Use of Models in Early Childhood Science Education[1]

Okul Öncesi Fen Eğitiminde Model Kullanımı

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Makale Geliş Tarihi: 05.01.2017 ***Yayına Kabul Tarihi: 06.03.2017***

Abstract

The paper aims to investigate early childhood teacher candidates' views about science education and their confidence in teaching science. After initial consideration of their views, the paper introduces the use of scientific models as a way to introduce scientific concepts to young children, and seeks participants' understandings of models and their use. The findings showed that, although all participants believed in the necessity of science education in early childhood classrooms, most of them did not feel themselves confident about it. They believe that science education should be done through physical materials but they do not hold promising understandings about models and their use in science education.

Keywords*: early childhood education; physical models; science education; scientific models*

Özet

Bu çalışma, okul öncesi öğretmen adaylarının fen eğitimine ilişkin algılarını ve fen öğretimine ilişkin özgüvenlerini araştırmayı amaçlamaktadır. Algıların değerlendirilmesinin yanı sıra, çalışmada, küçük çocuklara bilimsel kavramları sunmanın bir yolu olarak bilimsel modellerin kullanımı tanıtılmakta ve katılımcıların model ve model kullanımına ilişkin anlayışları araştırılmaktadır. Bulgular, tüm katılımcıların okul öncesi sınıflarında fen eğitiminin gerekliliğine inanmalarına rağmen, çoğunun kendisine güvenmediğini göstermiştir. Ayrıca, fen eğitiminin fiziksel materyaller aracılığıyla yapılması gerekliliğini düşünmelerine rağmen, öğretmen adaylarının modeller ve bunların fen eğitiminde kullanımına yönelik anlayışları yeterli bulunmamıştır.

Anahtar Kelimeler*: okul öncesi eğitimi, fiziksel modeller, fen eğitimi, bilimsel modeller*

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1. This paper was presented as an oral presentation at ERPA International Congresses on Education in Athens, Greece in June of 2015.

1. Introduction

Children are born with a natural curiosity and have a built-in desire to figure out how the world works. They are biologically prepared and motivated to learn about the world around them, just as they are biologically prepared and motivated to engage in social interactions, to learn to walk, and to learn to talk (French, 2004). Learning about the world through activities like mixing colors, creating shadows and observing earthworms are among the scientific activities for young children (French, 2004) and the need to a systematic initiation of such activities and science concepts in the early years of education is extensively documented in the literature (Eshach & Fried, 2005; Ravanis & Bagakis, 1998). It is argued that through interaction with these activities, children's intellectual and linguistic development will be supported since such activities will provide a context for hands-on, personal experience during which they form mental representations of complex phenomena, process complex language, and attempt to communicate their understanding of the experience to others (French, 2004). Moreover, it is believed that early exposure to scientific activities develops positive attitudes towards science, leads to better understanding of the scientific concepts studied later in their future science education, and develops scientific thinking and reasoning (Eshach & Fried, 2005).

As mentioned previously, the initiation of science to preschool children is accepted as significant. At this point, the development of an appropriate curriculum for preschool level, the use of appropriate science teaching strategies and the training of preschool teachers are among the issues to be considered by early childhood educators. It is doubtless that for preschool science education, specifically developed teaching approaches are needed (Ravanis & Bagakis, 1998). Children at those ages cannot form mental representations of phenomena by simply being told about them until they are 4 or 5 years old (French, 2004). During those ages, they make sense of their environments through their senses (Alisinanoglu, Inan, Ozbey & Usak, 2012); that is, personal experience with the environment is the primary source for the child's learning (French, 2004). Therefore, it is essential to provide children with the opportunities in which they can make observations, experience the natural world around them, use their creative thinking skills in their science explorations, and develop an understanding of nature and so on. This requires providing children with concrete examples and experiences with materials (Alisinanoglu, Ozbey & Kahveci, 2007). Models, at this point, seem to be very useful tools that bring abstract scientific phenomena in front of children as concrete materials. In other words, models function as powerful bridges that make unfamiliar scientific phenomena seem more relevant to children (Godek, 2004). Models, indeed, are expressed through modes like, concrete, visual, verbal, mathematical, and gestural representations (Davies & Gilbert, 2003). In other words, they can be physical objects, fictional objects, set-theoretic structures, descriptions, equations, or a mixture of these (Frigg & Hartmann, 2005). The concepts modeled are usually inaccessible or unobservable by their nature, and models serve as abstractions or simplifications of these concepts to make their features explicit and visible, and allow scientists, teachers or students generate explanations or make predictions about them. Models, which are physical objects, are also called as materialistic models, and serve as scientific representations of concepts like, Watson and Crick's model of DNA (Frigg & Hartmann, 2005). These models seem to be very useful in introducing several inaccessible scientific phenomena to young children. The use of a globe, for instance, may work well, if the teacher aims to introduce the shape of the Earth, the continents or the oceans. The model of the solar system, on the other hand, may serve as the only way to explain the concepts of day, night or seasons.

