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Developing Inquiry-Based Science Activities in Early Childhood Education: An Action Research

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Abstract

This study was carried out as collaborative action research aims to develop inquiry-based science activities in early childhood education. One volunteer teacher (T2) who desired to develop inquiry-based science activities, 14 of her students and the researcher participated in action research. The action phase consisted of six action cycles that reflect the progress over time. Data were collected through interviews and observations. Inductive thematic analysis was performed on the obtained qualitative data. Results showed that during the development of inquiry-based science activities, the teacher had supportive behaviors and utterances. At first, the teacher was planning and implementing at the confirmatory and structured inquiry level but afterwards, she could practice the guided inquiry and also achieved to activate all the inquiry skills during the fifth and sixth cycles. However, some difficulties originated from the teacher, school culture and parental involvement in the process. As a result, the teacher made significant progress in planning, implementing and evaluating inquiry-based science activities in her classroom for preschoolers. Finally, we conclude that inquiry-based science activities can be practicing at various inquiry levels in early childhood education.

Introduction

Young children are curious and eager to understand their physical and social environment (Worth & Grollman, 2003). Children start school with the experiences they have gained from the environment, a natural curiosity, and a desire to discover the causes of events and how objects work (Martin, 2001). When children realize that they can discover the objects around them through their movements, they start to learn science (Harlen, 2001). Science is a unique content area in early childhood education because it is well suited to children's innate curiosity about daily life and ways of gaining natural experience (French, 2004). Eshach and Fried (2005) stated that teachers' use of science as a part of the early childhood education program offers many opportunities for children. One of these opportunities is for children to develop a positive attitude towards science and to better understand the scientific concepts they will study later. As children explore their immediate environment through science, they encounter experiences in which they effectively construct knowledge and discover new relationships (Lind, 2000).

Children discover science content knowledge by using the scientific inquiry process (Lind, 2000). Inquiry is the process of asking questions and answering these questions systematically based on facts and observations (Eggen & Kauchak, 2006). The general purpose of inquiry-based learning is to develop the intellectual discipline and skills required for children to ask questions and to help them seek and find answers that emerge from their curiosity (Joyce, Weil & Calhaun, 2009). Children not only acquire the scientific process skills necessary to conduct research within the inquiry process, but also develop an understanding of science concepts and the nature of science (Lind, 2000). Next Generation Science Standards (NRC, 2012) emphasized that practices in different fields of science may change, but inquiry and problem-solving approaches are the basis of education. Besides, children can comprehend the nature of science and develop a scientific attitude by participating in inquiry-based science activities (Loxley, Dawes, Nicholls & Dore, 2016). Thus, the goals of science activities in early childhood education can be achieved with inquiry-based learning approach.

Inquiry-based learning is a model developed by Richard Suchman in 1962 for providing learners with the processes of researching and explaining the facts. The inquiry model aims to teach children the systematic methods, academic research skills, and language that scientists use in organizing knowledge and establishing principles (Joyce, Weil & Calhoun, 2009). Similarly, Schwab (1962) pointed out that learning processes starting with problem situations support children's inquiry skills and argued that science education should follow the ways of scientists. Scientific inquiry; includes skills such as identifying and demonstrating the problem, designing and conducting research, analysing the data, using models and explanations, and sharing findings (Keys & Bryan, 2001). Inquiry-based learning has four different models depending on the control of the teacher; confirmatory, structured, guided, and open inquiry models (Banchi & Bell, 2008). In the confirmatory model, students conclude by applying the instructions. Students are provided with the freedom to share their results in structured inquiry (Bevins & Price, 2016; NRC, 2012; Sadeh & Zion, 2009). In guided inquiry, the teacher provides the students with the research questions and procedures, but the students make the decisions themselves from the data collection step. The results are not known to the teachers and students in advance. Finally, in the open inquiry model, students can carry out their inquiry processes without the intervention of the teacher (Bevins & Price, 2016; Zion & Mendelovici, 2012).

In classrooms where inquiry-based learning takes place, children frequently ask and answer questions, focus on resources, provide solutions to scientific problems, and have increased control and success over the learning environment (Audet & Jordan, 2005; Cremin, Glauert, Craft, Compton & Stylianidou, 2015). Also, the most important long-term outcome of inquiry-based learning is that future learning skills become easier and more effective as children become more adept at learning processes by acquiring both knowledge and skills (Joyce, Weil & Calhoun, 2009). Besides, in the Next Generation Science Standards (National Research Council [NRC], 2012), it was stated that the inquiry-based approach suggested being used in science teaching, students can understand the nature of science and scientific knowledge with hands-on experiences. Therefore, inquiry-based learning is an ideal approach to support pupils' current knowledge and research skills to discover and contextualize new knowledge and answers to problems they have proposed (Bevins & Price, 2016).

Martin (2001) argues that children need to know how to inquire, make discoveries, and investigate scientific questions. Research shows that children can successfully participate in inquiry-based early childhood science education and engage in the inquiry process (Samarapungavan, Mantzicopoulos, & Patrick, 2008; Howitt, Upson, & Lewis, 2011). However, teachers should support children to gain the skills and understandings they need in the inquiry process. Therefore, the American National Science Education Standards recommend that science teachers at all grades improve themselves in the nature of the scientific inquiry, its importance for science, and the use of scientific inquiry processes and skills (NRC, 1996). For effective teaching, teachers should have a positive attitude towards science and take roles of initiating science, guiding the process, providing an environment and being a model (Harlan & Rivkin, 2001). Since the knowledge, curiosity and search for reasons acquired by children in early childhood are an important basis for their future learning (Galuert, Heal & Cook, 2003), inquiry-based science activities are needed in the preschool period. Thus, considering the importance of inquiry for science education and its contributions to children, it becomes evident that teaching inquiry-based science activities in preschool education and improving teachers' inquiry-based science activities are necessary.

