Chapter 11
Role of Play in Teaching Science in the Early Childhood Years

Berrin Akman and Sinem Güçhan Özgül

> At planning time, Gabrielle says, "I'm going to play with the doggies and Magnatiles in the toy area. I'm making a tall elevator." At work time, Gabrielle builds with the magnetic tiles while playing with the small toy dogs, as she planned. She stacks the tiles on top of one another in a tower-like form—her "elevator"—then places some dogs in it. The elevator then falls over. She repeats this several times but the elevator continues to fall over. Gabrielle then arranges the magnetic tiles into squares, connecting them to form a row. Gabrielle says to Shannon, her teacher, "I'm making doghouses because the elevator keeps falling down." Shannon says, "I was wondering what you were building, because you planned to make a tall elevator going up vertically, and now you are using them to make doghouses in a long horizontal row. You solved the problem by changing the way you were building." Gabrielle uses pretend talk while moving the dogs around. At one point she says, "Mommy, Mommy, we are hungry" and opens one of the doghouses and moves the dog inside where a bigger dog is placed. Gabrielle says, "Mommy says the food's not ready, so go play." While moving the dogs around, Gabrielle says to herself out loud, "We have to find something to do until the food is ready." Gabrielle says to Shannon, "Let's pretend we are going to the park." Shannon agrees and says, "I'm going to slide down the slide three times and then jump off the climber." As Shannon pretends to do this with one of the dogs, Gabrielle watches then copies her and says, "My dog jumped higher than yours." She then says, "Mommy says we have to go home now. We need to move our dogs over there so they can eat." The pretend play continues. At recall time, Gabrielle is using a scarf to hide some objects she played with. When it is her turn to recall, she gives clues about what is under the scarf. She shows the group a couple of magnetic tiles and dogs. Shannon asks her what she did with these materials during work time. Gabrielle talks about the problem with the falling "elevator" and then recounts the story about the doggies (Lockhart, 2010, pp. 1–2).

B. Akman (✉)
School of Education, Hacettepe University, Ankara, Turkey
e-mail: bakman@hacettepe.edu.tr

S. Güçhan Özgül
Necatibey School of Education, Balıkesir University, Balıkesir, Turkey

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Introduction

In the scenario, Gabrielle plans what she will do during her play, follows her plan and recalls what she has done. From this example, how do we explain the main cognitive functions such as memory, self-regulation, private speech, the ability to organize, focus, plan and practice skills that will later affect academic success? How are these cognitive skills or executive functions acquired in the most effective and convenient way? The researchers in the field of early childhood education indicate that one of the most effective tools in the development of early cognitive skills is play. Early childhood educators often emphasize that children acquire several cognitive skills through play (Lockhart, 2010; Ross, 2013).

Cognitive development encompasses all of the mental processes that maintain an individual's interaction with the immediate environment, beginning at birth. Cognition provides information with respect to the environment and assists in acquiring, storing, reorganizing and using information. The individual becomes competent in cognitive processes both qualitatively and in terms of content. Cognitive development demonstrates that the child is thinking with respect to the objects the child sees, hears, touches and tastes. The thought process involves the impulse-response relationship, the understanding of a succession of events, the appreciation of the similarities and differences between objects, the categorization of objects and rational response (Ministry of National Education (MONE), 2011). With respect to cognitive development, it is important that children reach conclusions as a result of their own efforts by attempting different ways of solving problems and by using their imagination and being physically and mentally active. There is a close relationship between play, which includes all of the aforementioned processes, and cognitive development.

Play constitutes an important part of a child's life and prepares a child for life experiences by creating the opportunity to develop a personality and skills (Egemen, Yılmaz, & Akil, 2004). According to Kelly-Vance and Ryalls (2008), play is an activity that excites, entertains and motivates children. The laughter and smiles that typically accompany play reinforce its fun nature. However, it is often overlooked that play is educational as much as it is fun. Certain parents believe that play contributes significantly to a child's development, whereas others consider play unnecessary and pointless (Johnson, Christie, & Yawkey, 1998). The research demonstrates that there is a strong relationship between play experiences and cognitive, emotional, motor and language skills. Children of all ages have a need to play and play forms the primary work of any child from any culture and of any condition (the types, materials and other characteristics of play may change) (Kindler, 2009).

From a development perspective, toys are an inseparable part of play, and through toys, a child is able to link the real world with imagination (Egemen et al., 2004). Toys assist a child in learning with respect to themselves and their environment and introduce several concepts. Through play a child will recognize and name the object or toy, understand its function, form cause and effect relationships, make selections, focus, and direct himself to a purpose. Play also promotes the functioning of cognitive processes such as classifying, analyzing, synthesizing, assessing and problem solving (MONE, 2009).

