A Quality Snapshot of Science Teaching in Turkish K-3rd Grade Programs

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Abstract

This study aimed to capture a vivid picture of the quality of science teaching in K-3rd grade programs in Turkey. The sample comprised 80 teachers in 20 K-3rd grade programs in Ankara, Turkey. A qualitative interpretative research design was used in this study. The data were collected using content analysis, observation and interviews. Phenomenological analysis were used to analyze the study data. The results showed that science topics are broadly covered in K-3rd grade science education curricula. Majority of teachers who teach science in K-3rd grade programs lacked a sound science education background. Classrooms in general lacked a specific rich science area. Range of science activities and teaching techniques were used in teaching science to young children. Telling/explaining and questioning were the most common instructional methods used. Assessment of science learning is usually equated with testing. Several practical implications for K-3rd grade programs, teachers, teacher education programs, and policy-makers are presented.

Introduction

Science is often viewed as an encyclopedia of discoveries, inventions and technological achievements. When science is taught in schools, teachers often promote this view by requiring the memorization of seemingly endless science concepts. Research shows that questions requiring recall of factual science information dominate in classroom practice (Harlen, 2001). Science is usually presented as a static collection of facts to be transmitted by the teacher and memorized by students. However, we are living in an age that science has been compiling a mass amount of new discoveries, facts, and data over the years (Charlesworth & Lind, 2010). It is literally impossible to teach all these scientific information to young children and totally unlikely for them to learn all. Yet, science is not the only subject that young children study in kindergarten programs and elementary schools. Thus, to improve the quality of young children's science learning experiences it is vital to understand how well science is taught in schools, the profile and competence of K-3rd grade teachers to teach science, the amount of time allocated for science learning, and the suitability of K-3rd grade learning environments for science teaching and learning.

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Is teaching science at early childhood and early elementary years worthwhile in terms of its impact on children's later scientific understanding and learning? This depends on what and how science is taught (Harlen, 2001) and on children's subsequent experiences of science learning at these levels. Science, in different forms, is taught at early years in almost all countries of the World. But, how is it taught? National Research Council (NRC) (1998) suggests that an approach to science teaching and learning that emphasizes the development of scientific thinking and a positive attitude towards science would seem to be the most appropriate strategy for education of young children. According to NRC the provision of high-quality science learning environments, science teaching and science learning experiences in early years will pay off with increased long-term achievement in, and student engagement with science. The quality of teachers, curriculum, instruction, learning environments and educational experiences children have in early years of schooling are closely linked with positive developmental outcomes for young children (Pianta, LaParo, Payne, Cox & Bradley, 2002). Thus, in this research, the researchers took the position that high quality teachers, curriculum, instruction and learning environments provide high quality science learning for young children.

Given the diversity of understanding and interpretation of quality teaching, defining and improving it require a framework designed to achieve an analysis of quality that enables its various dimensions to be specified, an approach to measurement that enables the important variables to be identified and assessed, a framework for improvement that comprehensively covers the interrelated components of the education system and allows opportunities for change and reform to be identified (UNESCO, 2004). With this in mind, the variables of quality teaching examined and assessed in this study included curriculum, teacher profiles, instructional methods and strategies, various elements of learning environment and assessment practices. A comprehensive science teaching quality study, such as the current one, enables a broader understanding of science teaching in K-3rd grade programs. Aiming to capture a snapshot of the science teaching in K-3rd grade programs, this study raises important questions about careful allocation of funding of future investments in science education. The research evidence indicates that young children's experiences during early years of schooling are critical. High quality teaching, curriculum and learning environments as well as the qualified teachers in schools are identified as the key levers for improving outcomes for young children and providing strong foundations for future learning (Bailey, 2002).

A science teaching quality portrayal study also contributes to the science education reform efforts in a significant way by building upon and adding to the lack of knowledge there is regarding the quality of teaching, teachers, curriculum, learning environments and quality of young children's science experiences. Specifically, examining quality of science teaching in K-3rd grade programs is imperative to understanding the science education reform movements and what works well at local levels in comparison to global perspectives of quality science teaching. Furthermore, outcomes of such a study provide stakeholders at the local level with an impetus for improving conditions for young children's science learning. The findings might shed light on the efforts of education bodies and committees to implement higher standards for early science education at the local levels. These efforts might target the changes in early childhood and elementary science education policies, development of new and improvement of existing national science education curricula and improvements in the systems for early childhood, elementary and science teacher education programs. It is more likely that the outcomes provide support for teacher education programs and faculty in designing programs for in-service and pre-service science, early childhood and elementary education teachers.