The research on inquiry-based science education in early childhood focus on the contributions and learning processes of children; the opinions, competencies, attitudes, practices, and vocational education processes of teacher candidates and/or teachers towards inquiry-based science education (Duran, Ballone-Duran, Haney & Beltyukova, 2009; Gropen, Clark-Chiarelli, Chalufour, Hoisington & Eggers-Pierola, 2009; Eckhoff, 2017; Ergazaki ve Zogza, 2013; Furtado, 2010; Howitt, Upson & Lewis, 2011; Mason, Carlson & Murphy, 2011; McDonald & McDonald, 2002; Oliveira, 2010; Roehrig, Dubosarsky, Samarapungavan, Patrick, & Mantzicopoulos, 2011; Samarapungavan, Mantzicopoulos & Patrick, 2008; Spektor-Levy, Baruch & Mevarech, 2013). Sporea and Sporea (2014) found that many preschool teachers had difficulties following the inquiry steps, and they tried to strictly control inquiry processes as in the old traditional science education approach. In another study, Ergazaki and Zogza (2013) concluded that preschool teachers experienced significant difficulties at the conclusion part of the inquiry-based science activities, and thus, children could not follow the inquiry circle. In Europe, cross-country projects draw attention to improve inquiry-based science education, focusing on changing the educational approach, not the science content (Osborne & Dillon, 2008). The relevant literature provides an understanding of inquiry-based science education in early childhood, but there is a need for studies focusing on teachers' behaviours, teaching processes, and problems experienced to develop inquiry-based learning practices in preschool science education.

In the Turkish Early Childhood Education Program (Ministry of National Education, 2013) it is stated that teachers should allow children to plan, implement, organize, inquire, research, discuss and produce in the learning process. Also, child-centered and discovery learning approaches of the Turkish preschool education program overlap with the aims of science education and inquiry-based learning approaches. However, in the education program, there are no clear recommendations on how the inquiry-based learning approach can be integrated into the learning process. Therefore, preschool education teachers should be supported for the inquiry-based learning approach in science education and more scientific studies should be done on inquiry-based science education. This support could help teachers to perceive and implementation of inquiry-based science activities so, desired contemporary early childhood education can be achieved.

Considering the importance of inquiry-based learning in preschool science education, benefits for children and the gap in the literature, it becomes clear that teachers' implementation process should be studied. Thus, the current study aims to reveal the development and implementation process of inquiry-based science activities in early childhood education.

Method

This study was designed as action research, which aims to develop inquiry-based science education in a preschool class. Action research is defined as studies conducted to improve both the applications and the meaning of a social situation (Munn-Giddings & Winter, 2013). In the educational research field, Johnson (2014) considered action research as a process that is carried out in a school or classroom environment to understand and improve the quality of teaching or practices, and to construct a bridge the gap between educational research and teaching practices. This study was aimed to reach a consensus between theory and practice with close cooperation and mutual negotiation of a researcher and a teacher. Accordingly, based on the teacher's practices and experiences, the action research was carried out systematically and collaboratively to solve the emerging problems while developing inquiry-based science activities for preschoolers under the guidance of the researcher. The action research process was based on Kemmis, McTaggart & Nixon (2013), which includes planning, action, observation-monitoring, and reflection cycles. The detailed information about the action research procedure was explained below.

Participants

This study was conducted in a newly established public kindergarten in Adana city, located in the southern part of Turkey. 14 teachers who hired in this school had previously taught in different cities of Turkey, but they started to work for the first time at this kindergarten. On the first day of the academic year, the teachers were informed by one of the researchers, and the volunteer teachers' opinions about science and inquiry were taken and the research process was explained. Only one of the teachers, who wanted to develop inquiry-based learning practices in science education and allocated time for research, voluntarily participated in the study. The teacher, whose identity was ethically concealed, will be referred to as the code name "T2" during the study. T2 is a 41-year-old female teacher and has ten years of experience in the profession. She was graduated from Anadolu University Distance Education Faculty, Preschool Teacher Training Undergraduate Program. The other participants of the study were 14 five years old children (9 boys-5 girls) enrolled in the group of T2 and the researcher himself. We assigned pseudonyms for children to protect confidentiality (*Sarp, Aylin, etc.*). In this study, the researcher has the roles of revealing the problem situation, planning the study, observing the process and analyzing the data, guiding, and providing theoretical and technical support to the teacher.

Data Collection and Analysis

Action research aims to understand and explain some situations in the educational environment by collecting data (Johnson, 2014). The data of this study were obtained through qualitative data collection methods. To ensure data diversity unstructured observations and in-depth open-ended interviews among the qualitative data collection methods proposed by Patton (2002) were used.

Eight learning process carried out in six action cycles by the teacher (T2) who wanted to develop inquiry-based science education in her classroom were observed. All inquiry-based science activities were observed and recorded by a video camera. The recordings were monitored by T2 and the researcher. Observations enabled the recognition of problem situations in the reflection stage of the action research for macro analysis. When the action research was over, the observation records were monitored by the researcher again, and inductive thematic analysis was used to obtain the findings.

During the action research, semi-structured and unstructured interviews were held with T2 at the planning, observation-monitoring, and reflection stages of action research. All interviews were recorded with a digital voice recorder. The recordings were listened to by the researcher and then transcribed into text. Data analysis was carried out on the written interview texts. For the thematic analysis, observation and interview transcriptions were coded. The codes were organized into categories and themes and thus, the behavioural patterns of T2 and the development process of the inquiry-based science activities had emerged.