Historically, play has been considered the most important element in child development. In addition to the belief that children play for egocentric reasons, there is the belief that play supports cognitive, emotional and social development; a theory that is also applied to adolescents and adults (Daw, 2009). For children of a young age, especially, play is an indispensable element of the learning process. Play provides learning opportunities; preschool children enhance their mental capacity for creativity and develop social and self-regulation skills and, for older children, play continues to support the reinforcement of self-regulation and literacy skills. Academically, play helps children to become self-oriented and self-motivated individuals and to enjoy the learning process (Bonura, 2009). Children use different cognitive strategies during play. For example, a child's ability to learn from a mistake or failure is a reflection of their problem-solving and cognitive skills (Bow & Quinnell, 2001).

The theorists, researchers and educators from various disciplines have discussed play and its contribution to the learning and development of children (Erikson, 1985; Freud, 1961; Piaget, 1962a; Vygotsky, 1966). Although the researchers that study play present different perspectives with respect to its characteristics (Krasnor & Pepler, 1980; Rubin, Fein, & Vandenberg, 1983), there is a consensus that play is a human behavior that demonstrates certain typical characteristics. These characteristics include that play is self-selected, self-directed, open-ended, voluntary, enjoyable, flexible, and motivating and represents an individual or group activity (Isenberg & Jalongo, 2001).

The theories that feature different dimensions of play present the relationship between play and cognitive development as a serious of ideas that they provide with respect to the definition, goals and importance of play. The following section provides an explanation of the different theories with respect to the concept of play (Bodrova & Leong, 2010; Bonura, 2009; Güler, 2007; Johnson et al., 1998; MONE, 2009; Nicolopoulou, 1993; Reid, 2001; Rothlein & Brett, 1987; Sevinç, 2004; Sutton-Smith, 1979; Sutton-Smith, 1998).

Play theories can be divided into two categories: classical theories and modern theories. The classical theories emerged in the nineteenth century and attempt to explain the focus and the source of children's play activities. The modern theories appeared after 1920 and focused on understanding the effects of play with respect to the development of the child. Although the classical theories, such as Hall's recapitulation theory, have encouraged the systematic monitoring of children's play that has resulted in an explanation of the phases of play that compose the modern phase theories (for instance Piaget's theory), this present study will highlight only the relationship between play and cognitive development and, therefore, only the modern theories will be described.

The Modern Play Theories

The modern play theories explain play and its contribution to a child's development and the antecedent conditions that cause play behavior to occur. In the following section, the play theories from two theoretical perspectives are described: psychoanalytic and cognitive.

The Psychoanalytic Theories of Play

Freud's Theory

Freud believed that play has a significant role in the emotional development of a child. According to Freud, play may possess a cathartic effect that cleanses a child of negative emotions concerning traumatic events. It is a natural dimension of development in healthy children, whose imaginary and dramatic defense mechanisms are in the early stages of development and who are experiencing the pressure of id energy. Play ends with the start of rational thinking, which is related to the development of ego (Johnson et al., 1998; MONE, 2009).

Repetitive play is another mechanism that allows children to process deal with unpleasant events. A child who repeats a negative experience during play can divide the experience into small and manageable parts. The child can therefore, piece by piece, slowly internalize the negative experience. Brown, Curry, and Tinnich (1971) explain the therapeutic value of repetitive play with the following examples: a group of preschool students experienced an unfortunate event and witnessed a worker become seriously injured when he fell nearly 6 m. The students watched the administering of first aid before the injured individual was transported to hospital by an ambulance. Initially, the majority of the children was influenced by the event and often reenacted the event during dramatic play (falling, death and injury, ambulances, hospitals). Only after a significant amount of time was there a decrease in the frequency of play and the discomfort of the children (as cited in Johnson et al., 1998).

Erikson's Theory

According to Erikson, play advances in stages that reflect the psychosocial development of children. Children form case models that assist them in learning to manage real life through play. Erikson emphasized that play is a mirror of a child's psychosocial development. Through play, a child creates new models to cope with real emotions, thoughts and events. Erikson, who focused on the effects of play on ego development, considers that a child dramatizes, through play, uncertainties, concerns and desires (Johnson et al., 1998).

The Cognitive Theories of Play

Piaget's Theory of Play

According to Piaget (Piaget, 1962b), children are interested in the play type that relates to their cognitive development level (Table 11.1). For instance, children under age 2 may be interested in play that is oriented to practice (that is, repetitive physical actions) and simple role activities. Because their necessary cognitive and social skills are not yet formed, they cannot effectively take part in more advanced dramatic or imaginary play (Nicolopoulou, 1993).