Science learning has been strongly advocated and emphasized in Turkish early childhood and early elementary education curricula for its importance to young children. Over the last decade, there has been considerable amount of curriculum changes across different grade levels of science education in Turkey. For instance, like many other countries, Turkey has now embraced a standards-based or an outcome-based approach to curriculum. However, no research efforts have been undertaken to examine the influence of changes on quality of science teaching and learning. While there has been extensive research (Cambell and Jobling, 2010; Harlen & Holroyd, 1997; Kallery & Psillos, 2001; Kelly

& Staver, 2005; Murphy, Neil & Beggs, 2007; Rennie, Goodrum & Hackling, 2001; Sackes, 2012; Sharp, Hopkin & Lewthwaite, 2011; Tu, 2006; Tytler, 2009; Wang & Lin, 2009) on the assessment of the quality of science teaching in early childhood and elementary education programs, only a few have been concerned with the overall quality of science teaching in different contexts. Many of these studies examined the quality variables such as curriculum, environment, teachers, students' learning experiences individually or a few of these variables together. This is also true for the Turkish context. Studies that examined the quality of science teaching in Turkish early childhood and elementary programs are limited and narrow in scope. Only a few studies of these studies examined the science curriculum for elementary grades (Aydin & Cakiroglu, 2010; Ercan & Altun, 2005; Es & Sarikaya, 2010; Eurydice, 2006; Tasar, & Karacam, 2008); a few portrayed science teacher profiles at different schooling levels (Eurydice, 2006; Telli, Brok & Cakiroglu, 2008; Yamac, 2014); and, several other studies examined elementary science learning environments (Acat, Karadag & Kaplan, 2012; Ozel, Yilmaz, Beyaz, Ozer, & Senocak, 2009). None of these studies looked into the different dimensions of science teaching comprehensively. To fill the gap in this area of research, the current study examined the overall quality of science teaching in K-3rd grade programs in Turkey. Specifically, this study addressed the following four critical questions relating to quality of science teaching and learning in K-3rd grade programs:

(1) What is the profile of science teachers in K–3rd grade programs in Turkey?

(2) How is science offered in K–3rd grade programs in Turkey?

(3) What is the place of science in K-3rd grade curricula in Turkey?

(4) How does science learning environments look like in K–3rd grade programs in Turkey?

Method

Sample

Convenient sampling technique was used in this study in order to maximize the diversity of programs, teachers and students. The sample comprised 80 classrooms (24 classrooms in private schools and 56 classrooms in public schools; in a total of 20 different schools) and 80 teachers in Ankara, Turkey. The ages of participant teachers ranged from 21 to 53 (M = 36.5). Sixty-eight of the teachers (85%) were female and 12 (15%) were male. Twenty-six (32.5%) were teaching kindergarten; 16 (20%) were teaching 1st grade; 14 (17.5%) were teaching 2nd grade; and, 24 (30%) were teaching 3rd grade.

All teachers who participated in this study had BS degrees. Sixty-two (77.5%) majored in education (early childhood and primary education); four majored in child development; four majored in Science and Arts; four majored in Agriculture; two majored in computer science; two majored in curriculum and instruction; one majored in communication and one in statistics. Teachers' years of teaching experience ranged from 1 to 33 (M = 11.57 years).

Data Collection and Analysis

This study employed a qualitative interpretative research design that measured different aspects of science teaching, enabling a rich snapshot of the quality of science education in Turkish K-3rd programs. The data for this study was collected using content analysis, observation, and semi-structured interviews. Using multiple sources to analyze science teaching in Turkey has the advantage of characterizing the picture through the eyes of teachers who participated in this study and capturing the data which the researchers could miss or consider unimportant.

The research process began with an analysis of curriculum documents and textbooks followed by teacher interviews and simultaneous classroom observations. Curriculum documents and textbooks were analyzed using content analysis (Silverman, 2011). The purpose was simplifying and reducing the large amount of data obtained from science sections of the curricula into organized segments. To do this, national early childhood and primary education curricula, published by

Ministry of National Education (MoNE), and private school curricula were examined in terms of structure and time allocated for science education and textbooks were examined in terms of science topic coverage.

In order to obtain clear picture of what was happening in K-3rd grade programs, in terms of science teaching, observations of learning environments and interviews with teachers were conducted. During the interview sessions, teachers were asked specific questions about their educational and professional background, their teaching, students' learning, instructional techniques they use, activities they offer, assessments that they conduct and science learning environments that they design. Simultaneous classroom observations were conducted by the researchers while interviews were conducted. A checklist—the 'Science Learning Environment Checklist (SLEC)' (see Appendix 1)— was used to record the observation data.

SLEC was developed by the researchers using the Early Childhood Environment Rating Scale Revised Edition (ECERS-R) (Harms, Clifford & Cryer, 2005), an observation tool that was developed to broadly assess global process quality of early childhood learning environments, as a reference. The researchers also asked two of their colleagues with expertise in early childhood and elementary science education to comment on the content and appropriateness of the SLEC. SLEC had items related to space, materials/equipment, instructional techniques and activities, assessment, and interaction. During the instrument development stage, inter-observer reliability was established independently by the researchers. To establish inter-observer reliability, the researchers worked together in coding the data and conducted several pilot observations together. During the coding training phase, discrepancies in coding were discussed and solutions were mutually agreed upon. Inter-observer reliability was 88 % for the coding for SLEC.

The analyses of the data for this study were founded on an phenomenological analysis (Moustakas, 1994)—a method that involves describing the meaning for several individual of their lived common or shared experiences of a phenomena as well as clusters of meaning from empirical observations of the phenomenon into themes. The basic purpose of phenomology is to reduce individual experiences to a description of the universal essence (Creswell, 2007).

To increase the credibility and validity of the results (Silverman, 2005), themes that emerged from the data were later verified by the participants to allow them to shape the themes emerging from the process. The researchers also asked two of their colleagues with expertise in the research topic and a background in early childhood and elementary science education to comment on the study design, research questions, and study results as they emerged.

Results

In analyzing data, the researchers initially developed a comprehensive snapshot of the science teaching in Turkish K-3rd grade programs. The phenomenological model for a snapshot of science teaching in K-3rd grade programs in Turkey, developed from this study, is shown in Figure 1.