Validity and Reliability

In this study, as Lincoln and Guba (1985) suggested, the researcher made long-term participation in research environments *(more than three months)*, made observations *(550 minutes)*, and triangulation of data from different sources to increase credibility. Besides, the analysis results were presented to T2 for the member-check to assure validity. Also, all data were recorded in all research environments and referential adequacy was assured. To increase the transferability, the data were presented in dense descriptions, thus revealing all the details of the process. Participants' quotations are presented in the original form. During the study, a validity committee consisting of three experts gathered in three meetings and supervised the content of the research, implementation processes and analysis of the data.

Action Research Procedure

Before the action research, the daily activities of the teachers in the kindergarten were observed in four weeks, and it was revealed that the teachers rarely performed the science activities compared to other activities and taught the science as a teacher-centered activity and not inquiry-based. In an observation, T2 presented a *"glass and candle experiment"* in the science activity. This activity was entirely teacher-centered, did not offer children the opportunity to experiment and did not allow children to involve in the inquiry process. In the preliminary interview with T2, it was found that she believed in the importance and necessity of science activities in early childhood education. T2 defined inquiry-based learning as *"learning without memorization"*, but it was revealed that she did not know how to adapt inquiry-based learning into science activities. Expressing that will be a beneficial experience for children and herself, she was willing to participate in the study to develop inquiry-based science activities. Before the action research, briefings about inquiry-based learning and science activities in early childhood education were held for the teacher to get information about action research and inquiry-based science activities. The briefings organized by the researcher in six sessions, three days a week, for two weeks, out of the working hours of T2.

This study, which was carried out by the collaboration of T2 and the researcher to develop inquiry-based science activities, was completed in two months with eight learning processes, implemented in six action cycles. Each action cycle includes the planning and acting of inquiry-based science activity, and then the observation-monitoring and reflection of the process by watching the video recordings of the activity. Based on the reflections T2 planned a new science activity to implement the inquiry learning. Figure 1 presents the action cycle model adopted in this study. T2 and the researcher held meetings during the planning and reflection stages of each action cycle, and this process was recorded with a voice recorder. In the reflection phase, T2 and the researcher revealed problem situations by following the inquiry-based science activities. The solutions were suggested for the determined problems were discussed and thus the next inquiry-based science activity was planned. The teacher is solely responsible for the planning and implementation of inquiry-based science activities, and the researcher has undertaken the tasks of the observer, guide and collecting data. In the sixth action cycle, the study ended by T2. She believed that she was planning and implementing child-centered and guided inquiry-based science activities including all the inquiry skills.

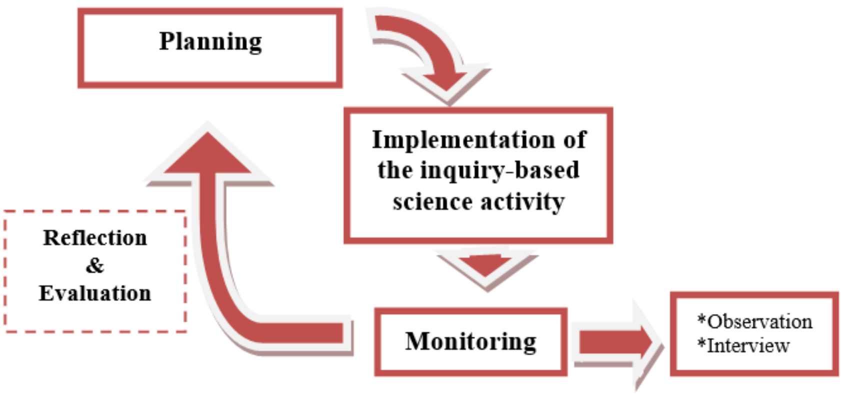

Figure 1. The Action Research Cycle

Results

As a result of the analysis, it was found that during the development of inquiry-based science activities in early childhood education, supportive teacher behaviors and utterances, practicing the inquiry skills and some difficulties concerning the implementation of inquiry had emerged.

Supportive Teacher Behaviors and Utterances

T2 had a set of behaviors and utterances that support inquiry during developing science activities and to apply the inquiry process. The teacher motivated children to ask the questions, created an atmosphere for inquiry, being a model for the inquiry and included children into the inquiry process, from the first action cycle to the last, before and during each activity. Starting from the second cycle, T2 aimed to support inquiry by parent involvement for inquiry-based science activities.

The teacher had motivated behaviors and utterances that help children to inquire while implementing the science activities she planned. In this context, the teacher led the children to collect data, make observations, present evidence and make conclusions. Also, as of the fourth action-cycle, T2 was motivated children to introduce new research questions to implement the guided-inquiry model. Children could follow the inquiry steps and experience inquiry-based learning thanks to these behaviors and utterances of the teacher. In the first inquiry-based science activity named *"Exploring autumn with leaves"*, where the teacher handed out "*guessing papers*" to the children and say "*we will collect leaves from the garden. Now you will paint this paper in colors of what you guess the leaves you will collect. What color of leaves do you think we can collect from outside*?" She encouraged children to guess and observe.

T2 also had an effort to create an inquiry atmosphere in her classroom. The teacher tried to create an atmosphere of inquiry in her classroom with behaviors such as drawing attention to children's answers, being interested in their discoveries, asking questions for their observations, and giving time to classroom share. *"What can the balloon do?"* was the second inquiry-based science activity, the teacher distributed wool gloves and plastic balloons to the children. She asked them to rub the balloon with gloves and try out which objects in the classroom could lift. In the meantime, the teacher observed the children's experiments and asked them questions contributing to the atmosphere of inquiry. In this process, T2, who heard one of the children saying *"we should bring it closer to something light"*, drew attention to the other children and thus aimed to create an atmosphere of inquiry in her classroom.

