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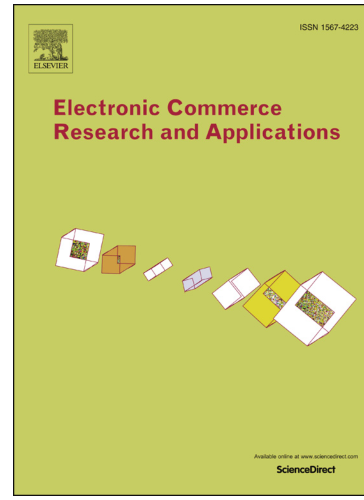


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# Smart Toys for Preschool Children: A Design and Development Research

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## Abstract

The purpose of this study is to devise guidelines for designing, developing, and using a smart toy for preschool children. Smart toys are technologically developed toys constructed with a meaningful purpose. This study uses the design and development research method. In the analysis phase, the smart toy developed in the pilot study was analyzed. In the design phase, focus group meetings were held with early childhood teachers to determine the objectives, story, and storyboard of the smart toy. In the development phase, two prototypes were developed, and formative evaluations were conducted with preschool children, early childhood teachers, and scholars. In the evaluation phase, the smart toy was evaluated by preschool children. Many design guidelines (categorized as content, visual design, or interaction) emerged during the study.

**Keywords:** Smart toy, human-computer interaction, design and development study, children, technology



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## Abstract

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# 1 Introduction

Personal, portable, and wirelessly networked technologies have become widespread in the lives of learners, including young children (Chan et al., 2006). Hence, it is important to research how best to integrate these new technologies into their lives. Appropriate technology use in early childhood education (ECE) settings provides rich learning environments for children who have difficulties generalizing their learning to other environments. Children in ECE environments require a variety of learning materials that support their learning and enable active participation. Accordingly, this study has an important role for children because new technologies like smart toys are often provided to children to support curriculum-related objectives.

The concept of a smart toy refers to a technologically developed physical toy constructed with a meaningful purpose. While classic electronic or digital toys use technological features only for increasing the attraction of the toy, smart toys provide a meaningful technologically augmented environment for children to carry out purposeful tasks interactively (Cagiltay et al., 2014). In the literature, the "Internet of toys" (IoToys; Chaudron et al., 2017; Wang et al., 2010), computationally augmented toys (Bers and Cassell, 1998; Glos and Cassell, 1997), digitally augmented physical spaces, and digitally enhanced physical spaces (Price and Rogers, 2004), all fall under the concept of smart toys. We prefer to use the term *smart toys* because "smart (intelligent)" is a distinctive term and clearly reflects its dynamic and adaptive concepts.

Based on the statistics, the current global smart-toy market was valued at around US$ 50,000.00 Mn and is expected to reach US$ 69,932.5 Mn by 2026 (Transparency Market Research, 2018). The report considered IoToys and STEM (science, technology, engineering, and mathematics) toys to be the leading components for increasing the smart-toy market value. Improving the interaction between smart toys and players can enhance the dominance in the market. Additionally, improving the STEM skills of children using smart toys can motivate parents to purchase smart toys for their children. The report also listed the types of smart toys on the global market, such as app-enabled mechanical toys, voice/image recognition toys, screenless toys, toys-to-life, puzzles and building games, and health tracking/wearable toys (Transparency Market Research, 2018). Because the popularity and market value of smart toys have been increasing, conducting scientific studies related to the design, use, and evaluation of smart toys can support the best practices for the market.

Existing research studies focus on evaluating the effectiveness of technological devices for young children's formal and informal learning. With the rapid growth of technology, wireless, hand-held, and augmented technologies have increased in popularity for adults and children. However, no detailed research studies on smart toys for early educational settings exist. Therefore, an investigation is needed on how to best integrate these toys into young children's learning environments.

This study aims to fill this gap by focusing on the design and development process and smart-toy play experiences of children. Because preschool curricula mostly require teachers to provide dynamic, flexible learning environments and create rich learning experiences, teachers and young children should be included in the studies. Design guidelines that will be gathered with the participation of preschool teachers can guide researchers or professionals in this field to choose smart toys that have appropriate designs and content for children. Hence, the main research question is "What are the design guidelines when designing a smart toy to support curriculum-based objectives?"

In summary, the present study seeks to design, develop, and use a smart toy for preschool children from 36 to 72 months old. This is expected to produce key design guidelines for integrating smart toys into preschool education. This will achieve two important goals: to design and develop a smart toy (1) in accordance with the needs of teachers and children (2) that has a supportive role for specific objectives of the preschool curriculum.

## 2 Literature Review

Cognitive tools enable learners to achieve goals they are already motivated to reach (Malone and Lepper, 1987). Because toys have great potential to motivate children to reach specific goals, smart toys can be considered cognitive tools. The goals of the instructional or cognitive tools are to increase motivation and interest and improve retention and higher-order thinking skills (Hogle, 1996). From this perspective, the nature of smart toys as cognitive tools for children's needs requires attention from instructional technologists. As Eisenberg (2003) stated, "we can look to various children's cultures around the planet; and we can explore how children's activities with materials might lend themselves to robust, creative, emotionally, and intellectually inspiring integration with technological artifacts" (p. 50). The important point is that smart toys can serve to integrate children's thinking, creativeness, imagination, reflection, and so on with technology. These toys create an environment that motivates children to play and promotes their cognitive activities. For instance, storytelling, mathematical thinking, and concept-learning activities can be augmented with smart toys.

Interaction also has a great influence on technological systems and instructional activities. Resnick (1998) emphasized that managing interactions with toys or other playable tools has a considerable effect on children's play and learning. From this perspective, structured and meaningful interactions with toys have an important role in children's lives. Smart toys have great potential to provide mutual interactions between children and systems (Cagiltay et al., 2014). Smart toys allow children to participate actively and interactively in mixed-reality environments. This is a distinctive point compared to classic electronic or digital toys because smart toys use interaction for purposeful tasks in authentic play environments. For instance, in the smart storytelling toy StoryTech, interactions can prompt children to share imaginative stories in mixed-reality environments (Kara et al., 2013).

Open-ended features can also improve the effectiveness of smart toys. Rather than providing a determined system, smart toys allow children to explore new things. For instance, children can decide how to handle plush (smart) toys in storytelling and are prompted to produce different stories for the toys (Kara et al., 2014). Combining physical and virtual realities in mixed reality makes open-ended features easy to develop. An important contribution of these features is motivating children to play collaboratively. Through open-ended smart-toy features, children can share their play activity with others and mutually enhance learning experiences. Similarly, Petersson Brooks and Brooks (2006) emphasized that "open-ended design features evoke children's motivation to learn and the physical and virtual explorations optimized a sense of being immersed which can enhance collaborative play and learning experiences" (p. 198).