TEACHER PROFILE

80 teachers

Interviews & Observation

- Generalist teachers
- BS degrees
- ECE & ELED majors
- Non-education degrees with teaching certificates
- Teaching across disciplines in a single class

CURRICULUM

Curriculum Documents & Textbooks

Document Analysis

- Life Studies curriculum
- Themes
- Life studies is as a discrete subject in ELED
- Integrated science in kindergarten

ENVIRONMENT

Programs

Observation & Interviews

- Large class sizes
- Lack of science specific areas in classrooms
- a few science labs
- Lack of science materials and resources
- Some technology
- information talk by teachers
- Enhancing talk with drawings in kindergarten
- Use of visual materials to anchor and augment talk
- Few interactions among students
- Strict discipline methods

INSTRUCTIONAL METHODS AND STRATEGIES

Teaching Practices

Observation & Interviews

- Telling, explaining, questioning, reading, experiments, projects, demonstrations, drama, play, story-telling
- Treating students alike
- Focus on acquisition of information
- Frequent use of individual work
- Very few small group work
- Frequent use of extrinsic motivation sources
- Supporting competition

ACTIVITIES

Teaching Practices

Observation & Interviews

- Simple science experiments
- Technology supported interactive instructions
- Few observations
- Few science/nature books, games, toys
- Few field trips

ASSESSMENT

Learning Environment

Observation & Interviews

- Assessment is equated with questioning, grading
- Frequent use of summative assessments
- Very few formative assessments
- Questioning students for factual information
- Observations
- Take home performance tasks
- Presentations

Figure 1. A Snapshot of Quality of Science Teaching in Turkish K-3rd Grade Programs

Teacher Profiles

Two major types of teacher profiles for the Turkish K-3rd grade program context—elementary generalist teachers (EGTs) and kindergarten generalist teachers (KGTs)—emerged from the analysis of the interview data. These profiles were sketched by the researchers after careful analysis of the teachers' responses to interview questions. Educational and professional qualifications were the elements utilized by the researchers to portray the profiles of the participant teachers.

The findings of this study indicated that science is offered by generalist teachers, with weak science education backgrounds. These teachers teach across disciplines in a single class. All participant teachers were graduates of 4-year undergraduate programs. None had a science education degree or certification. Majority of the EGTs majored in primary education and most of the KGTs majored in early childhood education. Interestingly 18 of the participant teachers (%22.5) majored in a discipline other than education. All of the non-education majors had to receive a 'pedagogical formation training' after they had completed their 4-year degree programs. This training is offered by teacher education programs at universities. The training consisted of 21-credit-hour of general pedagogical content and professional knowledge courses. These courses did not cover subject-specific (i.e., science) pedagogical content knowledge. Thus, none of the non-education degree teachers had training in science education pedagogy. On the other hand, the teachers with an education degree had only one or two science pedagogical content courses and one-to-three science content knowledge courses (i.e., biology, physics, chemistry) during their study at the college level.

Place of Science in K-3rd Grade Curricula

In this study, the place of science in K-3rd grade curricula in Turkey was examined in terms of structure—the topic(s) studied and the time allocated for science per academic year. The results revealed that science education is offered as part of an interdisciplinary thematic curriculum in K-3rd grade programs. Science in early elementary education (1st-3rd grade classrooms) is offered as part of an interdisciplinary course called "Life Studies." The curriculum for this course consisted of the following themes: personal, self and social development; science and nature; home; yesterday, today and tomorrow; life skills; etc. It is taught by EGTs as a discrete subject and a total of 160 minutes (four periods of 40-minute classes) per week is allocated for this course.[4] Yet, science was only one of the three-to-four subjects that are included in the interdisciplinary life studies curriculum; thus, teachers only spend one-third or fourth of the whole class time for covering science subjects throughout the academic year. On the other hand, science in Kindergarten classrooms is not taught as a discrete subject, separate from math, social studies, language, art, health and movement, drama, etc.. A considerable amount of teaching time per week is dedicated to science education in these programs.

An examination of kindergarten and early elementary education curricula revealed that the content of science education (extracted from the life studies curriculum content and textbooks) consists of a comprehensive list of themes (*See* Table 1). As it can be seen from Table 1, the Turkish kindergarten and early elementary education curricula recognize the developmental nature of science knowledge and skills that young children can acquire and consequently that the knowledge and skills can be achieved at a range of increasingly complex and sophisticated levels.

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[4] As of 2012-2013 year, the number of life studies course per week in 3rd grade was decreased to three from four by Ministry of National Education, and a 3-hour-per week science education course was added to 3rd grade programs.

Learning Environment

Physical environment – Space, equipment and materials

The results of observation and teacher interview data revealed a general picture of "moderate-quality" physical learning environments for science education in K-3rd grade programs. All kindergarten programs observed in this study lacked a science specific learning area. Some had tables used for science activities, some had live plants on window edges, some had water and sand tables; but, none spared a specific area of the class for science teaching and learning. As for the picture of elementary science physical learning environments, majority of the elementary programs that were observed in this study did not have science specific classes. These elementary education programs usually had multipurpose general classrooms, which were commonly shared for all subjects. Only a few public elementary programs and most of the private elementary programs spared a specific science room for science teachers; however, they were not much different than rooms that were allocated for other subjects. The major differences between science rooms and the rooms for other subjects were the displays on the walls and some materials included in these rooms. In terms of science lab, all private schools and only a few public schools had a science lab. However, these labs were generally used by upper grades. Teachers usually conduct their science activities in their own classrooms. In terms of class sizes, the results indicated that Turkish K-3rd classrooms have large class sizes. The number of students in kindergarten ranged from 20 to 25 and it ranged from 20 to 35 students in 1st through 3rd grade classrooms. These classes were taught by one teacher only.