Models are powerful teaching and learning tools; however, the misuse of models in education can lead to misunderstandings if they are presented as 'realities' rather than functional explanations. In other words, they should not be seen as realities themselves but be accepted as imperfect representations of scientific phenomena (Hitt, White & Hanson, 2005). Considering models as exact copies of reality, however, is a common naïve realist view among students (Van Driel & Verloop, 1999). Therefore, it has significant importance to make students aware of the difference that exists between the model and the reality. At this point, teachers' understanding and use of models is of great importance. If science education aims to provide children with first-hand experience with the environment as the primary source for their learning, teachers should hold sophisticated understandings about the nature of models, their roles in science and in science education.

Apparently, the use of models themselves does not satisfy all the criteria of appropriate science understanding. In the case of the globe, for example, the understanding about the Earth is not due to the child's interaction with the model but to the information provided by the teacher (Hadzigerorgieou, 2002). The role of the teacher, herein, is of crucial importance, since children's interaction with models does not make sense unless the related scientific information is provided by the teachers. Teachers' proficiency is required not only for appropriate model use but for appropriate understanding of all science concepts since science concepts cannot be developed through children's making sense of their personal experiences or peer interaction. However, research suggests that many adults, including educators, fail to provide children with the opportunities to experience science and understand the nature (NRC, 2007). One of the reasons for not providing science learning environments is, as research suggests, teachers' low self-efficacy in teaching science (Bleicher & Lindgren, 2005), although they are among the most important factors in this process (Wylie & Thomson, 2003). In other words, teachers play important roles in organizing learning experiences to support children's ability to perform scientific experience (Jones, Lake & Lin, 2008).

Considering all the above, since early childhood teachers are important factors that affect the quality of science education in early childhood classrooms, investigating their understandings and confidence in teaching science, and providing suggestions to support science education in early childhood classrooms becomes essential.

Purpose of the study

The paper seeks to reveal early childhood teacher candidates' views about science education in early childhood classrooms. Revealing teacher candidates' views of science education, the paper also introduces the use of physical scientific models as a way to introduce scientific concepts to young children since they acquire knowledge about their environment through playful interaction with objects. The paper tries to present early childhood teacher candidates' understanding of models and their use in science education, as well.

Research questions

The research questions investigated in this study are: (1) what are early childhood teacher candidates' views about science education in early childhood classrooms, (2) how confident are early childhood teacher candidates in teaching science, and (3) how are early childhood teacher candidates' understandings of models and their use in science education?

2. Methods

Participants

The participants of the study consisted of a total of 40 early childhood teacher candidates (2 males, and 38 females) with a mean age of 20.6 years. All participants were early childhood education majors from the faculty of education, department of elementary education in a public university in Turkey. An overview of the types of high schools that participants graduated from are presented in Table 1.

Table 1. Participants' demographic profile with respect to high school type

Type of high school	Frequency (f)	Percentage (%)
Technical & Vocational High School for Girls	29	72.5
Anatolian High School	6	15
Public High School	3	7.5
Anatolian Teacher Training High School	2	5
Total	40	100

Data collection and analyses

Data for this study were obtained through an open-ended questionnaire. In the questionnaire, participants were asked to respond to a number of questions that seek their views about science education in early childhood classrooms. The items in the questionnaire also included their understandings about scientific models and views about the use of scientific models in teaching science in early childhood classrooms.