The teacher tried to be a model for the process of inquiry-based science activities. She involved in the process with the children in all activities and be a part of the inquiry. In this context, T2 expressed the situations she was curious about, asked questions, made observations and experiments to collect data, exposed her predictions, used measurement tools and shared her results with children. In the third cycle of action, the activity named *"Who will be our guest?"*, the teacher asked each child to collect information about an animal whose life they were curious about and become an expert. T2 had been a model for children to explain the process; *"For instance, Sarp chose the jackal. If you do not know the features of the jackals, you will come and ask Sarp. Say; my friend, I'm wondering how do jackals feed? Sarp will tell you all kinds of information like that".*

When children distracted from the inquiry process, T2 tried to include them in the activity and thus inquiry-based science activities could be applied. Thus, it was observed that the teacher aroused curiosity in children, offered materials that would attract their attention, asked questions, reminded the inquiry steps, gave children feedback about the process and verbal reinforcement, and provided resources. In the fourth activity called *"What do animals eat?"* T2 asked children to guess how the animals choosing in the third activity were fed. Afterwards, data collection of children was ensured through videos and printed resources provided to children.

In this activity, T2 tried to keep each child in the inquiry process by providing the expert name tags for each, recalling the data collection tools, and drawing attention to the children's sharing.

Finally, under this category, T2 included families in the process. In the interview with T2 at the reflection session of the first action cycle, T2 made this decision; *"... Parents should also engage in the process, we should do the inquiry process as a form of parent involvement […] they can provide materials when necessary […] we should inform the families about the inquiry."* said. Upon this, T2 held a parents' meeting with the participation of the researcher, and organized family involvement activities in all subsequent activity plans. In this context, it was ensured that the children sustained their research and experiments at home, as a continuance of support of inquiry-based science activities practiced in the classroom.

Practicing the Inquiry Skills

The inquiry process was carried out because of the teacher's behavior and utterance that supported the inquiry throughout the six action cycles. In the planning and implementation of inquiry-based science activities, it was revealed that T2 practicing different steps and different types of inquiry with children from the first activity to the last one. In the first two activities, T2 was planning and implementing at the confirmatory inquiry level, a structured inquiry was carried out in the third and fourth activities, and a guided inquiry was practiced in the last two activities. From the first action plan, T2 aimed to plan and implement the child-centered and cyclical structure of inquiry, in which all inquiry skills were experienced, children could produce research questions. However, it was observed that the teacher managed to activate all the inquiry steps in the fifth and sixth activities and formed the inquiry-based learning cycle. In these last two activities, children produced research questions, decided on data collection methods and made conclusions.

The first inquiry-based activity was *"Exploring autumn with leaves"*, the teacher drew attention to the seasons, asked the children what color the leaves were in autumn and asked them to draw their predictions on a piece of paper. Then she gave the children Ziploc bags and took them out to the school garden. T2 had pupils observe the leaves falling on the ground in the garden and collect some of them. When the group returned to the classroom, the teacher gave the children magnifiers and asked them to examine the leaves and compare the leaves collecting with their predictions. After the children spent some time with the leaves, the teacher asked the children *"Why the leaves turn yellow?"*. Then, T2 provided a scientific explanation to the children about why the leaves turn yellow. At the end of the activity, the teacher asked; *"What did we do today? What color are the leaves in autumn? Why the leaves turn yellow? Did you have fun doing this activity? What can we do with these leaves?"* questions to children to evaluate the activity. It was determined that inquiry processes such as guessing, observing, collecting and sharing data were attempted in this activity. However, T2 planning and implementing inquiry-based science activities for the first time discern that she had a teacher-centered attitude in the reflection step of action research and could not fully perform the inquiry process. She said, *"I gave all information, before they completed the investigation"*. Therefore, in the second action plan, T2 decided to plan a science activity that would provide children with more opportunities to explore, collect evidence, and make the inquiry.

In the second activity, *"What can the balloon do?"* T2 conducted a static electricity experiment. In the beginning, the teacher introduced a bag containing balloons and woolen gloves to arouse their curiosity. Afterwards, she read the story of "Aladdin's Magic Lamp" and explained that *"...just like Aladdin rubbed the lamp the genie comes out, we will rub these balloons and it can attract some objects. These balloons are magical, but the magic of these balloons comes out when you rub them with woolen gloves."* And she posed an inquiry question *"What objects do you think the balloon can attract?"*. T2 asked the children to make predictions on the first column of the given experiment recording sheet and then brought the predicted objects to the desk and made the experiment with the balloon captures electrons from the wool. Some children stated that *"But teacher, I rubbed it a lot, it still does not attract anything", "mine does not elevate anything"*, T2 asked the children *"Why doesn't balloon rise anything?"*. The teacher enabled children to reason by directing this question. After a while, T2 put small pieces of paper on the table so that the children could see it and showed that the pieces of paper were stuck to the balloon by rubbing it with the glove. Recognizing this, children started experimenting by performing the same steps without any instruction from the teacher. Also, T2 said, *"What else can we do, what else can we rub against the balloon?"* She posed a new question of inquiry. Some of the children put the balloon on their hair and observed that their hair was taking off. Thereupon, T2 asked the children to draw which objects the balloon attracted to the second column on the experiment recording sheet and to explain the experiment process with the questions she asked. In this activity, it was observed that T2 implemented the steps of presenting the problem, guessing, collecting and sharing data of the inquiry processes. However, T2 stated that in the reflection of this action cycle, this experiment was not appropriate for children's age, provided limited inquiry opportunities, therefore, children distracted from the inquiry process and she could not use time efficiently. For this reason, in the third cycle, a science activity based on the natural interests of children, child-centered and containing all inquiry skills was planned and implemented at the level of guided inquiry.