Table 1. Themes Emerged from the Analysis of Turkish K-3rd Grade Curriculum and Textbooks

Grade	Themes
Kindergarten	body parts, senses, properties of objects and materials (size, weight, length, color, form, function, smell, sound, taste, etc.), characteristics of living and non-living things, natural environment and patterns in the environment, changes that occur in the world (plant growth, colors, stages of living things, time, night and day, seasons, weather, etc.)
1st Grade	body parts and their functions, senses, health and personal care hygiene, needs of living things, living things and their homes, environment and changes in the environment
2nd Grade	self and differences among individuals, self-care and health, food, nutrition and health, growth and health, changes in the body, healthy living, natural resources, keeping the environment clean
3rd Grade	similarities and differences among individuals, healthy living, natural disasters, protecting the environment, our planet: Earth

The most common science equipment and materials in Turkish K-3rd grade programs were microscope, magnets, magnifying glasses, thermometers, flashlights, measuring cups, science books and magazines, natural materials, live plants, TV and DVD players. Majority of the classrooms were provided with magnifying glasses, magnets, flashlights, thermometers, live plants respectively. Additional science materials included calendar, globe, materials with different softness, skeletons, and human body models, etc.. The results also showed that majority of the participant teachers brought their own science materials to their classrooms. In addition, most of the programs had a TV and DVD player that are used for educational purposes. However, only 16 of the programs had a computer placed in the classrooms and a printer connected to them. It is important to note here that all teachers stated that their programs had shared computers, printers, projectors, internet access, and other audio/visual materials that are used to add information and extend children's experiences.

Social environment – Interactions

In an attempt to capture a snapshot of quality of science teaching in Turkish K-3rd grade programs, the researchers also examined the interaction that occurs in K-3rd grade programs. To do so, interactions among students, between students and teachers, families and teachers and among teachers in regards to science teaching and learning were examined through classroom observations and teacher interviews. The results showed that the most common form of interaction observed between students and teachers was in the form of information talk (describing objects, events, actions, thoughts, etc.). Teachers spend most of their teaching time by providing factual information to students. They occasionally use visuals—i.e., drawings, pictures, short power point presentations and videos— to anchor and augment this talk and thus increase students' interest and participation.

Teachers also use questioning to guide children's thinking and increase interaction. They often use it to introduce a new activity or topic or to lead recitation of key facts and information as a way of reviewing knowledge that students have already acquired. Questioning usually happens individually rather than as a group. Teachers give permission to individual students to a question posed by them, rather than asking the students to work on the response of the questions collaboratively. Communication between the teachers and students were one way, in the form of teachers lecturing and questioning students.

Students in 1st-3rd grade, in general, are expected to sit quite and listen to the teacher or other students who were given the permission to speak. Very few interactions among students were observed in these classrooms. However, in kindergarten programs, children seemed to be interacting with one another very often and teachers spend most of their time with small and large group class activities. When children are offered science activities, they tend to be communicating with each other, observing and helping each other and sharing ideas with one another.

In terms of the interaction between teachers and parents/families, teachers were asked to share the frequency of their interaction with parents/families. Teachers, in 1st through 3rd grade programs, reported that they do not often communicate with parents/families and parents/families do not involve much in their children's education by coming to school but do so when a parent/teacher conference was held at school. However, teachers also reported that parents/families may visit school when they are not happy with the performance of their children at school. For the case of kindergarten parents/families, teachers reported that some parents pick up their children from kindergarten, and when they come they may have very short informal talks with them about how their kids are performing.

Instructional Methods, Strategies and Activities

Analysis of the teacher interview and observation data showed that teacher-centered classrooms appear to be the norm in Turkish K-3rd grade programs even though it was possible to see a range of instructional methods, strategies and activities in teaching science. Lecturing (telling/explaining) and questioning were the most common instructional methods that were observed in 1st-3rd grade classrooms. However, a few of the teachers also reported that they used problem solving, inquiry, drill/practice and demonstrations in their teaching. On the other hand, the type of instructional methods that are used in kindergarten programs were different compared to the ones used in 1st-3rd grade classrooms. The results revealed that drama, play, project-based learning, story-telling, reading were the most commonly observed instructional methods in teaching science to kindergarten students. Overall, the types of instructional methods fell into ten major categories (*see*

Table 2 for the frequency distribution of the instructional methods). It is important to note here that many teachers reported the use of more than one instructional methods in their classrooms.