Data were analyzed based on qualitative data analyses methods - more specifically, content analysis - to reveal themes and patterns about participants' perceptions about science education and use of models in early childhood classrooms. Through content analysis, qualitative data are coded and classified for the purpose of identifying the underlying themes and patterns.

3. Findings

The findings of this study are presented under two subheadings: 1) Early childhood teacher candidates' views about science education; and 2) Early childhood teacher candidates' understandings about models.

Early childhood teacher candidates' views about science education

Considering the fact that early childhood teachers are among the important factors that affect the quality of science education in early childhood classrooms, the first aim of this study was to examine early childhood teacher candidates' views about science education. Findings revealed that, all participants (100%) believed in the necessity of science education in early childhood classrooms. However, when they are asked whether they feel themselves confident in teaching science, 70 percent of them stated that they do not, while only 12 percent said that they do, and the rest were not sure. Below are sample excerpts from their responses:

> "I do not think that I have enough knowledge of science concepts and science education, except very simple things. I feel very unqualified for using science materials, as well as teaching science concepts" (P1).
>
> "I guess, this [science] is the area that I feel most unqualified for" (P4).
>
> "I am graduated from a Technical and Vocational High School for Girls. I know a little about science but I do not think I am qualified enough" (P10).
>
> "I do not feel that I am qualified enough because I do not have the required knowledge and skills to teach science" (P35).
>
> "I feel qualified, although not exactly. I find science concepts interesting, as well as children do" (P24).

Realizing the importance of science in early childhood education, the teacher candidates provided several reasons to support the necessity of science education in early childhood classrooms. Examples of the common reasons they mentioned are given in Table 2.

Table 2. Teacher candidates' views about the necessity of science education in early childhood classrooms

Reason:	Frequency (f)
To understand the happenings around	18

Reason:	Frequency (f)
To meet the innate curiosity	15
To provide a basis for later science education	9
To create awareness towards environment	3

As Table 2 suggests, participants mostly thought that since children are naturally curious, science education would meet their curiosity and would help them understand the happenings around. Moreover, some participants pointed out that science education at early childhood would provide a basis for later science education, and some thought that it would create awareness towards environment. Sample excerpts from their responses are as follows:

> "Science education in early childhood classrooms is absolutely necessary. Children at those ages are extremely curious. Their curiosity directs them to the nature, to science. We need to help them in their way to understand the happenings around" (P30).
>
> "Science education at early childhood is necessary. Children are curious about everything and ask a lot of questions. For example, when they ask how rain forms, we need to explain them in a way that they can understand. Therefore, we need to be informed about science concepts" (P23).
>
> "One of the aims of early childhood education is to prepare children to the upcoming elementary education. Therefore, it becomes important to introduce children with some simple scientific concepts. Conducting some simple experiments, for instance, may help. That's why science education in early childhood classrooms is necessary. It will provide a basis for their later science education" (P8).
>
> "Children are very curious. Science education meets their curiosity and allows them to be more sensitive towards their environment" (P27).

When participants were asked how science education at early childhood should be, they pointed out to several attributes as given in Table 3.

Table 3. Teacher candidates' views about the attributes of science education in early childhood classrooms

Attribute:	Frequency (f)
Simple	25
Physical/tangible materials	22
In laboratories/through experiments	16
Interesting	11
Game-based/through games	9
Out of the classroom (e.g. in school garden)	6
Based on observation	2
Safe	2

As seen in Table 3, the participants mentioned that science education in early childhood classrooms should be simple, interesting and safe. They stated that science education should be done through using physical materials, simple experiments, and games, as well. Moreover, they thought that science education should be done out of the classroom and should include the observation of scientific phenomena. Below are sample excerpts from their responses:

> "Science education in early childhood classrooms should be simple, and should cover some basic scientific concepts. It should be done through physical objects, so that children can easily comprehend" (P12).
>
> "First of all, it should be interesting and simple. All scientific activities should be done through games. As a teacher candidate, I am also planning to take my students out of the classroom and let them observe the nature" (P21).
>
> "Physical objects should be predominantly used in early childhood science education since children at those ages are at concrete operational stage. As teacher candidates, we also need to teach science concepts from simple to complex and from easy to difficult" (P30).
>
> "Science education should be definitely done through experiments" (P17).