In the third activity titled *"Who will be our guest?"* based on the experience T2 gained in the first two inquiry-based science activities, she focused on the natural interest and curiosity of children. During the planning period, T2 said, *"When Aylin brought a bird's nest from the garden, I decided to plan this activity. This was the chance, a great opportunity for inquiry both the bird's nest and the snail that we could not observe in the first activity… "*. T2 stated that children are naturally curious about animals and decided to plan the inquiry process based on questions such as *"what do animals eat", "how do they live", "how are they cleaned"*. The teacher started this activity by talking about the bird's nest found by Aylin and the snail on the leaves in the first inquiry-based science activity to attract the pupils' attention. Then she asked the children, *"Well, what can we do if an animal goes astray and comes to our class someday? How can we host it in our class? Where can we keep it? How does it live in our classroom?"* presented the problem with these questions. Then she asked the children to choose an animal and draw this animal in its habitat on their science notebooks. T2 asked how the children could gather more information about the animals. After listening to the answers of children T2 said *"… you responded that you can find them on the internet, ask your parents, ask your teachers. Besides, you can find some information in books and magazines. I will provide these (printed sources) to you for your research. Review it one by one.* " She directed them to review the books, magazines, encyclopedias and posters she placed in the science center. The children searched the resources for about twenty minutes and then T2 asked the children to share what they had learned from the books, what they did in the process, and how they felt. Lastly, the teacher encouraged the children to ask questions about the animal they chose to their parents when they went home, to draw the information they obtained on science notebooks, to collect information and to build a shelter for this animal, as a parent involvement activity. In this third science activity, T2 activated the inquiry skills of presenting the problem, guessing, collecting data, drawing conclusions. This activity at the structured inquiry level was child-centered compared to the previous ones. The inquiry process was practiced more flexible, the children engaged more in the process and the teacher used time more efficient. However, in this activity, the teacher's behaviors and utterance disrupting the inquiry atmosphere and inadequate classroom setup were the main problems for inquiry-based learning. For this reason, in the planning session of the fourth activity, T2 decided to use different strategies to support the enhanced participation of children, change the classroom routines and arrangement, and increase parental involvement.

In the fourth activity *"What do animals eat?"*, T2 aimed to follow the continuity and cyclical nature of the inquiry process. Based on her previous experiences, T2 stated that gaining the expertise of children on a subject would facilitate the inquiry. Thus, this activity was based on the animals that children were curious about in the previous activity and gathered information about them for a week. T2 initiated the activity by having the children share the conclusions of their research at home and school for a week. Then, the shelters of the animals exhibited and explained the features of animals by children to the class. T2 started the new inquiry process by asking the children how the animal they chose was fed, and asked the children to draw their existing knowledge or predictions on their science notebooks. Later, T2 encouraged the children to collect data on the feeding patterns of animals. In addition to the printed materials in the science center, T2 presented short videos of how the animals are feeding to children. After watching the videos, the teacher asked questions to children and directed them to draw the information obtained in the science notebook for helping them to record data. T2 asked children to compare their previous predictions with the evidence they had obtained, and thus the teacher activated children for making conclusions. T2 practiced the sharing step of inquiry by enabling the children to express what they did, found and felt in this activity. Also, at the end of the activity, T2 ended the process by asking the children to prolonged the conclusion and sharing steps with their families at home. In this activity, the teacher made progress in planning and implementing the inquiry process. In the reflection session, T2 said, *"Now I ask questions more easily. When they say something, I can enhance their curiosity. I'm trying not to give information directly. I also learn that if the children do not respond to the questions, I can say that I do not know either, let's investigate. "*. It was revealed that the teacher's utterance and behaviors had changed. However, in addition to these improvements, the children had to wait for others for a long time in the data collection step and it emerged as a classroom management problem. Besides, T2 stated that low family participation was a problem and affected her motivation. Lastly, there were no opportunities for generating new inquiry questions based on children's observations and curiosity.

For the fifth activity named *"Where is our cat",* T2 planned an inquiry process based on the question of *"what do animals do in the winter?"* related to the previous activity. After taking the opinions and predictions of the children, T2 reminded the animals that the children were investigated and asked everyone to explain how their animal was protected from the cold. Then, the children were informed that "the school cat" had not been seen in recent days. The predictions were taken from each child as to where the cat could be, and then the cat was sought for the suspected locations around the school. When the children could not find the cat, T2 asked; *"What could have happened to our cat? How can we find our cat? What things attract cats?".* She initiated the inquiry process by asking these questions. Different resolutions have come from the children to find the cat such as looking at the cafeteria, putting some milk, calling it "kitty kitty", making a cat bed, asking it to the security guard, asking the neighbors, making a wall hanging for the school garden, posting the pictures of the cat on the social media, and preparing a missing announcement. In this activity, the children were allowed to try out their decisions. For the first time, the inquiry process took place outside the classroom, such as the school garden, dining hall, waiting room and conference hall. In this process, it was observed that the children took photos while trying to find the cat for collecting data. Also, they communicate with others to find the cat. They described the features of the cat, they asked for help to attract the cat. T2 told the children that they would wait a few days and check regularly if the cat would return to school or not. Thus, the inquiry process had spread over a week. While looking for the cat, the children noticed a bee holding still on the window of the waiting room. They focused on the bee and wondered whether it was alive or not. Suddenly T2 decided to start a new inquiry process. Unlike the previous activities, T2 included this unexpected situation that children discovered naturally into the inquiry process. She started up a discussion about the bee and then announced that they would investigate the bee when they back to the class. T2 asked the children what they did in the activity, what ways they tried and whether they found the cat, and achieved the steps of conclusion and sharing.