Because play activity is considered one of the central points in preschool education, designing a toy that allows children to be included in play activities in accordance with children's needs is the focus of designing and developing a smart toy. Although today's children face new technologies, such as tablets and smartphones, daily, limited implementation has occurred in education, especially at the preschool level. Therefore, integrating appropriate play technology into preschool education is an important reason to design and develop smart toys. Moreover, several authorities have criticized using technology to separate children from reality with a focus only on a virtual environment. Hence, enabling play activity with a toy that provides both a physical and virtual environment is another important reason for designing and developing smart toys.

There have been several smart toy-related projects in the literature. Some researchers have focused on education. Heljakka and Ihamäki (2018) investigated the educational value of IoToys with the participation of kindergarten teachers, parents, and preschool children. They found that IoToys are helpful for educators because they enable exploratory play and attract the attention of children. Lampe and Hinske (2007) presented the Augmented Knight's Castle playset for enriching the pretend play of children by providing sound effects and verbal reactions from toys. The aim of the smart toy was to provide an interactive Middle Ages environment based on radio-frequency identification (RFID) technology. Piper and Ishii (2002) implemented PegBlocks, which is an educational toy aimed at showing basic physics principles to elementary school students.

Some of the smart toys focused on health care. Vega-Barbas et al. (2015) conducted a study to design, develop, and evaluate a smart sensor-enabled textile toy for healthcare activities. The aim of the research was to increase user engagement in e-health services. They indicated the potential of smart toys for increasing the confidence of users in monitoring psychomotor development during early childhood. Martin-Ruiz et al. (2015) investigated the Smart Cube to detect neurodevelopment disorders and notify family and professionals about the need to monitor a child's developmental level. In addition, Giannopulu and Pradel (2010) suggested that interaction between children who are autistic and a mobile toy robot could enhance the social skills of children during free spontaneous gameplay.

Other researchers have focused on creativity. Kara et al. (2014) developed StoryTech to help children create imaginative stories. Plush toys with RFID readers, background cards, and flash animation were the components of StoryTech. Virtual views of plush toys or background cards appeared in flash animation when the physical objects were placed on the RFID reader. Moreover, Fontijn and Mendels (2005) developed StoryToy, which is an environment with several stuffed farm animals telling stories and reacting to other animal's actions.

Based on the literature review, most studies show the benefits of using smart toys in different areas, such as education, health, and creativity. However, it is also important to be aware of the drawbacks. Privacy might be a disadvantage of using smart toys. Embedded sensors or cameras could be hacked, and player data could be at risk for manipulation (Brito et al., 2018; Holloway and Green, 2016; van Dijck, 2014). Additionally, parental limits of smart toy use because of the high cost and children's excessive use of digital technology is another disadvantage (Brito et al., 2018). Considering these limitations in designing and using smart toys might be helpful in determining the best practices.

The literature indicates that research on smart toys for young children has some limitations. As Cagiltay et al. (2014) stated, "Although the smart toys were developed for pedagogical purposes, early childhood scholars' or teachers' contributions have been limited" (p. 710). Whereas most countries' ECE curricula refer to information and communication technology (ICT) and programmable toys (Plowman and Stephen, 2003), smart-toy practices in the literature have focused on specific purposes for young children, such as storytelling, pretend play, and so on. Existing smart-toy projects have not provided applications for formal ECE environments, which is inconsistent with the ECE curricula. Moreover, researchers developing new toy technologies for young children tend to conduct small-scale user studies to test the effectiveness of these toys for young children.

Despite calls for investigation of how best to integrate new technologies into young children's formal and informal learning environments, design and development periods of new smart-toy technologies have not been adequately emphasized by researchers. Considering the views of young children and early childhood teachers during the design and development of these technologies is important for effective design guidelines, rather than only testing the effectiveness of the designed products. Although design-based research is seen as a proper methodology for designing new technologies for educational environments (Wang and Hannafin, 2005), most researchers have not applied design-based research in this field.

# 3 Methodology

Design and development research is defined as “the systematic study of design, development and evaluation processes with the aim of establishing an empirical basis for the creation of instructional and non-instructional products and tools and new or enhanced models that govern their development” (Richey and Klein, 2008, p. 748). Thus, design and development research involves all phases of creating a tool or model, and it was applied because it seeks to determine design guidelines and support them using a prototype. It is a systematic but flexible methodology to produce contextually sensitive design guidelines and theories (which reflect the originality of the sampling, data collection, and analysis procedures) that can guide other researchers (Amiel and Reeves, 2008; Wang and Hannafin, 2005). This research was conducted to produce the design guidelines of a smart toy, using qualitative data collection and analysis to determine these guidelines.

According to Richey and Klein (2014), creating new knowledge, obtaining sufficient field information, and making estimations are the main three goals of design and development research. They divided these research projects into two categories: “(1) research on products and tools and (2) research on design and development models” (p. 142). The present study fits in the first category because the focus is on the design and development of smart-toy technology. In the current study, the models by Reeves et al. (2004) and McKenney and van den Akker (2005) were followed. The final model of this study is shown in Fig. 1.