Table 2. Frequency Distribution of the Instructional Methods

Instructional Approach	Frequency	
	1st-3rd Grade Teachers (N = 60)	Kindergarten Teachers (N = 20)
Telling/Explaining	58	14
Questioning	52	10
Demonstration	32	16
Drill & Practice	26	8
Inquiry	25	8
Problem solving	25	6
Play	14	12
Drama	6	16
Story-telling	0	14
Guest speakers	11	6
Other	7	4

Teachers were also observed for the instructional strategies that they apply in their teaching science to young children. Majority of the study participants (both kindergarten and elementary teachers) treat all students alike, without considering the individual differences among their students (i.e., abilities, interest and learning styles), and respond to the group as a whole. They tend to focus on students' acquisition of the information provided. They expect students recite the information acquired and check if this is achieved through question-answer sessions. Almost all of the participants occasionally use extrinsic motivation sources (i.e., rewards such as grades, stars, candies, etc.) in their teaching. They use and support competitions in their classrooms. Teachers in 1st-3rd grade classrooms generally present the scientific knowledge through lecturing, textbooks and demonstrations. Students are rarely offered small group activities in these classrooms and are often given drill-and-practice activities.

Moreover, analysis of the science activities participant teachers brought into their teaching were conducted through observations, interviews and student work samples. The results indicated that majority of participant teachers use simple science experiments such as experiments with magnets and magnifying glasses, sink-and-float, color change, cooking, air, nutrition, growth, etc. A few teachers mentioned the use of nature/science books, games, or toys. Other response categories included use of interactive lectures, field trips, observation of plants and small animals, weather change, investigating soil, rocks and leaves.

Even though it is rarely done, it was found out that students' science learning in Turkish K-3rd grade programs is enriched by activities conducted in natural environments, in the community and at several other institutions such as hospitals and museums. Students were also taught by using technology. Even though the overall use of media in teaching was very common, the use of it in science teaching was scarce. Teachers also stated that they select their activities based on the unit objectives and based on the availability of the resources for activities. Except two teachers, none mentioned students' prior experiences, needs and interests as a criteria for selecting activities for their teaching.

Assessment

Teachers were also asked to describe the typical assessment methods and tools that they use in teaching science to young learners. The results highlighted that "assessment" in 1st-3rd grade classrooms is commonly equated with exams, questioning, grading, and providing feedback to students and parents. The exams generally consist of short answer questions and/or multiple-choice

tests. In the first grade classrooms, these exams are generally conducted orally. Questioning was the second most common method used by 1st-3rd grade teachers. Students were usually asked to respond questions at the end of the instruction, towards the end of class period, unit or chapter. They are usually asked to provide factual information that was covered during the instruction. Homeworks and take-home performance tasks were the third common assessment methods mentioned by the early elementary teachers. Other assessment methods cited were observations and oral presentations.

The findings also showed that the assessment methods which were used in teaching science to kindergartners included formal and informal observations, anecdotes, checklists and rating scales that were used to record the observation data, portfolios or collections of work samples as a method of demonstrating evidence of achievement. A few teachers also mentioned that they use work-and-drill practice, worksheets/workbooks to assess young children's science learning.

In terms of the use of formative assessment in teaching science to K-3rd grade students, only a few mentioned the use of formative assessment methods. These methods were limited by the frequent use of feedback, asking questions to tap student thinking and using projects to improve learning.

Discussion

This study examined the quality of science teaching in K-3rd grade programs in Turkey by capturing a snapshot of teachers in these programs, science curricula for these grades, learning environments (including space, equipment and materials) instructional methods and activities, assessment, and interaction in science learning environments. In general, the results demonstrated that the quality of science teaching and learning in Turkish K-3rd grade programs is moderate.

The researchers believe that the most important factor in determining the quality of science teaching and learning in Turkish K-3rd grade programs are the teachers who teach science in these programs. The results on teacher profiles suggest that science in these programs is taught by generalist teachers who have a wide range of educational backgrounds. The results also suggest that these generalist teachers are not well prepared to teach science to young learners in K-3rd grade programs. Most of these teachers have weak science education backgrounds. In order to teach science to young children, teachers need sound science content and pedagogical content knowledge and skills, which includes an understanding of science content and inquiry processes, knowledge of children and how children learn, and skills for facilitating children's experiences in ways that support their active inquiry and conceptual development (Chalufour, 2010; Sackes, 2012). Research shows that teachers more effectively teach and improve student learning if they have strong academic skills (Darling-Hammond, 2000), appropriate formal training in the field in which they teach (Ingersoll, 1999). Thus, the role of teachers in quality science learning is critical; their knowledge of children, of teaching and learning, and of pedagogical science knowledge. Children in Turkish K-3rd grade programs need teachers who have those skills. To be able to comment on the effects of teacher background on the quality of science learning at student level further studies are still needed to reach firmer conclusions.

Moreover, even though having sound science content and pedagogical content knowledge and skills through preservice education is essential, but it is not enough. As suggested by Goodrum, Hackling and Rennie (2000) teachers need continuous support to maintain best practice throughout their career. Considering the backgrounds of the teachers who teach science in Turkish K-3rd grade programs, they need professional support by participating in ongoing practice based professional development activities. In-service professional development on science content and pedagogical content knowledge and skills is needed by Turkish K-3rd grade teachers also because they lack the practical science skills which can be passed from teachers to young learners. Consequently, this may lead to a deterioration high quality science learning throughout the learning cycle of these young learners. Thus, it is fair to say that the field of early childhood and elementary education could better serve young learners and those who teach them science by providing high quality professional development programs on early childhood and early elementary science.