The next day, T2 reminded the children about the inquiry process and encouraged them to state what they were curious about the lost cat. She directed all children who revealed their questions to go out to the garden and to check whether the ideas offered the day before could work for finding the cat. The children went out to the garden and looked around the hanging rope, the milk container and the cat bed. When the children returned to the class, T2 asked the children to present the evidence, to make a conclusion, to share ideas and feelings. Thus, the second conclusion and sharing steps of inquiry were activated. The teacher assisted the children to keep looking for the lost cat at the end of the activity. In this activity, it is revealed that T2 performed the guided inquiry level. The teacher said that; *"We practiced each skill of the inquiry, it was originated from a real problem. As long as the children engaged in the inquiry enthusiastically, they arranged everything themselves. I am so happy, it feels great. It is nice to see the excitement of the children. "* in her interview on the reflection session and she stated her satisfaction with the process.

"Is our bee alive?" was the last inquiry-based science activity investigating the bee, which appeared during the previous inquiry process. The children kept and observed the bee in the science center for a week and tried to understand whether it was alive or not. When children visited the science center to checked the bee up with magnifiers and they collect data about bees, T2 asked some questions to deepen their curiosity and research. Children stated that *"its wing was hurt, it is sleeping, it is sick, its stringer is removed, it died and its antennae were broken".* Based on the shreds of evidence they found, some of the children stated that the bee was alive and others suggested that it died. The teacher asked the children *"What are we going to do with this bee?"* for enhancing the inquiry. Meanwhile, one of the children said, *"Let's take it to the veterinarian."* T2 asked the children *"what does a vet do?", "Which animals do vets take care of?", "Do you think vets take care of bees?"*

etc. to determine their prior knowledge. Children agreed that the vets can cure all animals and they can take care of bees as well. One of the children said; *"The vet should cure the bee, he listens to its' heart. Maybe he will make an injection. Then the bee will get better."* Accordingly, T2 included the idea of taking the bee to the vet in the inquiry process and tried to reveal their curiosity about the vets. T2 handed out papers and crayons to the children and told, *"Which animals do you think vets take care of? How can vet heal the bee? Draw your opinion?"* Meanwhile, T2 asked children "*What do you want to ask the vet?, What are you wondering"* and took note of all the questions produced by the children. As a parental involvement activity, the teacher sent an information letter and made the families aware of the inquiry process. She asked the families to note all the questions and findings of children about the bees, veterinarians or animals at home.

The next day, T2 decided to organize a field trip to a veterinary clinic within a week. She planned this trip for the children to collect data and enhance the inquiry. Before the visit, the children had reminded of the purpose of this visit and the inquiry cycle. On their visit to the clinic, the children were allowed to check the bee on the examination table. The children recited what they had known about bees and the vet gave more information about the bees and insects. The veterinarian also examined the bee and asked the children their conclusions. All children agreed on the bee was dead. Then, T2 ran a second data collection process for the children. They allowed asking questions the veterinary doctors about their profession. The children also had the opportunity to examine the materials available at the clinic and witnessed a dog in the examination. Returning to the classroom, T2 asked the children *"What have we learned from vets?", "What did you observe in clinic", "What happened to our bee?" , "How do we conclude that the bee was dead?".* By asking these questions T2 activated the inquiry skills including making conclusions and sharing the process. In this last activity, it was observed that the teacher and the children successfully implemented the inquiry process and skills.

At the beginning of the study, the teacher could not use the inquiry opportunities and she stuck on the plan, but in this activity, she was able to organize the inquiry process according to the interests of the children. Also, children started to produce inquiry questions and were able to use different data collection methods to get information. Children engaged longer in the activity and the inquiry is enriched with parental involvement and expert support. After this activity, the teacher said, *"I think the activity was very good, we practiced all the inquiry skills. The children were very engaged and they were actively into the inquiry. Under these conditions, we tried to do the best and we did it… "*. The action research completed in this cycle as the school term ended after the teacher stated that she had achieved to plan and implement inquiry-based science activities.

Difficulties in Implementing the Inquiry-Based Science Activities

During the six action cycles, it was found that when T2 attempted to develop inquiry-based science activities and to conduct the inquiry skills, some problems had emerged. These problems were categorized under three themes, originated from the teacher, school culture and parental involvement.

Firstly, in the category of problems caused by the teacher; ruining the inquiry atmosphere, blocking the inquiry opportunities, diverging from the purpose of inquiry and using time inefficiently. The analysis showed that some of these problems solved during the action research process yet some remained even though the incidence rate decreased. It was observed that T2 resolved the problem of diverging from the purpose of inquiry in the progress of time. The teacher had a tendency towards answering her questions, categorized under the behaviors and utterances ruining the atmosphere of inquiry, did not recur after the first action cycle. Likewise, blocking the new inquiry opportunities had ended. It was found that in the last two action cycles, T2 easily took the new inquiry opportunities into the science activities. These improvements occurred when T2 recognized the problems thanks to the monitoring and reflection steps of the action research and created a reflective perspective on her behaviors and attitudes. However, the problems originated from the teacher on the decrease but persisted in the inquiry process. For instance, T2 still violated the children's decision-making opportunities, ruining the inquiry atmosphere by warning about the classroom routines and restricting the opportunities of data collection and conclusion.

