, 2007; Leuhmann and Markowitz, 2007).

It can be said that the scientific research process presented to the participants through the inquiry-based research approach provided them with knowledge, skills, and experience in scientific process skills and conducting scientific research. Both science center educators and teachers stated that the design that includes creating research questions, forming hypotheses, making observations, collecting data, analyzing data, making inferences, and writing conclusions contributed to their own development, and they planned to implement such an instructional design process when teaching this or other topics in their classes. The use of multiple methods when measuring the age of a tree also showed many participants the importance of diversity in data and the effective methods and approaches for reaching scientific knowledge.

It is thought that the workshop can provide various gains to students such as scientific process skills, scientific research skills, awareness of the diversity of scientific methods, and developing questioning thinking. Science centers have effects on developing positive attitudes towards science, evaluating the context of scientific developments, understanding how science affects their lives, arousing curiosity and developing questioning minds, effective problem-solving, creativity, innovation, critical thinking, and decision-making skills, which in turn promote lifelong learning and development of science and technology that affect the well-being, education, success, and skills of current and future generations. They are important learning resources for formal education systems and contribute to strengthening the knowledge bases of relevant communities, affecting students' motivation, learning processes, and career choices, and empowering teachers by providing more effective ways of teaching science, mathematics, and technology (Toronto Declaration, 2008). Therefore, considering the gains for participants and potential gains for possible students, it can be said that the workshop has the potential to fulfill similar gains to the expected mission of science centers.

The aspects of the workshop that can be evaluated as difficulties or challenges in terms of application are mainly the necessity for teachers and trainers to have conceptual and scientific process skills in terms of mastering the content, as well as the procurement of materials and supplies. Concerns about the necessity for science center educators and teachers to have conceptual mastery and scientific process skills can be considered natural. However, given the mission of the science center, this should be considered as a natural necessity, and especially science center educators must ensure their competencies in this regard. Another aspect criticized about the workshop is that it does not directly overlap with the school curriculum. It has been determined that teachers' expectation is for the workshop subject to directly focus on the gains in the curriculum to be able to apply it in the classroom. The reason for this is that due to the density of the curriculum, topics are taught theoretically without application, and if there is to be an application, it must be oriented towards the gains. Science center educators think that the subject of the workshop can be related to the curriculum and can be beneficial, but it should not be evaluated as an obligation. In addition, reasons such as exam preparation and the material resources of the school are other main factors that prevent application. However, almost all participants think that the workshop can be used in the science center without any concerns. It has even been determined that participating in the workshop can provide cognitive gains as well as interest and curiosity in scientific research, interest in nature, attitude, and sensitivity in students. Visits to science centers increase students' achievements, attitudes, scientific curiosity, and interests, ensure the permanence of knowledge, and make knowledge concrete (Birinci-Konur, Şeyihoğlu, Sezen & Tekbıyık, 2011; Bozdoğan, 2008). It can be said that this science education workshop supported by exhibitions has the potential to provide all the mentioned gains.

Education programs carried out in science centers are also important in terms of supporting or completing exhibition visits. This is because visitors may not examine the mechanisms in depth and may not have adequate questioning skills (Gutwill & Allen, 2009), younger visitors may not read the labels or the labels may not be suitable for their age levels (Hakverdi Can, 2013), the visit duration may be short and visitors may not prioritize learning (Gilbert & Stocklmayer, 2001; Rennie & Williams, 2006), visitors may give up examining the mechanisms due to difficulties they experience when using them (Yaşar, 2014), and various reasons such as visitors' experiences (Falk & Dierking, 2016) can cause learning in science centers to fall below expectations. The workshops that modeled the exhibitions developed within the scope of the BILMER Project, have shown positive effects on students' learning and attitudes (Kanlı and Yavaş 2021). Educators working at the science center will enrich the gains of the participants by guiding students who visit this environment and participate in workshops and activities with a questioning research perspective. In this context, conducting workshops related to exhibitions by educators will be beneficial for the content of education to be comprehended by students and for effective learning to be achieved. Although various difficulties and challenges have been mentioned, participants think that the workshop can be used in science centers and classrooms.

Regarding the strong aspects of this workshop, 32 participants have expressed various opinions. These include the richness of visuals, the availability of all necessary materials, sufficient slide presentations, the provision of sample materials from daily life, support for learning by doing, support for effective learning, the usefulness and good preparation of worksheets, the stimulation of curiosity, interest and desire, the creation of environmental awareness, support for questioning skills, an increase in interest and curiosity in scientific research, a connection to the curriculum, the ability to take home the growth rings obtained from the workshop, and the presence of both theoretical and practical aspects. According to Pilo, Mantero, and Marasco (2011), the inclusion of inquiry-based activities, collaborative work, critical thinking, and problem-solving skills in science centers is a notable feature that helps students learn by doing. To enhance students' scientific literacy, help them think like scientists, and prepare them for future scientific work, it is thought that a focus on scientific process skills and attitudes towards science is necessary. Learning from a field trip to a science center is a valuable support for classroom instruction and an excellent way to prepare students for future learning (Storksdieck, 2006). It is evident that this workshop supports these aspects of science centers. In particular, it is thought that workshop activities related to exhibitions will provide richer learning, and that science centers can provide more support to education without time and material constraints.