Teachers are not the sole contributors to quality of science teaching that takes place in Turkish K-3rd grade programs. Thus, the researchers also examined the picture of the early childhood and primary education curricula through content analysis of the curricular documents and textbooks used in K-3rd grade programs. The results showed that, in Turkey, science is offered as part of an interdisciplinary life studies thematic curriculum in first through third grade primary school programs. It has an emphasis on scientific facts and information. Overall, the life studies curriculum covers too many topics (including science). Yet, teachers tend to offer more than what the curriculum suggests. They spend less time on science investigations and do not focus much on science inquiry skills to cover the comprehensive curricular content. As suggested by National Research Council (1998) the science education curriculum for young children should have more emphasis on investigations in order to develop understanding, ability, values of inquiry and knowledge of science content. Rennie, Goodrum and Hackling (2001) asserted that experimental investigation is central to the pursuit of science and the learning of science; thus, minds-on, as well as hands-on, practical work is an essential component of the science curriculum. Rather than focusing mainly on scientific facts, Turkish first through third grade curricula should integrate all aspects of science content for young children and promote experiential learning, hands-and-minds-on practical work.

Moreover, the students in Turkish K-3rd grade programs should be provided with chances to investigate real-life topics through projects that are not limited by time periods so that they make sense of the world around them. Good science investigations take place over extended time, both short term and long term. Worth (2010) asserts that engaged children may stay with science investigations for significant periods of time, and some children may need time to get involved. The course scheduling in Turkish 1st-3rd grade classrooms (40-minute-class periods) limits inquiry-based science learning. In addition, science work in interdisciplinary life studies curriculum is episodic and not available regularly during the week. This effects the continuation of learning and reduces the opportunity that students might have to draw conclusions from their investigations. Time dedicated to science education in the first through third grade primary school program curricula in Turkey brought limitations to the teaching of science in these programs. Thus, there was a need for reexamination and modification of the science education component of the Turkish early elementary education curriculum. Nonetheless, the curriculum documents and textbooks examined in this study do provide guidance for kindergarten and early elementary education teachers; but, it is important to note that the nature of the documents cannot guarantee good teaching. It is the teachers who interpret these documents and they are the ones who can guarantee a quality learning based on the curriculum documents, students' backgrounds, needs and interests.

Another quality measure related to science teaching examined in this study was science learning environments, specifically physical environment (space, equipment and materials) and social environment (interactions among students and between students and teachers). Even though there was a quality variation between public and private programs and between kindergarten and early elementary programs, analysis of the physical learning environments in Turkish K-3rd grade programs revealed a general picture of moderate quality physical learning environments. The major quality issues in K-3rd grade programs were class size, availability of science materials and resources and physical space.

There is a plethora of early childhood and elementary education research (Cambell & Jobling, 2010; Earthman, 2004; Fisher, 2000; Pianta et al, 2002; Rennie, Goodrum & Hackling, 2001; Tu, 2006; Tytler, 2009; Wang, 2009) that suggests students and teachers are affected by properties of a physical learning environment that includes, but not limited to, space, seating, furnishings, resources, materials, tools, etc. The arguments in these research studies suggest that physical environment might contribute to optimal teaching and learning (Higgins, Hall, Wall, Woolner & McCaughey, 2005). Thus, in order to improve the quality of science teaching and learning in Turkish K-3rd grade programs, poor conditions in learning environments, which were portrayed in this study, need to be improved. For instance, class size was an issue in Turkish 1st-3rd grade science teaching (class sizes ranged from

20 to 35). Research cannot suggest an ideal class size, as it depends on the capabilities of the teacher and the students, and the nature of the science tasks undertaken (Rennie, Goodrum & Hackling, 2001). However, some research studies also suggests that the young children benefit most in terms of academic outcomes from small classes (Blatchford, Bassett, Goldstein & Martin, 2003; Ehrenberg, Brewer, Gamoran & Willms, 2001; Finn & Achilles, 1999), because children receive individual attention during science learning activities. In addition, to be able to execute 'practical' science work effectively in K-3rd grade programs, a class size smaller than 25, and a teacher to student ratio of less than 1-to-14 for 6-to-8-year olds is needed (NAEYC, 2013).

Moreover, results of the current study also highlighted that the size of the classroom space, the seating arrangement and the availability of science learning areas in these classrooms were also problems observed in Turkish K-3rd grade programs. Science in Turkish public K-3rd grade programs is taught in multipurpose general classrooms. The sizes of classroom spaces were small compared to the number of students in the classrooms. Majority of these classrooms do not have a science specific learning areas. They are not rich in terms of 'developmentally appropriate' science equipment and materials (some teachers use age and grade inappropriate equipment and material for young children). The ones that have the basic science equipment and materials share them with other classrooms. Despite the discouraging findings that most public schools lack the necessary science materials and equipment participant teachers in this study reported that they bring their own material to enrich children's science learning experiences and every school has computers, internet connection, TV and DVD player for common use. As suggested by UNESCO (2004), effective teaching and learning require wide and equitable availability of learning materials. Thus, the picture of physical learning environments for K-3rd grade science teaching in Turkey calls for urgent attention. Since this picture is poor, particularly in public schools, the Ministry of Education or the government in general needs to rethink of policies governing production and distribution of science learning materials and equipment.