Apart from restricting teacher's behaviors and utterances other difficulties that prevent inquiry-based science activities also experienced. In the reflection sessions of each action cycle, the researcher and T2 recognized other problems affecting the inquiry process and tried to make solutions to eliminate these difficulties. Some problems originated from the school culture preventing the inquiry process such as the attitudes and behaviors of school caretakers, other teachers and the school administration. T2, who wanted children to explore the leaves in the school garden in the first activity, was warned by the cleaning staff. The caretakers asked not to do activities in the garden, as the children's shoes were muddy and dirtied the school. Upon this, in the second action plan, T2 informed the school caretakers and administrative staff about the nature of inquiry-based science activities and reached a consensus on the activity time and cleaning time. Another problem was the inquiry learning process was frequently interrupted by other teachers. T2 stated that *"My colleagues deliberately sabotaged the inquiry process because they underestimated our endeavor. Although I explained to them the importance of the process and my intention, they didn't care much about my attempt and class routines. They just entered the class and asked trivial questions, so the kids were distracted and the inquiry process was ruined."*. She also expressed that because of the interruptions she got stressed and frustrated. However, these interruptions reduced in time, and the last two activities were done without any obstacles caused by the colleagues. Besides, in this category, it was determined that the physical conditions and the educational philosophy of the school also restrict the process. T2 stated that the facilities of the school were not sufficient for the inquiry process and the school administration did not support the inquiry-based science activities. T2 tried to implement the inquiry-based science activities even though these difficulties had arisen.

Another problem confronted by T2 during the implementation of inquiry-based science activities was low parental participation. At the end of the first action cycle, T2 decided to carry out parent involvement activities to support the inquiry process. Therefore, T2 held a parents' meeting about inquiry-based science activities. Even though families stated that they were willing to participate in the activities, they did not support inquiry-based activities at home. Especially in the third and fourth activities, the teacher planned parental involvement activities for enhancing the data collection and sharing steps of inquiry at home were a failure. So, in the development of inquiry-based science activities, low parental involvement regarded as a problem by T2 restricting for implementing the inquiry processes. Concerning this, T2; *"I thought family participation was* *necessary. I wanted the children to research at home, too. I wanted to send the science-notebooks for home - every day. But, bringing the notebooks from home to school was difficult. Families did not help children in their inquiry. I'm getting pissed off. They thought that kids have to learn at school not at home. And they could not take any responsibility for supporting their kids' learning. Parents opinion that education is a chore and so they do not want to take any responsibility."* This situation directly affected the inquiry process of the teacher and decreased her motivation.

Discussion

During this action research carried out in teacher-researcher cooperation to develop the inquiry-based science activities in early childhood education, it was determined that the teacher exposed supportive behaviors and utterances and thus practiced the inquiry skills. Also, some challenges emerging from the teacher's behaviors and utterances, school culture and low family participation restricted the inquiry process.

Firstly, the findings revealed that the teacher attempted to motivate the children, create an inquiry atmosphere, be a model for the inquiry process, engage children and involve parents. During the inquiry-based science activities, the teacher regarded the importance of supporting children in different ways in each action cycle to accomplish the inquiry process. Keys and Bryan (2001) identified that one of the characteristics of the teacher using the inquiry-based learning approach was to develop rich and profound meanings of ways how to involve children in practice. Similarly, Cremin et al. (2015) argue that children who are supported by their teachers in inquiry contexts are interested in resources, ask questions, capable of using problem-solving skills, and thus find the opportunity to produce their understandings and strategies aimed at inquiry-based learning. Under this category, T2's efforts to create an in-class inquiry atmosphere in the process were noteworthy. Wolf and Laferriere (2009) emphasized the importance of creating an inquiry environment that enables children to ask questions easily and helps them experience the scientific research process. Many behaviors and utterances supporting the inquiry reveal that T2 was willing to perform inquiry-based science activities.

Secondly, T2 activated different inquiry models and skills to achieve the inquiry-based science activities. In this context, it was determined that the teacher ran the inquiry skills of introducing the problem, making predictions and observations, collecting/recording data, analyzing / interpreting results, making conclusions and sharing. During the implementation phase of the first action plan, it was found that T2 could not fully follow the inquiry process. Likewise, Sporea and Sporea (2014) found that many preschool teachers had difficulties following the basic inquiry process. In the study of Ergazaki and Zogza (2013), teachers could not activate and prompt making predictions, investigations and interpreting the results accurately. However, in the current study, T2 noticed this problem since the second action cycle and attempted to implement the inquiry process. In this category, T2 developed the learning process by applying and evaluating the theoretical knowledge obtained from the briefings about inquiry-based learning and science activities over time in action cycles.

The progress of teacher's expertise on inquiry-based science teaching can be associated with the action research process. Action research is carried out to understand and improve the quality of instructions or practices based on the teacher's own experiences (McTaggart, 1997; Johnson, 2014). Thus, this study anticipated contributing to the professional development of the teacher. In studies focused on inquiry-based learning professional development programs (Gropen et al., 2009; Furtado, 2010; Roehrig et al., 2011; Duran et al. 2009), teachers achieved some positive gains. Gropen et al. (2009) revealed that the vocational education program designed to improve science activities had a strong impact on teachers' science knowledge and inquiry-based classroom practices. Similarly, Duran et al. (2009) concluded that the vocational training program enabled teachers to understand the inquiry process. Furtado (2010) stated that the professional development program for inquiry-based science education successfully achieved the goals of inquiry-based teaching and learning. Furthermore, Roehrig et al. (2011) found that teachers' attitudes towards inquiry changed positively at the end of the first year of long-term in-service training, and at the end of the second year, there was a statistically significant increase in the inquiry-based teaching practices they carried out in their classes. In this study, the action research provided the teacher; reflection, evaluation, reorganization and implementation opportunities on her teaching practices, and thus supported the positive development of inquiry skills, behaviors and utterances.