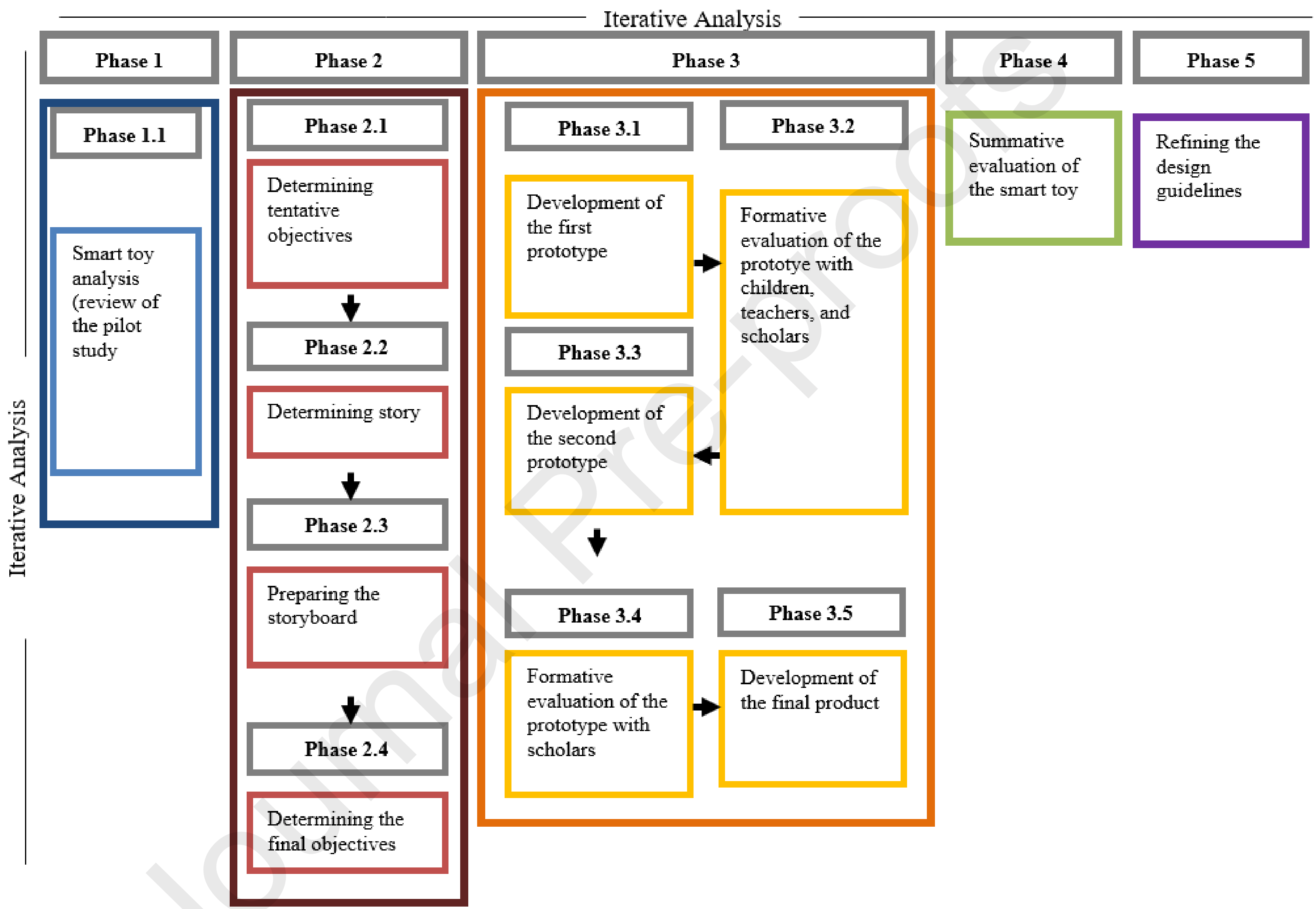


**Fig. 1.** Method based on design and development research models by Reeves et al. (2004) and McKenney and van den Akker (2005).

*3.1 Pilot Study (Smart Storytelling Toy – StoryTech)*

A smart storytelling toy, StoryTech, was designed and developed to promote the storytelling skills of children (Kara et al., 2014). The smart toy consisted of four main components: flash animation, RFID-based plush toys, background cards, and an RFID reader. When children put the plush toys or background cards onto the RFID reader, the virtual character of the object appears on the screen showing a flash animation.

The smart toy offered a known story to accustomed the children to playing with the smart toy and prompted children to produce their own stories. A well-known rabbit and turtle story was presented via flash animation, and children were only expected to place the rabbit or turtle when prompted by the narrator. In the second level, children were free to put animals and background cards on the RFID reader. Different animals, such as lions, rabbits, turtles, polar bears, and sheep, and different background cards, such as night, farm, and North Pole cards, were available for creating stories.

*3.2 Participants*

Since design and development research requires several phases, such as analysis, design, development, and evaluation, several participants, who were selected using convenience sampling, were included in different phases of this study. According to Marshall and Rossman (2011), "researchers' site selection and sampling often begin with accessible sites" (p. 107). In the analysis phase, the smart toy was presented to a group of teachers as a pilot study. This was the starting point for the researchers to better conduct the design and development of the study.

For the design phase, four early childhood teachers were involved in focus group meetings on determining specific objectives, stories, and storyboards to be considered for the smart toy. Participants were eager to share their thoughts, had at least 5 years of teaching experience, had a positive attitude toward technology use in preschool education, and were able to attend group meetings regularly. All teachers were selected from the same public preschool for convenience, providing a friendly environment among teachers. All teachers were female and used computers for several practices in ECE classrooms.

For the development phase, after developing the first prototype, a formative evaluation was conducted with preschool children, early childhood teachers, and scholars. Five children from a private preschool were selected to test the first prototype. In addition, two children from the public preschool of the early childhood teachers who attended focus group meetings were included. Children's ages ranged from 38 months to 69 months. All children who showed an interest in playing with the first prototype and could share their reactions with the guidance of their teachers were selected.

The early childhood teachers who also participated in the design phase were selected to test the first prototype. The teachers were interviewed because it was important to provide a connection between design and development. Three teachers out of the original four attended (one was on vacation at the time).

In the evaluation phase, a summative evaluation was done with 10 preschool children and three early childhood teachers. To provide consistency between the design, development, and evaluation, the same teachers who also attended focus group meetings in the design phase and formative evaluation in the development phase were selected. New teachers were also interviewed to enrich the data and gain a more diverse perspective on the smart toy.

### *3.3 Data-Collection Instruments*

*Formative Evaluation Interview (FEI)*: The FEI protocol was used to conduct individual semi-structured interviews with three early childhood teachers about the first prototype of the smart toy. The FEI protocol involves an interview plan and questions. There were five main questions addressing the following: what teachers think about the general design of the first prototype, what the design problems of the first prototype are, what revisions are needed in the first prototype to eliminate design problems, what the content problems of the first prototype are, and what revisions are needed in the first prototype to eliminate content problems.

*Summative Evaluation Interview (SEI)*: A SEI protocol was used to conduct individual semi-structured interviews with six early childhood teachers about the design and use of the smart toy. The SEI protocol included an interview plan, demographic questions, and eight questions on the content and process, addressing what teachers think about the design components of the smart toy, what they think about the content and scenario of the smart toy, what they think about the interaction, how the smart toy affects the motivation of children, how the smart toy can be used for assessment and evaluation, how the smart toy can be used in and out of the classroom, and what the advantages and limitations of the smart toy are.

*Focus groups*: Focus groups can range from 4 to 12 persons (Marshall and Rossman, 2011). One of the advantages of the focus group is creating a supportive environment to help participants express and understand their own views (Bogdan and Biklen, 2007). As Marshall and Rossman (2011) emphasized, “in action research and in program design and evaluation, focus groups are especially useful” (p. 149). Six focus group meetings were held with four early childhood teachers and a programmer in the design phase of the study. The purpose of the first focus group meeting was to design a smart toy by determining specific objectives, a story, and a storyboard. A focus group meeting was held with two instructional technology (IT) scholars and one ECE scholar who had been members of the doctoral committee in the formative evaluation of the first prototype in the development phase. The goal of the meeting was to test the first prototype and obtain the views of the scholars to determine the problems and revisions. A new focus group meeting was held with the same scholars from the formative evaluation of the second prototype in the development phase. The goal was to test the second prototype and obtain the views of the scholars to determine the problems and necessary revisions.