Workshops that will be applied in science centers contain challenges in terms of serious learning outcomes, no matter how rich the content is designed and presented in the rich learning environment that the science center offers. This is because it is difficult for individuals with different levels of preparedness, who come here apart from students in the same class, to achieve maximum outcomes at the same time. However, regardless of the circumstances, instructors and content developers should strive to develop appropriate content for students who participate in the science center workshop to obtain maximum efficiency during the limited time they spend here. The characteristics that science center workshops should have, both in line with the BILMER Project and the literature, include being appropriate for the level, connected to the curriculum, contributing to students' learning of science, contributing to students' cognitive and affective development, interactive and collaborative, including various learning-teaching methods and techniques, being related to science center exhibitions, including the nature of science, the history of science, and the inquiry-research approach, including scientific process skills, being fun and explanatory, arousing curiosity, being interesting, relating to daily life, enabling students to leave with a product, including scientific process skills, exploring problem-solving strategies, and providing the possibility of leaving the workshop with a self-made product if possible (Allen & Crowley, 2014; Anderson, Kisiel & Storksdieck, 2006; ASTC, 1996; Bamberger & Tal, 2008; DeWitt and Osborne, 2010; Grinell, 2002; Gutwill & Allen, 2012; Köseoğlu & Eren-Şişman, 2019; Luehmann, 2007; Rennie & McClafferty, 1995). These characteristics should be maximally present in workshops, no matter what discipline or level they are in. In fact, these qualities are similar in any content design where any learning outcomes are expected, but the well-structured design of the content developed for the science center is more important due to the different characteristics of the participants. The developed workshop was created in line with the literature and was determined to have similar characteristics.

In the context of a science education workshop associated with a biology exhibition that could be used in science centers:

● No matter how rich the content of science education workshops to be applied in science centers and presented in the learning environment is, the readiness level of students attending the workshop may differ. It is quite difficult to ensure the development of the cognitive, affective, or psychomotor skills targeted by the workshop and to achieve maximum efficiency in a very short time. This research presents an example of a teaching sequence associated with an exhibition that specifically aims to increase the effects of exhibitions on learning. A science center education workshop example to be developed in different fields and topics, especially in the fields of biology and chemistry, will not only provide them with sample content that educators see as a need for their professional development, but also support students in acquiring gains in different subjects.

● Workshops should include features that carry the mission of the science center. For example, they should aim to instill various affective features such as learning while having fun, curiosity, questioning ability, the perception that science is doable, and a positive attitude towards science. At the same time, a content design should be made that can present scientific process skills in particular. It has been observed that the research inquiry approach is preferred as a learning approach, providing natural learning outcomes. Similar approaches can be used to create new learning designs.

● Science education workshops to be held in science centers do not have to include curriculum gains. However, workshops to be offered, especially on topics that cannot be applied due to material resources and time constraints in schools, can provide support to students' learning gains. Teachers can also plan a part of their science center visits for participation in this workshop.

● There is very limited research on the effects of science centers on understanding the nature of science. Therefore, studies to develop content for science centers that aim to develop the understanding of the nature of science are important.

● Teaching sequences to be developed for science centers should be prepared in detail, including guidance and hint questions if necessary, considering that educators come from different fields. This study showed that worksheets are effective. Worksheets related to the topic can be developed.

● The opinions of science center educators and teachers with field experience in the development of science education workshops are significant. Including them in these processes will be meaningful. Additionally, student applications of the workshop developed in this study can be conducted to obtain feedback.

● It is important for students participating in the workshops to leave with materials they can take with them for recall and permanence. Therefore, this can be included in the content development process.

Acknowledgement

This research was created from a part of the first author's doctoral thesis titled "Reflections of Research-Inquiry-Based Science Education Workshop Applications Developed for Science Centers to Science Center Instructors and Teachers". The second author took part in the development and implementation of the research contents, and the third author supervised the thesis. The thesis was developed within the BİLMER Project titled “A Teacher and Trainer Professional Development Model for Increasing the Effectiveness of Science Centers in Science-Society Communication and Science Education” with the code of 114K646. That project was also supported within the scope of TÜBİTAK-SOBAG 1001 program.

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