Piaget (1962b) described three types of play that correspond to a child's cognitive development level: sensorimotor play, imaginary play and games with rules. For babies and young children, the child's sensorimotor actions are the first dominant types of play. These self-centered body movements reflect the narcissistic character of the first level of psychological development and the formation of the first sense of belonging for the child. During the preschool period, a child's play includes fantasy and symbolization and, in symbolic play, strong feelings and magical thoughts are common. When children begin primary school, their play becomes more realistic and complex and includes interpersonal interactions and events (Reid, 2001).

Piaget (1962b) accepts play as a phenomenon in which the child combines experiences, knowledge and understanding. The child controls these factors through play. While doing this, the child enters a process of equilibration by using the current schemas that the child possesses. Because this equilibration is always subject to change, the process rather than the results is significant in free play. With respect to children's play, assimilation and accommodation behaviors are generally activated at the same time; however, one may dominate at any given moment. At an early age, a child's desire and curiosity for learning initiates play activities. Play requires imitation with respect to the events that necessitate accommodation behavior. In this situation the child is required to make a change within his cognitive structure. This behavior is repeated until it is assimilated and initiates the play phenomenon. If the knowledge presented to the child is different from the child's current schema, the presented knowledge becomes unintelligible for the child to the degree that the assimilation and accommodation mechanisms are not able to assist the child in understanding that information (Sevinç, 2004; Wadsworth, 1989).

Piaget's constructivist theory posits that children acquire knowledge through their own experience and not from the knowledge that is presented by families and

Table 11.1 Piaget's play theory

Age	Cognitive level	Dominant play type
Age 0–2	Sensorimotor	Practice play
Age 2–7	Pre-operational	Symbolic play
Age 7–11	Concrete operational	Games with rules

Source: Johnson, Christie, and Yawkey (1998) teachers. For example, young children develop mathematical understanding and knowledge by interacting with their environments. Play-based mathematical activities provide a child with the opportunity to try more than one solution and to observe and improve social interaction (Bonura, 2009).

Vygotsky's Theory of Play

According to Vygotsky(1978), young children have difficulty understanding abstract ideas because the meanings and objects are combined as a whole. Consequently, young children cannot think about a horse without seeing it. When children begin imaginary play and the use of objects (such as a piece of wood) to represent something else (such as a horse), the meaning begins to separate from the object. Eventually, children consider meaning to be independent of an object. Vygotsky's view with respect to play is a comprehensive one. He separated development into three levels: "Actual development" (independent performance), "potential development" (aided performance) and the *zone of proximal development*, or the distance between the actual and potential development levels. Play can contribute to development by operating as a stepping stone within the zone of proximal development and can enable children to reach higher levels of performance (Bodrova, 2008; Johnson et al., 1998).

Vygotsky considers play to be a type of magnifying glass that reveals new skills in formal learning environments. He does not overlook the biological basis of play activity in humans because these tendencies can also be observed in animals. However, he posits that symbolic skill is a part of humankind's hereditary nature. Vygotsky states that the realization of symbolic skill includes a social process and the nature of this process is an important research topic for psychology (Bodrova & Leong, 2010; Johnson et al., 1998; Nicolopoulou, 1993).

According to Vygotsky, true play has three components (Bodrova & Leong, 2010):

- Children create an imaginary event.
- Children adopt roles and play games.
- Children follow a series of rules determined by the specific roles.

The creation of an imaginary event and role play are considered a common characteristic of pretend play. Vygotsky argued that play is not something that develops spontaneously but is formed based on several rules. Imaginary situations and role playing are planned, and there are rules for joining the game. The main effects of play are the following (Bodrova & Leong, 2010):

- Play creates a zone of proximal development for the different areas of cognitive development.
- Play facilitates the separation of thought from actions and objects.
- Play facilitates the development of self-regulation.

– Play promotes motivation.
– Play promotes the adoption of perspective skills.

The common aspects of modern theories are that children find ways to express themselves with pretend play or imaginary play and that play is a setting used to meet these desires (Johnson et al., 1998; Rothlein & Brett, 1987; Sevinç, 2004).

An Overview of the Studies on Play and Cognitive Development

Nicolopoulou (1993) presents a critical approach to play research concerning cognitive development and presents an analysis of two important theoretical frameworks; Piaget and Vygotsky. Nicolopoulou favors Vygotsky's play approach. Nicolopoulou argues that play promotes cognitive development and provides a micro learning environment within which children practice and develop the cognitive skills that are critical for elementary grades and beyond. Wood and Attfield (1996) suggest that recent play studies in developmental psychology focus on the cognitive benefits of play for young children and that they support the view that play provides a unique context for children to develop cognitive skills and conceptual understanding with respect to social and natural phenomena.