*Observations*: Marshall and Rossman (2011) emphasized that recording direct observations is of great importance. Observations were applied in usability testing of the smart toy in the development and evaluation phases. Observation as a data-collection tool was used for children because of the difficult nature of interviewing young children (Marshall and Rossman, 2011).

### *3.4 Data Analysis Techniques*

In this study, an inductive analysis was applied with content and descriptive analysis. Content analysis enables researchers to analyze written content (Fraenkel and Wallen, 2006). Marshall and Rossman (2011) explained qualitative analytical procedures as “organizing the data, immersion in the data, coding the data, writing analytic memos, generating categories and themes, offering interpretations, searching for alternative understandings and writing the report” (p. 209). Qualitative data analysis started with organizing the data for this study. All data gathered via interviews, focus group meetings, and observations were organized and transcribed into an MS Word document. After organizing the data, the coding based on the content analysis process was applied.

Qualitative coding requires reviewing the data to find patterns and generating words or phrases to represent these patterns (Bogdan and Biklen, 2007). Therefore, the researchers coded all themes and sub-themes for different kinds of data, such as interview transcripts and focus group meeting notes. Axial coding was applied because “axial coding enables [the] researcher to group the codes according to conceptual categories that reflect commonalities among codes” (Marshall and Rossman, 2011, p. 215). After the axial coding process, themes emerged. The researchers composed themes by considering commonalities among the created codes. After creating themes, the researchers tried to create meaningful connections by examining the themes and related codes and making interpretations.

The study was approved by the university ethical committee. All the parents were formally informed via consent forms and agreed to the participation of their children in this study. Anonymity was guaranteed. To increase the reliability of the study, intercoder reliability was calculated (.90) for the teacher interviews, finding a good level of reliability. To increase the validity of the study, interviews, focus groups, and observations were used to gather data, in accordance with triangulation methods, from several participants, such as early childhood teachers, preschool children, and scholars. For member checking, one of the transcriptions of the interviews conducted with the teachers was sent to the interviewee to check the raw data of the taped interview. The feedback of the interviewee was that the data were consistent with the taped interview.

This study was limited to early childhood teachers, preschool children, and scholars who attended as participants. A smart toy with computer interaction was the main consideration in this study. Although smart toys can be self-contained or interactive with digital devices, the main material of the study was a computer-interactive smart toy. This could limit the effect of the study because the technology includes only the smart toy interacting with the computer.

## 4 Results

In the analysis phase, the pilot smart toy was analyzed as a starting point for the design period of the study. The literature was reviewed to gain information about the latest studies. The analysis phase contributed to the research by allowing researchers to deepen the understanding of the smart-toy concept and the related studies.

In the design phase, six focus group meetings were held with four early childhood teachers to design the smart toy. The phases included determining tentative objectives, determining the story and its components, preparing the storyboard, and deciding the final objectives. Design guidelines started to emerge in this phase. The focus group meetings with preschool teachers were analyzed scientifically, and common points were noted as guidelines.

Early childhood teachers prepared tentative objectives for the story. They ascribed importance to goals and objectives for any material used in preschool education. Additionally, teachers believed that several objectives of different developmental areas, such as cognitive, language, social-emotional, motor, and personal care needed to be considered. Therefore, the tentative objectives and their indicators in developmental areas for cognitive and personal care were determined based on the national preschool curriculum.

After determining tentative objectives to be pursued in designing the smart toy, focus group meetings continued in order to create the story. Teachers decided to create a story about an environment in which children spend time in their daily routines. Hence, the teachers proposed several ideas, such as presenting school, house, or park environments; for instance, a teacher stated:

> *There can be a girl. There can also be rooms of a house. Colors can be given with slippers that a child wears. The child can wear the red slippers and go to the kitchen. Stuff in the kitchen can be given in the toy, and it also involves young characters*.

The agreed story topic was rooms in a house. They also emphasized that using a child character in the story was important so that children can identify with the character. A 5-year-old girl (Ayse) was selected as the character in the story. In addition, teachers decided that the story should be about a rest day for children because the story must consider the school environment on weekdays. Based on the teachers' ideas, the story must be realistic and consistent with real life.

Teachers also pointed out that the story starts with developing personal care skills and then continues with developing cognitive skills. On the concept of color, teachers agreed on using three primary colors (red, blue, and yellow). For the narration and voice of the child character, teachers emphasized using warm and familiar sounds for children. Therefore, teachers decided to use the voice of a woman for narration and a 5-year-old girl's voice for the sound of the young character. Based on the ideas and statements of the teachers, the first draft of the story was produced. Before preparing the storyboard, the second draft was reviewed during the focus group meetings. Based on the reviews and notes, a storyboard consistent with the second draft and teacher feedback was prepared.

Although teachers agreed that several objectives of different developmental areas can be pursued in the smart toy, the context was restricted to cognitive and personal care skills to design the smart toy for 36- to 72-month-old children. For that purpose, the final objectives and their indicators for these skills were determined based on the national preschool curriculum:

- Cognitive Skills

  *Objective 1:* Gives attention to object/situation/event.

  *Objective 2:* Observes objects or material.

  *Objective 3:* Groups objects or materials by their properties.

  *Objective 4:* Follows location-related instructions in space.

*Objective 5:* Recognizes geometric shapes.

*Objective 6:* Recognizes symbols used in daily life.

*Objective 7:* Creates patterns with objects.

- Personal Care Skills

*Objective 1:* Applies the cleaning rules on the body.

*Objective 2:* Feeds self adequately.

*Objective 3:* Uses tools and equipment for daily life skills.

In the development phase of the smart toy, several sub-phases were also accomplished. The first prototype of the smart toy was developed based on the storyboard created in the design phase. Formative evaluations were conducted with preschool children, early childhood teachers, and IT and ECE scholars. Based on these evaluations, new design guidelines emerged and were added for different themes, such as content, visual design, and interaction. The second prototype was developed based on the revisions from the participant feedback in the formative evaluation. A new formative evaluation was also conducted with scholars to evaluate the second prototype, based on which the final version of the smart toy was developed. The detailed development process is explained below.

Based on the storyboard prepared in the design phase, there were five main scenes: introduction, bathroom, kitchen, child's room, and patterns. These scenes were developed in Adobe Flash by considering the details mentioned in the storyboard. A screenshot of a sample scene is shown in Fig. 2.