The findings of this study suggest that more than half of the teacher candidates focused on the use of physical materials for science education in early childhood classrooms (Table 3). The use of physical scientific models, at this point, is a useful alternative; however, findings presented in the following section showed that participants did not hold promising understandings about models and their use in science education.

Early childhood teacher candidates' understandings about models

In early childhood classrooms, physical scientific models may be used as valuable tools to introduce scientific concepts to young children. The participant teacher candidates' understandings about models and scientific models, however, were found to be unsatisfactory (Table 4 and Table 5).

Table 4. Teacher candidates' definitions of model

Definition:	Frequency (f)
Exemplary person/thing/case	34
Types of a thing/concept (e.g. models of cars)	6
3D representations (e.g. that of unavailable concepts)	4
Top models	4

As seen in Table 4, teacher candidates mostly referred to exemplary people, exemplary things, or exemplary cases, as they defined models. Some of them, on the other hand, believed that models are types of things, like models of cars; or are three-dimensional representations. Interestingly, four of the teacher candidates mentioned about top models in their definitions. Below are sample excerpts:

> "The term 'model' reminds me of something that you imitate or, emulate or, you take as a model for yourself. To be a model, on the other hand, the 'thing' should have a unique, a distinctive characteristic" (P12).
>
> "A model is the best example we refer to, to indicate an attribute we want. 'Ozge Ulusoy *[A Turkish Top Model]*' for example, is a good example for us to see how a woman's physical appearance should look like" (P13).
>
> "A model is a physical representation of something so that it becomes more convenient to us and we can understand it more easily. For example, the globe, the DNA model, …" (P20).
>
> "Three-dimensional state of an existing thing (e.g. Cell model)" (P22).

Similar to the understandings about models, teacher candidates' understandings about scientific models also indicated their confused minds. Most of the teacher candidates made their unique definitions of scientific models, so that common definitions and their frequencies stayed at low numbers (Table 5). The common definitions, therefore, were very limited.

Table 5. Teacher candidates' definitions of scientific models

Definition:	Frequency (f)
Exemplary person/thing/case related to science	9
3D explanatory materials of scientific concepts	6
Supplementary materials	4
3D materials	4

As Table 5 suggests, some teacher candidates thought that scientific models are exemplary people, things or cases related to science. Some others believed that they are supplementary or three dimensional materials used in science. Below are some examples from teacher candidates' definitions of scientific models:

> "A scientific model is emulating a scientist who achieved a great success in his/her area" (P16).
>
> "I actually do not have any idea but they may be the methods that scientists use in their investigations" (P5).
>
> "Scientific models are tools that are used to teach scientific concepts" (P6).
>
> "A scientific model can be an activity that is designed in the light of science. Science-fiction magazines, for example, may be scientific models" (P8).

As seen in Table 5, only six teacher candidates (out of 40) provided an acceptable definition by defining models as three dimensional explanatory materials of scientific concepts. One of them stated that:

> "The macquettes of phenomena that are unavailable in nature may be scientific models. The model of the human organelles, for example, may be a scientific model, since we do not have the opportunity to show the inner organelles to our students in a real human body" (P2).

Although displaying confused understandings about scientific models, all teacher candidates (100%) believed in the necessity of using scientific models in science education (Table 6).

Table 6. Teacher candidates' views about the use of models in early childhood science education

Reason:	Frequency (f)
To reify scientific phenomenon	23
To provide permanent learning	7
To take interest	5
To facilitate learning	3
To simplify concepts	2

Teacher candidates thought that since scientific models are 'visual', they reify several abstract or unavailable concepts, facilitate learning and provide permanent learning. They also believe that models simplify scientific concepts, and take interest of children. Below are some examples from their responses:

> "We need models in science education because some scientific concepts are abstract or unavailable. They need to be simplified and reified through models. The explosion of a volcano, for example, may not be seen to us but a model of it works well" (P12).