The studies concerning the relationship between play and cognitive development suggest a positive correlation (Coolahan, Fantuzzo, Mendez, & McDermott, 2000; Howard, Jenvey, & Hill, 2006; Howes & Smith, 1995). Howes and Smith (1995) demonstrated that playing mental games enhances a child's cognitive skills. Cherney, Kelly-Vance, Glover, Ruane and Ryalls (2003) investigated the effect of stereotypical toys on the complexity of young children's play and the resulting cognitive development. The results indicated that non-stereotypical toys increase the complexity of preschooler play and have the potential to support cognitive skills. Gmitrova & Gmitrov, 2003 examined the effect of teacher-centered and child-centered pretend play on the cognitive development of preschool children. The results demonstrated that during the child-centered pretend play, children were more likely to engage in sophisticated cognitive skills. A study by Shaklee and Demarest's (2006) demonstrated that playing with blocks supported a child's learning of mathematics and science concepts. Levine, Ratliff, Huttenlocher and Cannon (2012) found that early puzzle playing experiences are likely to support the development of children's spatial transformation skills.

Pretend play includes imaginary behaviors and the use of objects to represent imaginary objects (for example, pretend eating, enacting a pretend tea party). This behavior is common in the pre-operational stage and constitutes approximately 17 % of preschool and 33 % of day care games (Bonura, 2009). Vygotsky (1978) states that pretend play is a spontaneous child activity, and children typically perform at the highest level of their zone of proximal development. The basic skills that are reinforced with pretend play involve working memory (children need to remember their roles while acting out the characters), cognitive flexibility (they must regulate the decisions that other children make) and creativity. Creative play is geared more toward self-regulation and the reinforcement of working memory. However, whereas a realistic stage setting including costumes and devices may be considered necessary for young children, older children use symbolic equipment to develop their creativity (Bonura, 2009).

Learning Through Play

Learning and playing are natural, intertwined processes in early childhood (Osborne & Brady, 2001; Pramling Samuelsson & Asplund Calsson, 2008). Certain researchers have defined the relationship between play and learning as "inseparable" and "complementary" (Osborne & Brady, 2001; Pramling Samuelsson & Johansson, 2006) and have suggested that the connection between play and learning has led most people to perceive play and learning as vital, at least for young children. Play has a crucial role as a "learning medium" that helps young children to explore their environment, practice novel situations, and seek knowledge (Bergen, 2009; Elkind, 2008; Pelegrini, 2009; Pramling Samuelsson & Johansson, 2006). A strong connection between play and learning has long been emphasized in the early childhood education literature (Bergen, 2009; Bodrova & Leong, 2007; Broadhead, 2006; Henricks, 2008; Piaget, 1976; Pramling Samuelsson & Johansson, 2006). Whereas most studies have focused on theoretical backgrounds, definitions and categorizations of play, certain contemporary studies have focused on other aspects of play including its role within the early childhood curricula, the developmental characteristics of play (such as social or physical), and the pedagogical effectiveness of play (Bodrova & Leong, 2010; Broadhead, 2006; Henricks, 2008; Pelegrini, 2009; Trawick Smith, 2009, 2012).

Young children have substantial competency and curiosity in the exploration of the world around them (Eshach & Fried, 2005; French, 2004; Gelman & Brenneman, 2004; Ginsburg & Golbeck, 2004; Mantzicopoulos, Samarapungavan, Patrick, & French, 2009; Saçkes, Trundle, Bell, & O'Connell, 2011; Trundle & Saçkes, 2012; Tu, 2006; Zimmerman, 2000). Children's innate drive to learn creates a foundation for future academic life (Eshach & Fried, 2005; Trundle & Saçkes, 2012). Young children learn from experiences, explorations, interactions (Broadhead, 2006), imitation and variation (Lindahl & Pramling Samuelsson, 2002). Play has the potential to offer a rich and developmentally appropriate learning environment where young children have the opportunity to explore, interact and imitate (Bergen, 2009; Pelegrini, 2009).

Learning through play has been considered an effective pedagogical tool in supporting the development and learning of young children (Trawick Smith, 2009, 2012). Play has also been emphasized in the early childhood curriculum and position statements of many countries and, with respect to professional organizations, as a developmentally appropriate way of supporting the learning and development of young children (see the National Curriculums of Sweden, Turkey, Tasmania and the position statements of National Association for the Education of Young Children-NAEYC). However, the empirical evidence concerning the effectiveness of play in facilitating the acquisition of concepts and skills by children is limited (Cheng & Stimpson, 2004; Codone, 2001; Schulz & Bonawitz, 2007). The limited number of research studies that have been conducted with preschoolers were designed to reveal a child's achievement and performance on learning tasks as a response to direct instruction, play based activities or scaffolding activities in certain tasks (Bulunuz, 2013; Holton, Ahmad, Williams, & Hill, 2001; Sarama & Clements, 2009). The results of these studies demonstrated that children involved in play-based activities perform better on learning tasks.