**Fig. 2.** Screenshot of a scene in a child's room.

After developing the virtual content, plush toys and background cards with RFID tags were adapted to the virtual environment of the smart toy. The RFID tags were placed into each toy, and the RFID codes were used in programming the smart toy. Toys appropriate to the characters developed in the virtual content are presented in Fig. 3.

**Fig. 3.** Plush toys equipped with RFID tags.

The pictures of scenes or objects used as cards in the smart toy were attached to RFID cards. Each card had a unique RFID code, and these codes were used in programming the smart toy. Cards used in the smart toy are presented in Fig. 4.


**Fig. 4.** RFID cards with pictures of objects.

Based on the storyboard in the design phase, the RFID reader was referred to as a "hand" to make the object familiar to children. Accordingly, a hand picture was attached to the reader, as presented in Fig. 5.

**Fig. 5.** RFID reader with the picture of a hand.

### *4.1 Formative Evaluation*

After developing the first prototype, a formative evaluation was conducted with preschool children via observation. The first prototype was developed based on two curriculum elements: personal care and cognitive development. Table 1 summarizes each child's duration of play for personal care and cognitive development.

**Table 1**

Duration of play for the first prototype

| Gender | Age | Personal Care Skills (minutes) | Cognitive Skills (minutes) | Total Play Time for first prototype (minutes) |
|---|---|---|---|---|
| Male | 38 months | 4.20 | 9 | 13.20 |
| Female | 40 months | 4.15 | 8.30 | 12.45 |
| Male | 45 months | 4.20 | 7.40 | 12.00 |
| Male | 55 months | 4.20 | 6 | 10.20 |
| Male | 56 months | 4.10 | 9.30 | 13.40 |
| Male | 62 months | 3.30 | 6.45 | 10.15 |
| Female | 69 months | 5 | 5.30 | 10.30 |

According to the observation notes, all children completed the tasks of personal care skills easily. However, children aged 36 to 60 months had several difficulties in the scenes of cognitive skills. These children could not solve the patterns. Some children could not understand which pattern needed to be solved first because three different patterns were shown in the same scene. Therefore, it was important to use only one pattern on each screen and to start from the basic pattern, making them more difficult in later scenes. Thus, the content must be clear and easy to understand for children. In some scenes, a time gap occurred after voice narration. This negatively affected the flow of play because children had to wait after completing a task. Therefore, time breaks should be small to prevent loss of concentration during play.

Based on the observation notes, children could damage toys if they did not have plush features because they dropped the toys several times and grabbed them roughly. Hence, using soft plush toys was an advantage because these toys cannot be destroyed easily. Moreover, all children participating in smart-toy play sessions were guided by their teachers. Hence, teachers helped the children when they had difficulties understanding or following the scenes. Thus, the guidance of teachers can increase the effectiveness of smart-toy play at school.

Teachers' feedback on the first prototype was obtained via semi-structured interviews. Three early childhood teachers who also participated in the design phase of the study were included in this formative evaluation of the prototype. Based on the responses of all teachers, there should be an option for teachers to jump to different scenes, such as the bathroom, kitchen, child's room, or the pattern when desired. Thus, there should be a way to show nonlinear content in smart-toy play. According to the teachers, a pattern scene including only three different patterns on the same screen was not adequate. Teachers wanted to see more and varied patterns. In addition, children should see different kinds of examples in the content of the smart toy.

Based on the responses of teachers, the character and narrator voices were not consistent in some scenes. While the voice of a woman was narrating, the character of the 5-year-old girl was shown on the screen. Hence, the design must be consistent, and the related visuals should appear with the correct voices. According to all teachers, the virtual mom and dad characters should also be dynamic rather than static. They pointed out that both the main character and environmental and background components should be dynamic to appeal to children. Most teachers noted that the colors of objects that are not emphasized in any activity should be different than the colors of the activity objects. Therefore, the visual design should not confuse children, and the objects emphasized in the smart toy should easily be differentiated from other objects in the same environment. Two of the teachers stated that the feedback given after putting a wrong toy or card onto the reader was good, which was important. Thus, feedback should be given after both correct and wrong moves in smart-toy play.

Scholar feedback on the first prototype was obtained via a focus group meeting. Three scholars participated in this formative evaluation of the prototype. Whereas two were from the field of instructional technology, one was from the field of ECE. According to the ECE scholar, the number and variety of patterns were not adequate for the children. He stated that, because the pattern activity included different variations, some of them can be presented in the smart toy. He also declared that patterns should be presented from simple to complex and that different variations should be presented in order. The ECE scholar stated that using positive feedback rather than negative feedback can be more suitable for children.

In addition, all of the scholars emphasized that feedback should be clear and easy to understand for children. They pointed out that feedback statements should be explanatory for the object or card put onto the reader. All scholars declared that the smart toy should also provide unstructured content for children. Children or teachers using this smart toy should have a chance to proceed to any scene rather than follow the structured content of the smart toy. They also emphasized that the guidance of the teacher is important in using nonlinear structures in a smart toy.

Scholars mentioned that the differences between real shapes and their virtual images can create conceptual confusion for children. Therefore, the plush toys and their visual images must match. All scholars mentioned the importance of showing animation or visuals in accordance with the narration. Additionally, they emphasized that animation or visuals should not mix with any other animation or visuals to prevent chaos in the scenes. According to the ECE scholar, children can use the help of an adult while playing with the smart toy. In addition, one of the IT scholars stated that a child playing with a smart toy can easily identify with a virtual character whose age is similar. Moreover, one of the IT scholars expressed that, when the child puts a toy or card onto the reader, the previous voice narration must stop, and the related visual or animation with its narration should appear. According to her, this was important for improving the interaction between the child and smart toy because the flow of the play is continuous.

### *4.2 Development and Evaluation of the Second Prototype*

The second prototype was developed based on the feedback from the children, teachers, and scholars in the formative evaluation of the first prototype. The visual of a female character was added because she narrates the introduction scene. A "get information about how to play" part was developed. A female character showed how to play with the smart toy. She asked the player to place the bathroom and kitchen cards in order to move to the related scenes. Additionally, she asked the child to put the bear toy onto the reader to show the visual image of the toy. When the bathroom scene appeared, Ayse also appeared in the bathroom. Ayse turned the tap on, washed her hands with soap, turned the tap off, and put the soap on the soap dish. The tap was closed, and soap was on the soap dish while Ayse was brushing her hair. A sample screenshot is presented in Fig. 6.


**Fig. 6.** Screenshot of the bathroom scene in the second prototype.

Scholar feedback on the second prototype was obtained via a focus group meeting. The same three scholars who joined the previous focus group meeting participated in the formative evaluation of the second prototype. In addition, a semi-structured interview was conducted with an additional ECE scholar to obtain more feedback. According to all scholars, it was important to separate smart-toy play into different modules. They emphasized that there should be an option to jump to any scene by putting the related card onto the reader.