During the action research process, T2 had some restricting behaviors and utterances in the inquiry-based science activities. Thanks to the reflection process of action research, the teacher reflected upon her teaching practices, she noticed and tried to solve the restricting behaviors and utterances. Teachers' control of their own teaching experience can affect their practice and teachers become more competent decision-makers regarding their work with a systematic reflection approach (Larrivee, 2006). The restricting behaviors and utterances of the teacher still existed but decreased. This finding may be related to the consequence of teachers' classroom management skills and ten-year teaching habits. Sporea and Sporea (2014) examined the implementation of inquiry-based science activities and concluded that the teachers tried to control the inquiry processes too much just as in their old conventional science education approach. In inquiry-based teaching practices, the teachers should provide sufficient guidance for the process and not restrict children's inquiry attempts and experiences (Eggen & Kauchak, 2006). In our study, assuming this guidance role and decreasing restricting behaviors and utterances by the teacher took a long time. Roehrig et al. (2011) supported this finding; after one year of professional development for inquiry-based teaching, teachers' attitudes towards inquiry have increased. Also, Duran et al. (2009) argued that although professional development programs proved to be effective, the teacher beliefs should be supported consistently. In this regard, long-term action research could provide the teacher to change some attitudes and behaviors transferring from the former professional life that limit inquiry-based learning. Lastly, it is found that T2's failure to use time efficiently in the implementation of the second, third and fourth activities affected the inquiry process negatively. Pozuelos, Gonzalez & Canal de Leon (2010) stated that when teachers implemented inquiry-based learning they experience time constraints for some tasks demanding more time and effort. However, T2 gained experience in inquiry-based science activities and used time more efficiently in the last two activities.

One of the difficulties in the inquiry process was the school culture. Pozuelos et al. (2010) stated that to implement an inquiry-based learning program at school, teachers are needed to provide a proper working environment for allowing collaboration, cooperation, accessible alternative materials, social awareness, and supporting colleagues. Pozuelos et al. (2010) also revealed that these problems originated from school culture and climate should be resolved for applying inquiry-based science activities.

Another problem faced by T2 in the implementation of inquiry-based science activities is low parental engagement. Perhaps the expectation of the teacher from parental involvement activities was too high. Pozuelos et al. (2010) found that some of the participant teachers stated that parental engagement in inquiry-based learning was low and parental support was minimum. In our study, T2 also complained about similar problems caused by low parental engagement. However, effective parental involvement is a key element of education not only supporting the achievement of children from preschool to further education levels but also improving the relations with families, teachers' morale and the school climate (Hornby, 2000; Hornby 2011). Also, Saracho and Spodek (2008) emphasized the importance of reproducing the observations and research in various places such as the school garden and home for young children. Therefore, inquiry-based science activities should also be supported by parents. T2 was affected by low parental involvement and her motivation towards inquiry-based activities decreased. This finding could be attributed to the teacher's increased burnout. Friedman (2006) describe burnout as the perceived inconsistency between ideal professional expectations and challenging environmental factors and it causes negative feelings such as low morale, low self-esteem and stress. Friedman (2006) stated that teachers anticipate being recognised and respected for their expertise and efforts. The decreasing motivation of T2 can be explained by the phenomenon of teacher burnout because she could not get enough appreciation from the families. Teacher's motivation is considered a crucial effect on inquiry-based science activities.

Conclusion

This action research concluded that the teacher made significant improvements in planning, implementing and evaluating the inquiry-based science activities in her classroom. During the development of inquiry-based science activities, supportive and restrictive behaviors and utterances of T2 had existed. One of the conclusions of this study is that the teacher should support the inquiry process with a wide range of behaviors and utterances to engage five-year-old children. Thus, the teacher evolved into a child-centered and guiding teaching role during the process. The second conclusion is that some difficulties occurring from the teacher herself and the external factors during the implementation of inquiry-based science activities. These problems could recede over time through the action research cycles. While the inquiry-based science activities, the teacher could not find enough support in the school culture initially, afterwards thanks to the enduring and persistent attitude of the teacher the inquiry-based science activities found a place in the school. Parental involvement activities planned by the teacher to support children's inquiry processes had emerged as a problem due to low participation in some action cycles. Besides, the teacher stated that the physical facilities of the school were insufficient to perform inquiry-based science activities. In conclusion, not only the teacher's attitudes and behaviors but also the school culture, parental involvement and physical facilities of the school are important factors to carry out inquiry-based science activities in early years' education.

In this study, we found that the engagement of children increased. They gained experiences, started asking questions, revealed their curiosity, and communicated more with their teacher and peers during the inquiry-based science activities. Finally, we conclude that inquiry-based science activities can be practicing at various inquiry levels in early childhood education. However, at this point, the preschool teacher should be supported procedurally, practically, technically and emotionally. Thus, in this collaborative action research, the teacher successfully implemented inquiry-based science activities with the knowledge and experiences obtaining from her practices and reflective evaluations on her teaching. Thereby, the purpose of early childhood science education can be accomplished through inquiry-based science activities in which children actively take part in problem-solving situations originating from their curiosity and experience the inquiry skills.

Recommendations

According to the results, teachers should be informed about teaching methods and techniques supporting the inquiry and creating an inquiry atmosphere to perform inquiry-based science activities in the preschool stage. Attempting to carry out inquiry-based science activities the teachers should plan the learning experiences that are associated with children's immediate surroundings, appropriate to their developmental level. Also, these activities should be planned and conducted to use basic inquiry process skills. In this regard, printed, audio-visual resources should be provided to teachers. Since school culture has emerged as an important factor in this study, colleague cooperation, teachers' professional development, research projects, collaboration with universities-organizations should be encouraged and supported. The school should determine a curriculum embracing inquiry-based learning and create an accepting and open atmosphere for applying the inquiry. While applying inquiry-based science activities, teachers should be provided with the opportunity of reflective evaluation to recognise the difficulties encountered in the process. Teachers' awareness about the process can be increased with monitoring and evaluation tools such as evaluation forms, diaries and camera recordings regarding their practices at regular intervals.

This study is focused on a teacher's developing process of inquiry-based science activities. We recommend future research, to focus on the progress made by children, to expand the study group of teachers and to search the outcomes of the inquiry-based science activities both for teacher and children.

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