Science Through Play

Science is an experience and part of everyday life, even for young children (Saçkes, Trundle, & Smith, in press; Van Schijndel, Singer, van der Maas, & Raijmakers, 2010). Because children have an innate curiosity and motivation for exploring new things in their environment (Mantzicopoulos, Patrick, & Samarapungavan, 2008), a child's first encounter with science is actualized as soon as they independently discover and interact with an interesting entity (Tu, 2006). Science is described as both the body of knowledge and the activities that expose that knowledge (Zimmerman, 2000). Science consists of two distinct types of knowledge: domain specific knowledge and domain general knowledge (Zimmerman, 2000). The domain specific knowledge includes knowledge concerning objects and their relationships in certain areas of science such as astronomy and biology (i.e., animate and inanimate entities), and the domain general knowledge includes the cognitive skills that are required to understand and produce the domain specific knowledge, also termed science process skills or scientific thinking skills (i.e., observation and classification) (Eshach & Fried, 2005).

The traditional view (see Piaget's and Flavell's works) concerning the competence levels of early childhood claims that children are incapable of performing certain cognitive tasks (i.e., conservation and reversibility). However, the findings of recent studies have suggested that children possess remarkable cognitive abilities that help them understand how things function in the natural world (Andersson & Gullberg, 2012; French, 2004; Mantzicopoulos et al., 2009; Metz, 1995; Nayfeld, Brenneman, & Gelman, 2011; Peterson & French, 2008; Wellman & Gelman, 1998). This phase of learning "how things work" directly reflects a domain specific knowledge of science. The studies have demonstrated that children develop conceptual understanding of various domains of science in early childhood. For example, Vosniadou and Brewer's study (1992) reveals that children use their initial reasoning skills to explain the appearance of the earth using their daily experiences. The results of Opfer's study (2002) demonstrated that 5-year-olds can utilize sophisticated criteria to decide what is "alive". The majority of young children can recognize the changes in clouds before rainfall; however, this recognition appears not to promote their understanding of the composition of clouds (Saçkes, Flevares, & Trundle, 2010). The studies have demonstrated that children have notably distinct natural world models that differ from scientific models (See Chaps. 3, 4, and 5). These alternative mental models (or initial explanatory frameworks, naïve ideas, or misconceptions) of young children can be based on any science topic (Gelman, 2005) and are usually resistant to change (Chi, 2008). According to Pine and Aschbacher (2006), the longer a nonscientific idea is held by a child the more difficult it is to influence.

The second science knowledge type, domain general knowledge, is composed of scientific reasoning or thinking skills and includes skills such as observing, inferring, classifying, measuring, problem solving, and finding patterns (See Chap. 7). The studies have demonstrated that even preschool children are capable of performing these skills to a certain degree (Akman, Üstün, & Güler, 2003; Carey & Spelke, 1996; Eshach & Fried, 2005; Opfer & Siegler, 2004; Zimmerman, 2000). According to French (2004), science is considered a privileged content area in preschool classrooms because it coheres with a child's tendency to explore his surroundings. An emphasis on science in early childhood education is consistent with the theories and findings with respect to conceptual development and can complement the early competencies, attitudes and natural curiosity of young children (Pine & Aschbacher, 2006).

The integration of both domain specific and domain general scientific knowledge into preschool classrooms requires extensive research on developmentally appropriate, inquiry-based science curricula for early childhood education. Such efforts should be supported by the research that examines early childhood learning with respect to science, including the findings and beliefs concerning early childhood competency and interest in science. The developmental theory and educational practices are frequently considered as separate domains (Gelman & Brenneman, 2004); therefore, the preparation of knowledge-rich scientific teaching programs and learning activities that integrate theory and practice has become essential. To broaden the repertoire of science teachers and to facilitate planning, distinct and unique science programs for early childhood have been developed (e.g., French, 2004; Gelman & Brenneman, 2004). French's ScienceStart! and Gelman and Brenneman's PrePS curricula aim to create an environment that includes a broad range of materials, opportunities and support for young children to improve their science knowledge. In addition to the science programs, play activities are accepted as a support and facilitator of early childhood science teaching (Yoon & Onchwari, 2006). Similarly, the nature and philosophy of science are relevant to early childhood dispositions worldwide and offer children the opportunity of "doing science" independently (National Research Council, 1996). Because children learn and play, science teaching through play is a current issue for early childhood education scholars (Nayfeld et al., 2011; Yoon & Onchwari, 2006).