Additionally, an ECE scholar stressed that negative feedback should generally not be used. In contrast, he stated that the correct input of the object should be reinforced, and explanatory feedback narrating the name or shape of the object should be used. Based on the information from the scholars, the last scene of the smart toy should be presented clearly, and children should be informed about what they accomplished at the end of the smart-toy play. The interviewed ECE scholar mentioned that background music can be used to attract the attention of children. He also stated that background music can be changed by the child playing with the smart toy, and different music can be given in different scenes.

### *4.3 Development, Evaluation, and Refinement of the Final Version*

The final version of the smart toy was developed based on the feedback of the scholars in the formative evaluation of the second prototype (Fig. 7).

**Fig. 7.** Children playing with the smart toy.

The evaluation phase was the last step in the design and development research before refining the design guidelines. In this phase, researchers conducted a usability study of the final smart toy. Table 2 shows the usability testing results on the time spent on different scenes. The tests lasted 15.44 min on average. Since four of the 10 children did not prefer to “get information about how to play with the smart toy,” the duration times of the introduction scene were 1, 15, 30, and 30 minutes. The findings also showed that the duration of the scenes on personal care skills was similar for all children except one. Therefore, almost all children were successful at completing the personal care skills part and did so within similar time periods. However, older children completed the cognitive skills part more quickly than younger children. Therefore, the young age group, especially 3-year-olds, spent more effort accomplishing cognitive-related tasks.

**Table 2**

Quantitative findings on smart-toy usability

| Gender | Age | Introduction scene (minutes) | Personal care skills scene (minutes) | Cognitive skills Scene (minutes) | Pattern scene (minutes) |
|---|---|---|---|---|---|
| Male | 38 months | 1 | 9.50 | 9.10 | 7.50 |
| Female | 41 months | 3.40 | 3.30 | 6.50 | 8 |
| Female | 47 months | 2 | 4.30 | 5.35 | 5.25 |
| Female | 50 months | 2.05 | 4 | 4.40 | 4 |
| Male | 54 months | 0.15 | 3.05 | 3.20 | 3.45 |
| Female | 61 months | 2 | 2.55 | 4.30 | 3.10 |
| Male | 69 months | 2 | 4.30 | 5.50 | 4.30 |
| Female | 69 months | 2.10 | 2.50 | 3.30 | 3 |
| Male | 69 months | 0.30 | 4.40 | 4 | 2.20 |

| | | | | | |
|---|---|---|---|---|---|
| Female | 69 months | 0.30 | 4.15 | 3.40 | 3.20 |

Guidelines that emerged in different phases, such as the design, development, and evaluation, were finalized and refined in Phase 5. These design guidelines are presented in the Discussion section below.

# 5 Discussion

In this part, these design guidelines in accordance with related themes were discussed along with the findings in the literature.

## *5.1 Content*

The first design guideline in the "content" theme was: *A variety of plush toys or cards should be included in smart toy play*. This is important because teachers expect to use more varied toys while playing with smart toys. Since teachers prefer to use the smart toy collaboratively in classroom settings, using a variety of plush toys or cards allows each child to interact with a plush toy or card. Similar to this design guideline, Hinske (2009) stated that multiple objects should be involved into virtual content.

The second design guideline in the "content" theme was: *High numbers of plush toys or cards should not be included in the smart toy to prevent loss of focus and concentration of children*. This guideline is of importance because using high numbers of plush toys or cards can decrease the playability of the smart toy. In parallel to this guideline, Kehoe et al. (2004) conducted research about virtual peer systems and concluded that "a balance needed to be struck between the presence of too few toys and too many toys. Two or three items in each room seemed to be a good compromise" (p. 4).

The third design guideline in the "content" theme was: *Content of the smart toy should be suitable for children aged 36–72 months.* This is important since early childhood teachers integrate activities based on the preschool curriculum into classroom settings. Lampe and Hinske (2007) developed the Augmented Knight's Castle, providing interactive learning experiences for children by combining physical and virtual realities. They emphasized in their study that the content and its structure should be suitable for developmental needs of children. This was similar to the design guideline about the necessity of smart toy's content suitable for preschool children.

The fourth design guideline in the "content" theme was: *Feedback should be clear, explanatory, and easy to understand for children.* This guideline is important to help children focused on the smart toy play. Fontijn and Mendels (2005) developed StoryToy, which is an environment including several stuffed farm animals telling stories and reacting to each other's actions. They concluded that direct and immediate feedback is necessary to keep children focused on the play. In addition, Hinske (2009) stated that "feedback should always be immediate, correct and comprehensible" (p. 77). These findings reaffirmed the design guideline about clear, explanatory, and easy to understand feedback in content of the smart toy.

The fifth design guideline in the "content" theme was: *Instructions or directions used in the virtual content should lead children to focus on the play and prevent loss of concentration.* Since preschool children can easily be distracted, directions can guide them to finish the tasks while playing in a fantasy environment presented by the smart toy.

The sixth design guideline in the "content" theme was: *Each screen of the virtual content of the smart toy should be designed as clear and easily understandable by children.* This guideline can ensure consistency of the smart toy play. This consistency may improve play experiences of preschool children. Hanna et al. (1998) supported this guideline by proposing that design-related instructions should be easily understandable.

The seventh design guideline in the "content" theme was: *Smart toys supporting specific goals and objectives should be used in preschool education.* This design guideline indicated that curriculum related activities should be integrated into smart toy play in an unobtrusive way. Since early childhood teachers use the smart toy as a supportive material in preschool education, it is important to design the content in accordance with the objectives mentioned in the preschool curriculum. Similar to this design guideline, Large and Beheshti (2005) suggested as an interface design guideline that adding educational objectives into web portals can enhance children's experiences while having fun.

The eighth design guideline in the "content" theme was: *A detailed "Help" screen should be presented before starting to play the actual content of the smart toy.* This design guideline is important because it aims to provide detailed and necessary information about how to play with the smart toy. Inal (2011) also asserted that detailed instructions explaining play procedure in a physically interactive game should be given to children to adapt them effectively.

The ninth design guideline in the "content" theme was: *Instructions, directions, or narrations should mostly be performed by a virtual young child character to improve identification of the child (player) with the character.* This guideline can be linked to the view that the virtual young child character who is the same age as the child playing may support involvement and identification of children. This was also similar to Inal's (2011) suggestion that avatars should be used in game environments to secure attention of children.