> "We need models in science education because many scientific concepts are abstract in nature and are difficult to understand. When we reify them through models, we facilitate to understand them and therefore come up with permanent learning" (P16).

> "Since they are visual, teaching through models provides permanent learning. They also make the concepts more interesting to children" (P36).

Some teacher candidates in this study specifically took attention to children's lack of abstract thinking abilities as they mentioned about the use of scientific models in early childhood science education, and believed that since children at early ages did not develop abstract thinking abilities yet, models would provide them with the chance to see and touch scientific phenomena. Below is an example:

> "Children at early ages do not have the abstract thinking abilities. With the help of models, however, they see, touch and, if possible, manipulate the scientific phenomenon and learn easily" (P16).

4. Discussion

Findings indicate that, early childhood teacher candidates participated in this study believed in the necessity of science education in early childhood classrooms. They believed that early childhood science education would help children understand the happenings around, meet the curiosity they innately hold, provide a basis for their later science education, and create awareness towards environment. Interestingly however, their responses to the questionnaire indicate generally low levels of personal teaching efficacy. When they were asked whether they feel themselves confident about teaching science, most of the teacher candidates stated that they do not. This could be due to the lack of science education in their backgrounds as most of them were graduated from Technical and Vocational High Schools (See Table 1). In Technical and Vocational High Schools in Turkey, science courses (more specifically, physics and chemistry) are presented as *elective* courses that they may take.

The participants of the study pointed out to several attributes that science education in early childhood classrooms should have. They believed that scientific activities in early childhood education should be simple, interesting, game-based and safe. Moreover, they thought that such activities should be done out of the classroom and should include the observation of scientific phenomena. Besides these attributes, a considerable number of the teacher candidates (N=22 out of 40) believed that science education in early childhood classrooms should be done through using physical materials by claiming that such materials would reify abstract or unavailable scientific phenomena and thus, facilitate children's learning of scientific concepts. The use of 'physical scientific models' at this point may be a useful tool since scientific models are accessible representations of abstract concepts, and are also organizational frameworks to teach and learn inaccessible phenomena (Gilbert, Boulter, & Rutherford, 1998). In fact, several scientific concepts or processes cannot be reproduced in the classrooms; however, their models are available to use, and the use of such scientific models improve students' understanding in the development of scientific ideas and the development of a better understanding of the scientific concepts (Gobert & Buckley, 2000; Hitt, 2004; Treagust, Chittleborough & Mamilia, 2002). If the structure of science education in early childhood classrooms is organized around a number of basic physical scientific models, early childhood teacher candidates would find the chance to visualize and explain basic scientific concepts to the children. With the help of models, abstract concepts will become concrete since they become tangible for children (Hitt, White, & Hanson, 2005). The use of such models also promote meaningful learning (Falcao, Colinvaux, Krapas, Querioz, Alves, Cazelli, Valente, & Gouvea, 2004), and by giving children the opportunity to explore, describe and explain scientific ideas, models make science relevant and interesting (Hodgson, 1995; as cited in Harrison & Treagust, 2000). Models increase children's curiosity and imagination, and therefore enhance creative thinking (Harrison & Treagust, 2000), as well.

Findings of this study, however, suggest that, efforts to improve early childhood science education should put more emphasis on teacher candidates' understandings about scientific models and on the ways to integrate scientific models into the activities done in early childhood classrooms. Teacher candidates need to be informed about scientific models, since most of them held limited understandings of them by simply defining them as 'exemplary things' and considering them as just 'visual structures' (See Tables 4 & 5). In early childhood education, teachers perform several types of activities, including science, mathematics, visual arts and music; however, it is observed that they rarely prefer to perform science activities. In parallel with this assertion, most of the teacher candidates in this study (70%) also did not feel themselves confident about teaching science; and it is predictable that when they become teachers, they will probably avoid doing science activities. At this point, efforts should also put to improve the early childhood education programs in the universities in terms of science education, so that teacher candidates display higher personal efficacy in teaching science.

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