The scholars of early childhood education attribute new meanings and philosophical frameworks to the play and science relationship. Lazslo (2004) defined science as the playing of ideas in an innovation and discovery process. Similarly, Abrahams and Millar (2008), stressed the definition of science as the interaction of ideas and observation in science-based physical activity. Throughout childhood, children take advantage of play in their social, emotional, physical and, especially, intellectual development (Hirsh, 2004; Youngquist & Pataray Ching, 2004). When children are asked to name their favorite activity, the answer always includes play (Pramling Samuelsson & Asplund Calsson, 2008). The integration of play in the learning environment naturally facilitates the involvement of children and the reaching of educational goals. Thus, the active participation of children in science activity in play settings develops self-perception as a science learner, understanding of various science concepts, and the perception of science as interesting (Mantzicopoulos et al., 2008). The research studies demonstrate that preschool teachers do not present playful science activities although they may be aware of the importance and benefits of play in childhood science learning and other domains (Nayfeld et al., 2011; Cheng & Stimpson, 2004; Saçkes et al., 2011; Tu, 2006). Because many studies stress that the teacher role in play is crucial (Bodrova, 2008; Taylor et al., 2004; Trawick Smith, 2012; Wu & Rao, 2011), early childhood teachers must develop an awareness of the relationship between play and science (Youngquist & Pataray Ching, 2004). Bulunuz (2012) stressed that to incorporate science teaching through play, it is required that both science and play are weighted equally in terms of value. Similarly, Travick-Smith (2009) indicated that play must be conducted in a theory-grounded, planned and assessment-based classroom. The advancement of science teaching through play depends on the development and dissemination of practical and effective implementation methods. The inquiry-based teaching approach that is commonly used and valued in science education at the elementary level (Pine & Aschbacher, 2006; Tatar & Kuru, 2006) can be a practical and effective way to provide developmentally appropriate, play-based science learning experiences for young children.

The Research on Play-Based Science Instruction for Young Children

The studies that have focused on the influence of children's play on scientific thinking skills and conceptual understanding of natural phenomena are limited. Cook and colleagues (2011) designed two experiments that examined the exploration patterns of children using beads and a custom-built machine. The children's task was conducted under different conditions (e.g., given information and ambiguity). In the experiments, researchers provided different levels of information and different types of evidence (ambiguity or unambiguity) to children with respect to the activation and exploration of the machine. The children interacted and played with the machine for 1 min. Each child's interaction data with the machine (e.g., duration and the functions explored) was recorded by the researchers. The results demonstrated that children can distinguish both the presence of evidence and the complexity of the evidence available. The children were able to recognize and use the effective evidence to generate novel interventions to gain additional information. The researchers indicated that various factors are integrated and are used in the completion of tasks by children. These various factors, such as prior knowledge, evidence and recent experience, are important for guided exploratory play. These results are relevant with respect to the studies concerning the connection between scientific inquiry and children's play.

The study by Bonawitz and colleagues (2011) investigated the effect of pedagogical intervention in children's spontaneous exploration and self-discovery. A new toy, designed by researchers was presented to children with different types and amounts of intervention (Exp 1. pedagogical, interrupted, naïve and baseline conditions, Exp 2. direct, indirect child, and indirect adult and intentional conditions). The different conditions were based on different types of interaction among the adults, the children and the toy, and there was a gradual diminishing of intervention from pedagogical to baseline conditions. The results of the first experiment demonstrated that teaching constrains a child's spontaneous exploration and self-discovery, and the second experiment supported the findings of the first experiment that children have a tendency to discover new properties independently rather than through other intentional conditions. The researchers highlighted the dichotomy of instruction in children's exploratory play. Instruction has certain positive effects on learning-instructed information; however, it also causes certain undesired effects on the spontaneous exploration of untaught information.

In another study, Schulz and Bonawitz (2007) hypothesized that children are able to distinguish confounded and unconfounded evidence and that children tend to engage in more exploratory play when evidence is ambiguous. The researchers designed an experiment to reveal the play preferences of children concerning a familiar and novel toy when the evidence was confounded or unconfounded. The results of the study supported the prediction of researchers that children tend to select and explore confounded evidence while experiencing a new object or condition. The researchers suggest that childhood exploratory play can be associated with childhood causal learning and scientific inquiry skills; however, there is a need for further research in these areas.

In a recent study, Bulunuz (2013) investigated children's understanding of science concepts with respect to direct instruction versus a science through play dichotomy. The quasi-experimental design research was conducted in two typical public kindergarten classrooms. The children studied were all 6-years-old. Two groups of children were taught certain science concepts/phenomena (i.e., float/sink, air, living/nonliving) through instructional intervention or direct instruction. The experimental group experienced lesson plans and hands-on activities that were prepared by the researcher, whereas all lesson plans for the comparison group were prepared with the advice of the teacher. The learning through play for the experimental group consisted of three steps; introducing all concepts throughout the semester, implementing several activities and integrating science activities with other subjects. The results according to the quantitative analysis of pre-test and post-test interviews demonstrated that children in the experimental group were more effective at learning science concepts through a science through play approach than the children from the comparison group who experienced the direct teaching. The results demonstrate that a goal-oriented curriculum and materials for integrating play and science teaching in kindergarten classrooms are required.