The tenth design guideline in the "content" theme was: *Smart toys should be designed to give multiple tasks rather than providing a single and simple task.* This design guideline can be associated with the complexity of virtual content. Since it can be hard for early childhood teachers to make children finish the whole content while playing with the smart toy, teachers should have an option to focus on specific content. This guideline also indicated that children should be challenged while playing with a smart toy instead of doing tasks in a drill and practice way. Because challenge is one of the components of flow in game play, it can also be advantageous in smart toy play to keep children in the flow. Similar to this design guideline, Hanna et al. (1998) proposed that activities presented in computer products should be complex for children.

The eleventh design guideline in the “content” theme was: *Background music should be used as optional to attract attention of children.* Adding background music to the content of the smart toy may increase the attractiveness of smart toy play. Similarly, Hinske et al. (2009) carried out a user study of an augmented toy environment with elementary school children. They found that background music made the environment fun for children and that children were positive about background music although they preferred to ignore it sometimes.

The twelfth design guideline in the “content” theme was: *The final scene should be presented clearly and children should be informed about what they accomplished at the end of the smart toy play.* This guideline is about supporting children throughout smart toy play since children need rewards related the tasks that they accomplished. Similarly, Hanna et al. (1998) suggested that reward structures suitable for developmental needs of children be used in user interfaces.

The thirteenth design guideline in the “content” theme was: *The story should be realistic and consistent with real life.* Kehoe et al. (2004) developed a virtual peer system, Sam, and performed design experiments with children. Children successfully interacted with a life-sized virtual character with a real-world appearance and created meaningful stories. This finding can be associated with the design guideline above since realistic characters or content which has life like activities can improve engagement of children into play environments.

The fourteenth design guideline in the “content” theme was: *Dynamic content should be presented.* This guideline indicated that the content presented in the virtual environment should include both visual and audial components, creating a dynamic smart toy environment for children. This guideline can be associated with the view that using animations or multimedia components in the content of the smart toy may increase the playability of the toy. Similarly, Inal (2011) found as a design guideline for interactive game environments that a variety of age-appropriate animations and sounds should be integrated into interactive game environments.

The fifteenth design guideline in "content" theme was: *Sounds or narrations should be warm and familiar for children. If an adult voice is used, a woman narrator should be preferred generally.* This guideline was about using all sounds suitable for children's needs. Since most of the teachers are female and children interact with women adults more than men, using a woman voice may enhance the familiarity of children to the smart toy play. Teachers also emphasized that a woman's voice needs to be used if there is a need for an adult narrator in virtual content.

The sixteenth design guideline in the "content" theme was: *Time intervals among narrations should be small to prevent loss of children's concentration on the play.* This guideline indicated that the flow of smart toy play should not be interrupted with unnecessary pauses.

### *5.2 Visual Design*

The first design guideline in the "visual design" theme was: *Size and design of both plush and virtual objects should be parallel to real life.* This can be related with providing consistency between children's daily life play and play with the smart toy. This was similar to the finding that design of toys should be consistent with real life (Hinske, 2009).

The second design guideline in the "visual design" theme was: *There should be realistic animations and graphics.* This may enhance both attractiveness and familiarity of the visual design. Similarly, Lampe and Hinske (2007) claimed in their study that "realistic illustrations of the figures, buildings and objects of the playset intensify the immersion into the game" (p. 4).

The third design guideline in the "visual design" theme was: *Smart toys should be designed in accordance with the needs of 36–72-month-old children.* Since 36–72 months old children are in the preoperational stage of Piaget's intellectual development stages (Ripple and Rockcastle, 1964), designing the smart toy based on the characteristics of this stage can be helpful for children. Similar to design guideline shown above, Inal (2011) proposed that all visual design components, such as colors, sounds, and animations should be suitable for age groups of children

The fourth design guideline in the "visual design" theme was: *Design and use of plush toys should be clear and age-appropriate for children.* Plush toys are one of the important components of the smart toy. Plush toys can also be seen as the specific part which is different from other educational softwares or games. Therefore, designing plush toys in accordance with children's age level characteristics may enhance the motivation of both children and teachers to play with the smart toy. Hinske (2009) supported this guideline by saying that "designers should respect children's intelligence by creating adaptive and age-appropriate toys" (p. 92).

The fifth design guideline in the "visual design" theme was: *Soft plush toys should be used because they cannot be destroyed easily.* Teachers, in the present study, mentioned that soft plush toys can be used in a smart toy system because of their durability. Hence, using soft plush toys can increase the long-term playability of these toys. According to Hinske (2009), "augmented toys that contain highly sophisticated technology must be very reliable and durable since some children played quite vehemently and strained our play set severely" (p. 92).

The sixth design guideline in the "visual design" theme was: *Visual design of plush toys should be consistent with content, goals, and objectives.* This design guideline is important because it is about designing plush toys as suitable for specific objectives focused in context of smart toy play. Since early childhood teachers prefer to use smart toys at ECE settings, integrating curriculum based content into the smart toy may support teachers' use of these toys as alternative materials in learning and teaching activities. Hinske (2009) explained this by stressing that "a toy should never be seen as a sole play object but should be put in context because it helps to understand the conveyed educational content" (p. 93).

The seventh design guideline in the "visual design" theme was: *Animations should be preferred as positive feedback in smart toy play.* It can be understood from this guideline that a variety of feedback types, such as animations and visual feedback, should be used, especially after successful task completion. This may keep children motivated and enhance their confidence during smart toy play. For example, Lampe and Hinske (2007) used both verbal and musical feedbacks in the Augmented Knight's Castle playset, which was developed for enriching the pretend play of children. Hinske (2009) also mentioned the importance of presenting a variety of feedback styles.

The eighth design guideline in the "visual design" theme was: *Objective-related animations should be presented in a timely fashion when a child places the related toy or card.* This guideline was similar to the seventh design guideline. Since children may get bored easily while doing an activity, response time of the smart toy should be sufficiently small to keep the children's concentration high.

The ninth design guideline in the "visual design" theme was: *Visual design should not confuse children and the virtual objects focused on in the toy should easily be differentiated from other objects.* The reason of this design guideline can be associated with keeping children's focus on the play environment. Druin et al. (2001) supported this guideline by proposing that items presented on the screen should be large and distanced from other objects to control and select them easily.

The tenth design guideline was: *Characters used in the virtual content of the smart toy should be dynamic.* Since the characters or avatars used in virtual content of smart toys act like animated pedagogical agents leading children to accomplish several tasks in smart toy play, these characters can be associated with animated pedagogical agents. In the literature, animated pedagogical agents have a valuable impact on interactive learning experiences, since they are lifelike characters (Johnson et al., 2000; Lester et al., 1997).