Another quality measure examined in this study was the interactions in learning environments. In an attempt to capture a snapshot of quality of science teaching in Turkish K-3rd grade programs, the researchers also examined the quality of interactions that occur in K-3rd grade programs. The results highlighted that the most common forms of interaction observed between students and teachers in K-3rd grade classrooms were information talk (a form of one-way communication; students sit quiet and listen to the teacher; students ask for permission to speak) and questioning. Occasional use of visuals—i.e., drawings, pictures, short power point presentations and videos— to anchor and augment this talk was also reported by participant teachers. The results also showed that the interactions among students were very few (mostly during large group discussions) in 1st-3rd grade classrooms and more common in kindergarten classrooms. The researchers believe that the nature and quality of interactions in a learning environment improve students' academic achievement. Consistent evidence suggests that the curricula, the teachers, instructional methods by themselves can not make a big difference in the quality of learning (LaParo, Pianta & Stuhlman, 2004). Effective interactions among students, and between teachers and students are essential for promoting long-term school success (LaParo, Pianta & Stuhlman, 2004; Locasale-Crouch et al, 2007; Pianta, Belsky, Houts, & Morrison, 2007). Thus, to improve the quality of science teaching and learning in Turkish K-3rd grade programs students should be given opportunities to participate, share, discuss, reason in solving scientific problems/tasks. There needs to be a mutual respect among students and between students and teacher in the learning environment. Brenneman (2011) asserts that, during these interactions, teachers need to be well versed in the kinds of knowledge that students already have about science topics, the reasoning skills they possess, and the potential limits of those skills.

UNESCO (2004) suggests that what goes on in the learning environment has been identified in numerous studies as the crucial variable for improving learning. The way that students learn and teachers teach are of critical concern in any educational reform designed to improve quality. With this in mind, the researchers also examined a snapshot of what goes on in the learning environment (i.e.,

teaching strategies, methods, activities) through observations and teacher interviews. It appeared from the results of this study, in teaching science, teacher-centered learning environments appeared to be the norm in Turkish K-3rd grade programs. Even though it was possible to see occasional use of a range of student-centered instructional methods, strategies and activities (i.e., inquiry, problem solving, demonstrations, observations, reading, projects), the common methods of teaching were telling and explaining, questioning and using drill/practice activities. Rather than individualizing their instructions, participant teachers tend to treat all students alike, provide whole class instruction (through lecture, demonstrations, reading, interactive presentations) and respond to the class as a whole. The researchers believe that good teaching or instruction leads to effective and lasting learning. National Research Council (1998) asserted that science teaching must promote active learning, inquiry, problem solving, cooperative learning, discussions and decision making. Tytler (2009) also confirms that students should be given opportunities to interact with their peers and teachers and establish connections between what they learn and their lives, interests, concern.

The findings of this study on instructional methods, strategies and activities call for and advocacy for the use of inquiry based active learning strategies in teaching science in K-3rd grade programs. In order for Turkish young children benefit from their science classes, teachers of science in K-3rd grade programs should plan inquiry-based programs for their students and guide and facilitate learning. They need to promote problem solving, inquiry and process skills, hands-and-minds on exploration and observation skills. Students in these programs should be provided learning experiences that actively engage all students individually and as members of collaborative groups. They need to be given responsibilities for their own learning, encouraged to ask questions and to request resources to enhance their learning. Their learning experiences should be enhanced through opportunities for outdoor learning (field trips and visits to science centers and exhibits) so that their interest and enthusiasm for and engagement in science increase.

Assessment is an integral part of the science teaching and learning process, thus should enhance the quality of teaching (Goodrum, Hackling & Rennie, 2001). The examination of assessment practices in K-3rd grade programs, in this study, highlighted that assessment in early elementary science education is equated with exams, questioning, grading and providing feedback to the students and parents. It is also evident from the results of this study that assessment in kindergartens are done both formally and informally using observations, portfolios and through work-and-drill practices. To improve the quality of science teaching in K-3rd grade programs, a sound assessment policy is crucial. For the assessment to be influential, it should be consistent, regular and reliable, reconcile both formative and summative assessments with a strong focus on providing feedback to the learner and teacher (UNESCO, 2004). Evidence shows that by giving feedback to students, formative assessment can help improve their learning (Black & Wiliam, 1998). Moreover, the assessment process in K-3rd grade science learning environments should involve identifying evidence of children's science learning during everyday classroom activities by collecting data over time from multiple sources (actions, talk, and artifacts that children create). Individual student portfolios composed of teachers' descriptions of students' learning as well as children's work products (activity samples, pictures of children at work, drawings, concept maps, journals and so on) provide evidence used to assess children's science learning (Brenneman, 2011).

Implications

Based on the findings of this study, several practical implications for K-3rd grade teachers and programs, teacher education programs, teacher educators, and policy-makers can be drawn. The current study was vital for early childhood and elementary science teachers Turkey, as it provided opportunities for these teachers to explore their science teaching practices and provided useful information to those engaged in early childhood and elementary education in Turkey. This study may also encourage K-3rd grade teachers to re-examine their science teaching practices and learning environments. A clear implication of this study for teachers is that much can be done to significantly improve science education in K-3rd grade programs by improving teacher effectiveness in teaching

science. This, in turn, requires attention to science education pedagogy and the way kindergarten and early elementary teachers teach science.

This study has implications for kindergarten and early elementary education programs as well. There is no perfect science learning environment that is very optimal for science learning. However, providing a variety of spaces within a learning environment supports interactions among students and between students and teacher. Non-traditional, modern learning environments may encourage students to fully participate in activities with others as they build their own understandings of science concepts and phenomena.