The findings of these four studies emphasize that exploratory play provides a broad range of opportunity for early childhood science education. Children are likely to benefit from structured pedagogical interventions. However, unstructured learning experiences appear to initiate the use of scientific thinking skills in early childhood. More studies are required to examine the influence of different types of play on the learning of science concepts and the development of science process skills.

Inquiry-Based Science Teaching

There has been more focus on the teaching of science and science education since the introduction of educational reforms of the mid-twentieth century. The National Science Education Standards (NRC, 1996) recommend inquiry as a method for teaching and learning science. The National Research Council provides a comprehensive definition for the inquiry:

> "Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results." (NRC, 1996, p. 23)

The inquiry-based learning process is promoted as a "gold standard" in the science education literature because it is effective in facilitating the conceptual understanding of scientific phenomena (Trundle & Saçkes, 2012). The inquiry-based instruction investigates a set of phenomena and draws individual or group conclusions based upon evidence (Kuhn, Black, Keselman, & Kaplan, 2000; NRC, 1996). Inquiry is a method for teaching science in addition to a method to be mastered by children (Padilla, 2010). Scientific inquiry is central to science learning. Scientific inquiry promotes the active learning processes and the integration of all students, in addition to the cultural and intellectual diversity of contemporary science in classrooms (NRC, 1996). The NRC (2000) highlights five important features of classroom inquiry: (1) the posing of scientific questions, (2) the use of evidence to provide an explanation, (3) the evaluation of explanations, (4) the noting and assessment of alternative explanations, and (5) the discussion of explanations. These active processes of scientific inquiry encourage children to construct new knowledge and develop science process skills. Similarly, Samarapungavan, Patrick and Mantzicopoulos (2011) specified certain characteristics of effective science instruction in early childhood classrooms; these include domain specific and contextually relevant themes and engagement in the process of inquiry with the use of science process skills (e.g., asking questions, making predictions, gathering data through observations and tools, evaluating the coherence of evidence and predictions, drawing conclusions and sharing findings with others).

The scholars have offered different categorizations for the inquiry-based method of teaching based on the complexity of tasks and the amount of support provided. Bell, Smetana and Binns (2005) proposed four levels of inquiry: confirmation, structured, guided and open inquiry. Lederman (2009a) has offered a similar hierarchy; exploration, direct inquiry, guided inquiry and open ended inquiry. Within this hierarchy of inquiry–based instruction methods, moving from confirmation to open inquiry causes the nature of instruction to become more complex and less scaffolded. For instance, at the exploration or confirmation level, children receive direct support from teachers, whereas at the open-ended inquiry level, children plan and implement their own inquiry experiences. The researchers suggest using guided inquiry-based science teaching activities in early childhood classrooms, where research problems and materials are incorporated and children are expected to create their own solutions (Howitt, Lewis, & Upson, 2011; Lederman, 2009b; Trundle & Saçkes, 2012). Samarapungavan and colleagues (2008) posited that guided inquiry within the context of early childhood classrooms provides an investigative context that encourages children to construct meaningful new knowledge.

The research findings with respect to inquiry-based learning at the elementary-grade level have demonstrated that most children develop scientific thinking skills and construct a rich understanding of scientific concepts (Metz, 2004). The studies have demonstrated that children are actually more capable of developing richer scientific thinking skills than some Piagetian and non-Piagetian researchers imply (Metz, 1995). Mantzicopoulos, Patrick and Samarapungavan (2013) indicated that as children engage in scientific inquiry activities in early childhood, they are able to develop a foundational understanding of inquiry. In classrooms that utilize the inquiry-based approach, children, as do scientists, conduct research on problems and questions. This method of teaching is likely to promote science achievements among children (Bell, Smetana, & Binns, 2005; Tatar & Kuru, 2006; Wu & Hsieh, 2006). The inquiry-based science curriculum offers children the opportunity to explore, observe, predict, and reflect (Wu & Hsieh, 2006). The learning cycle is one of the most well-known and widely used inquiry-based approaches to teaching science.

Karplus and Atkin, with the support of the National Science Foundation, developed the 3E learning cycle as an instructional strategy within the scope of the Science Curriculum Improvement Study (SCIS) program (Abraham, 1997; Ajaja & Erawvoke, 2012). The 3E learning cycle was based on Piaget's mental functioning model (Abraham, 1997; Marek, 2008). According to the model, mental functioning processes correspond to learning cycle phases that are labeled exploration, explanation (concept development), and extension (expansion) (Marek, 2008). When a child is exposed to a new condition, it is called disequilibration and results in assimilation between the existing concepts and the new concept. The exploration phase of the 3E learning cycle is similar to the equilibration process used when children begin to learn new knowledge in the inquiry-based learning environment. The reequilibration process accommodates new schemas for novel knowledge/conditions. In the explanation phase of the 3E learning cycle, children are able to progress in concept development. During the final process of mental functioning, children organize schemas. This process of mental functioning is similar to the extension phase of the 3E learning cycle. The 3E learning cycle suggests that through scientific exploration, children can be encouraged to first explore materials and then to construct a conceptual understanding and to implement or expand the concept to other situations.

The 5E learning cycle was developed by Bybee in the 1980s within the context of the Biological Sciences Curriculum Study (BSCS) that aims to organize developmentally appropriate experiences for systematic science education (Bybee, 2006). Detailed information with respect to the 5E learning cycle is presented in the report of the BSCS for the Office of Science Education National Institutes of Health (Bybee, 2006). The five phases of the model are described as engagement, exploration, explanation, elaboration and evaluation (Bybee, 2006; Bybee et al., 2006). The first phase, engagement, includes the preparation of methods and learning opportunities to reveal relevant pre-knowledge and actions with lesson content. The exploration phase includes experiences in which a child's existing understanding is challenged by various learning opportunities such as activities and discussion. The explanation phase introduces scientific concepts that cohere to a child's scientific explanations. The elaboration phase is composed of activities that are required for reflection on the scientific concepts and vocabulary in new conditions. The last phase, evaluation, provides a concluding activity for children to evaluate their understanding. According to Yoon and Onchwari (2006), the 5Es instructional model provides learning opportunities that can encourage children to follow their innate curiosity, explore the natural world, and develop problem-solving skills. Many studies on learning cycles have demonstrated that students display higher achievement, positive attitudes, and improved development of concepts and process skills after learning cycle-based instructional interventions (Miller, Trundle, Smith, Saçkes, & Mollohan, 2012).

Conclusion

Children have a tendency and an inborn curiosity for exploration of the natural world. During early childhood, children should be exposed to a variety of science learning opportunities in a playful context. The inquiry-based learning cycles supported by play appear to be a promising method for planning and implementing developmentally appropriate science learning activities for early childhood settings. The blending of child-friendly pedagogical methods may promote the early childhood learning of science in preschool classrooms.

Play "as an act of inquiry" (Youngquist & Pataray Ching, 2004) may inform the design of inquiry-based science learning activities in early childhood. Because play functions as an inner drive to learn and explore, it can be incorporated into early childhood educational activities more effectively than any other method. Childhood education professionals should recognize that play is the most effective and natural way for a child to learn (Bredekamp & Coople, 1997). The use of an inquiry-based approach and learning cycles in preschool classrooms may require certain adaptations and developmentally appropriate methods. The integration of play with inquiry-based science learning activities can promote the learning of science in early childhood. The play activities that are embedded within the phases of a learning cycle may promote a child's understanding of science concepts and the use of science process skills. A recent study with preschool children implemented this idea (Miller et al., 2013). Children's understanding of day and night and objects in the sky was examined before and after play-based science instruction to determine the instructional effectiveness. The instructional intervention of the study was based on a play-based 5E learning cycle model for children. The children were able to explore concepts and materials within the phases of the learning cycle while playing. The play materials and settings related to targeted concepts were available to the children during the instructional intervention. The results of the study demonstrated that play-based science instruction assists preschoolers in the development of a scientific understanding of the basic astronomy concepts. Play is also suggested as an alternative resource for early childhood science education in Cambodian schools that mainly serve the children in extensively poor and disadvantaged areas (Reyes & Ebbeck, 2010).

There is a consensus among early childhood educators and researchers that children learn most effectively through play (Bergen, 2009; Bodrova & Leong, 2007, 2010; Broadhead, 2006; Elkind, 2008; Henricks, 2008; Osborne & Brady, 2001; Pelegrini, 2009; Pramling Samuelsson & Johansson, 2006; Schulz & Bonawitz, 2007). However, the evidence that supports the idea of using play as a pedagogical tool is limited. Few studies have examined the context of play activities or play-based science instruction and their influence on childhood science and mathematical concept learning and the development of scientific and mathematical thinking skills (Cook, Goodman, & Schulz, 2011; Bonawitz et al., 2011; Miller et al., 2013; Nayfeld et al., 2011; Sarama & Clements, 2009; Oers, 1996). Additional studies are required to reveal the ways in which children learn within the context of play-based science instruction and whether the inquiry-based science instruction supported by play is effective in young children's understanding of basic science concepts (Cook et al., 2011; Miller et al., 2013; Schulz & Bonawitz, 2007; Trundle & Saçkes, 2012).

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