The present study also has implications for early childhood and elementary teacher educators and teacher education programs not only in Turkey but also in other parts of the world. By closely examining these results, teacher education programs and faculty members might reconsider the structure of early childhood and elementary teacher training programs to better prepare newly qualified teachers to teach science to young children. In addition, results obtained from this study might give insights to teacher education programs and teacher education faculty to design professional development workshops that might help teachers in the field to be equipped with the knowledge and skills to incorporate contemporary science education practices in their teaching. Teachers do not enter the teaching profession as finished products. Continuous professional development is critical to developing and maintaining high quality science teachers. The education bodies which hire, supervise and evaluate teachers must ensure that all teachers in their jurisdiction have the chance to improve their classroom instruction by receiving ongoing training aimed at professional growth and better student outcomes.

This study has implications for educational policy makers. It highlights seven major educational policy areas that call for attention—developing and/or restructuring relevant science curriculum content, using and managing time well, ensuring that students have high quality teachers, using effective teaching methods/strategies, ensuring continuous professional development for teachers based on their needs, developing and distributing developmentally appropriate science learning materials and developing a sound assessment policy. The results presented in the current study may serve a vital role in reforming early childhood and elementary science education to better meet the needs of youn students.

Limitations and Further Research

The current study, with its rich data, lays the groundwork for examining and understanding science education practices in K-3rd grade programs. However, it is not without limitations. The sample size in this study was small (20 programs and 80 K-3rd grade teachers), and the geographic location was very specific. To improve generalizability, future research should include a larger sample that consists of programs and teachers from different regions of Turkey. Some of the conclusions drawn here in the current study were deduced from teachers' depictions of their own practices and a few observations that were conducted in K-3rd grade programs. A much more close examination of teacher practices might give us a much clearer understanding of the quality of science teaching and learning in Turkish K-3rd grade programs.

Conclusions

This study suggests that to improve science teaching and learning in K-3rd grade program, there is a need for high quality teachers, effective science teaching methods and strategies and high quality science learning environments. To accomplish this, teachers need to reflect on their professional and personal qualities, on their teaching and assessment practices, and utilize the science resources/materials that are available for science teaching.

Teaching science in the early years of schooling can be challenging. Teaching and learning at this stage is closely linked to concepts, events and phenomena surrounding children's everyday world. As Chalufour (2010) suggested effective science teaching needs to embrace science knowledge, skills and processes, and provides multiple opportunities for young children to use these knowledge, skills and processes so that they can apply these across the many experiences they have in their daily life. Beginning to build this knowledge at an early age involves teachers who are well grounded in science education knowledge and practice. Science education at K-3rd grade level should provide students with purposeful and meaningful learning experiences that are of high quality and developmentally appropriate. In addition, in order science learning to be effective teachers need to possess the knowledge of child development and learning, the knowledge of science content and science education pedagogy, and the knowledge of developmentally appropriate science learning environments.

It was important at the outset of this study to develop a framework of 'effective' teaching and learning in science, which might guide teachers, schools, teacher education programs and policy makers in improving science education practice in K-3rd grade programs. Priority should be given to improve the quality of science teaching and learning in the early years of schooling so that our young students can experience a rich science education experience that will make a difference in their lives.

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APPENDIX 1. *Science Learning Environment Checklist (SLEC)*

Checklist completed by :	Date :
School :	Grade :
Number of students in class :	

<p align="center">SCIENCE LEARNING ENVIRONMENT CHECKLIST</p>

Space	✔	Materials/Equipment	✔	Instructional Techniques	✔	Instructional Activities	✔	Assessment	✔	Interaction	✔
Adequate space for students		Science books/magazines		Telling/Explaining		Observation		Summative assessments		Information talk	
Adequate space for activities		Computer & Printer		Questioning		Experiment		Formative assessments		Information sharing	
Space for movement		Internet		Demonstration		Prediction		Norm-referenced		Cooperation	
Desks in raws		TV & DVD player		Drill & Practice		Reading		Criterion-referenced		Collaboration	
U-shape seating		Natural materials		Inquiry		Writing		Exams		Students have a voice	
Individual desks		Live plants		Problem solving		Movement		Performance tasks		Small-group discussion	
Circle seating		Living animals		Play		Construction		Oral Questioning		Rules exist for interaction	
Units of tables		Microscope		Drama		Field trip		Observation		Rules are positively-framed	
Tables for different activities		Binoculars		Story-telling		Hands-on work		Worksheets		Too many rules	
Science lab is available		Magnets		Guest speakers		Projects		Homeworks		Extrinsic motivation sources	
Outdoor space is available		Magnifying glasses		Individualized instruction		Reviews		Portfolios		Students feel valued	
Furnishing is suitable		Flashlights		Whole group instruction		Technology supported activ.		Feedback		Small group interaction	
Safety regulations followed		Mirrors		Small group instruction		Drill & Practice		OTHER:		Large group sharing	
Lighting is adequate		Thermometers		OTHER:		OTHER:				Interaction among children	
Ventilation is sufficient		Measuring cups								Teacher support is available	
Temperature is appropriate		Sand/water table								Peer support is available	
Sound level is appropriate		Balloons								Family/parent interaction	
Students can hear/see teacher		Paper								Opportunities for ind. work	
OTHER:		Stationery								OTHER:	
		Blocks									
		OTHER:									