The eleventh design guideline in the "visual design" theme was: *The virtual part of the smart toy should be designed in a similar way to computer games for young children.* This guideline indicates that the virtual content of smart toy should be designed as providing entertainment for children via game-like design. Because children enjoy playing with computer games and they are used to the visual design of these games, computer-game-like design of the virtual content of the smart toy may be familiar for preschool children. This design guideline can also be associated with Inal's (2011) suggestion that cartoon-like game components should be included to make design appealing and effective.

The twelfth design guideline in the "visual design" theme was: *Design should be consistent, and related visuals should appear in accordance with the voices used.* According to this guideline, suitable consistency should be provided to children to make smart toy play effective.

The thirteenth design guideline in the "visual design" theme was: *Explicit, simple, and clear visuals should be put on the cards to be noticed and differentiated from other cards easily.* According to the findings, cards should be differentiated from any other cards easily and children should identify the visuals on these cards without any effort. Simple visuals may prevent children loss of their control in the smart toy play environment.

The fourteenth design guideline in the "visual design" theme was: *Correct / positive / desired visuals or animations should be shown in the middle of the screen since the focus is mostly on there.* Scholars participating in the study emphasized that visuals should be shown at the middle of screen to catch children's attention. Because young children may not easily identify the objects on the screen, this guideline may help children focus on the objects easily.

### *5.3 Interaction*

The first design guideline in the "interaction" theme was: *The virtual environment should be interactive and children should change the environment according to their desires.* Children's control of the smart toy may help children understand the smart toy play easily. Similarly, Kehoe et al. (2004) emphasized in their study on the virtual peer system Sam that "we intend to create user profiles for individual children that will enable Sam to adapt story selection to their preferences" (p. 5). Additionally, "children should be empowered to select from available educational content to give them a feeling of autonomy and control" (Hinske, 2009, p. 93). These findings in the literature reaffirmed that children should have control in interactive smart toy systems to handle both physical toys and virtual content easily.

The second design guideline in the "interaction" theme was: *Guidance of teachers should be given to increase the effectiveness of smart toy play.* Guidance or help of teachers during smart toy play may enhance the effective play, especially in classroom settings. According to Luckin et al. (2003), children, in general, have a tendency to get help from human companions, such as parents and teachers, rather than machines. In addition, Hinske (2009) suggested that teachers should be able to change and arrange educational content. These findings supported the design guideline of guidance of teachers in smart toy play in preschool settings.

The third design guideline in the "interaction" theme was: *Characters used in the virtual content of the toy should be designed as similar to a real young child's appearance and voice.* This design guideline aimed at using realistic objects in virtual part of smart toy. In addition, the reason of this guideline can be associated with effective identification of the child player with the main character in the content. Lampe and Hinske (2007) supported this guideline by stating that realistic visuals allow children to become deeply immersed in the activity.

The fourth design guideline in the "interaction" theme was: *Virtual images of plush toys should match entirely to create an effective interactive environment in smart toy play.* Meaningful connection between real objects and their virtual images may decrease the confusion of children and help them maintain the smart toy play. According to Lampe and Hinske (2007), "there should be semantic mapping between the physical and virtual realities, i.e. the appearance of the physical toy figure is semantically connected to the role or function such a figure played in real life in the Middle Ages" (p. 4). Lampe and Hinske (2007) also stated that "this semantic mapping empowers children to easily understand the role or function of a play object, and therefore allows fast and intuitive understanding" (p. 4). Additionally, Hinske (2009) proposed that semantic mapping be performed in designing all play objects. These findings support the design guideline that there should be meaningful connection between physical toys and their virtual characters to enhance interactivity.

The fifth design guideline in the "interaction" theme was: *Feedback should be given immediately when a child puts a toy or card onto the reader.* If children cannot get any feedback on their actions, they can easily get distracted. Therefore, feedback for the actions of children in smart toy play should be provided to keep children's concentration high. Fontijn and Mendels (2005) found in their study that feedback should be provided to children immediately and directly following the subject of the feedback. In addition, "the immediate feedback from the observed behavior of the robot allows children to examine and reflect on their initial mental models with respect to the outcomes they observe and gives them a chance to debug and extend their thinking. (Frei et al., 2000, p. 4). Farr et al. (2012) also found in their study that "system response provided immediate feedback which motivated children to continue to interact" (p. 121).

The sixth design guideline in the "interaction" theme was: *The smart toy should enable children to play collaboratively.* Because early childhood teachers prefer to use smart toys collaboratively at classroom settings, they should be designed in accordance with the collaborative play. In addition, collaborative play among children is supported in the literature as creating an interactive environment for children. Hence, collaboration among children while playing with the smart toy can be seen as an important strategy. Similarly, Cassell and Ryokai (2001) developed StoryMat, offering a play space that records and recalls children's storytelling and found that collaboration of children improved their experiences.

The seventh design guideline in the "interaction" theme was: *The smart toy should be easily controllable to improve the interaction between player and smart toy.* This guideline is important because children should easily understand how to play with the smart toy and they should handle all virtual and physical objects. Similar to this guideline, Hinske (2009) suggested that the play environment should always be controlled by players.

The eighth design guideline in the "interaction" theme was: *Children's voices should be recorded in smart toys for using storytelling activities.* Recording voices allows children to see what they accomplished at the end of the smart toy play. In accordance with this guideline, StoryMat recorded children's own stories and then replayed these stories to enhance storytelling experiences of children (Cassell and Ryokai, 2001).

The ninth design guideline in the "interaction" theme was: *The virtual character or avatar should do narrations mostly rather than a voiceover to improve one-to-one interaction level.* This design guideline is important because virtual characters, which can also be considered as animated agents, can provide one-to-one interaction with children by doing all necessary narrations.

## 6 Conclusion

Smart toys can be considered as new forms of play activity combining physical toys with virtual settings. Since play activities have a valuable role in preschool education, smart toys have potential to support and enhance these play activities by including not only physical toys but also the richness of virtual mediums. In addition, these toys may be the materials enhancing ECE settings by integrating technology into preschool curriculum appropriately.

Many design guidelines emerged in the course of the study. These guidelines were categorized as content, visual design, and interaction. It is expected with these guidelines that the best smart toy practices can be applied in preschool education. The design principles emerged at this study can guide instructional designers to design and develop similar systems combining physical and virtual realities. Smart toys can be alternative and supportive materials, since they have not only enjoyable, fun and augmented characteristics but also a structure allowing curriculum-based components.

With this study, a smart toy was designed, developed, and evaluated with contributions of early childhood teachers, preschool children, and scholars. Although the study provides a road map for designing and developing smart toys, several research studies still need to be done to improve the smart toy literature. It is expected that the results of this study will help children, teachers, researchers, and instructional designers who are interested in smart toys.

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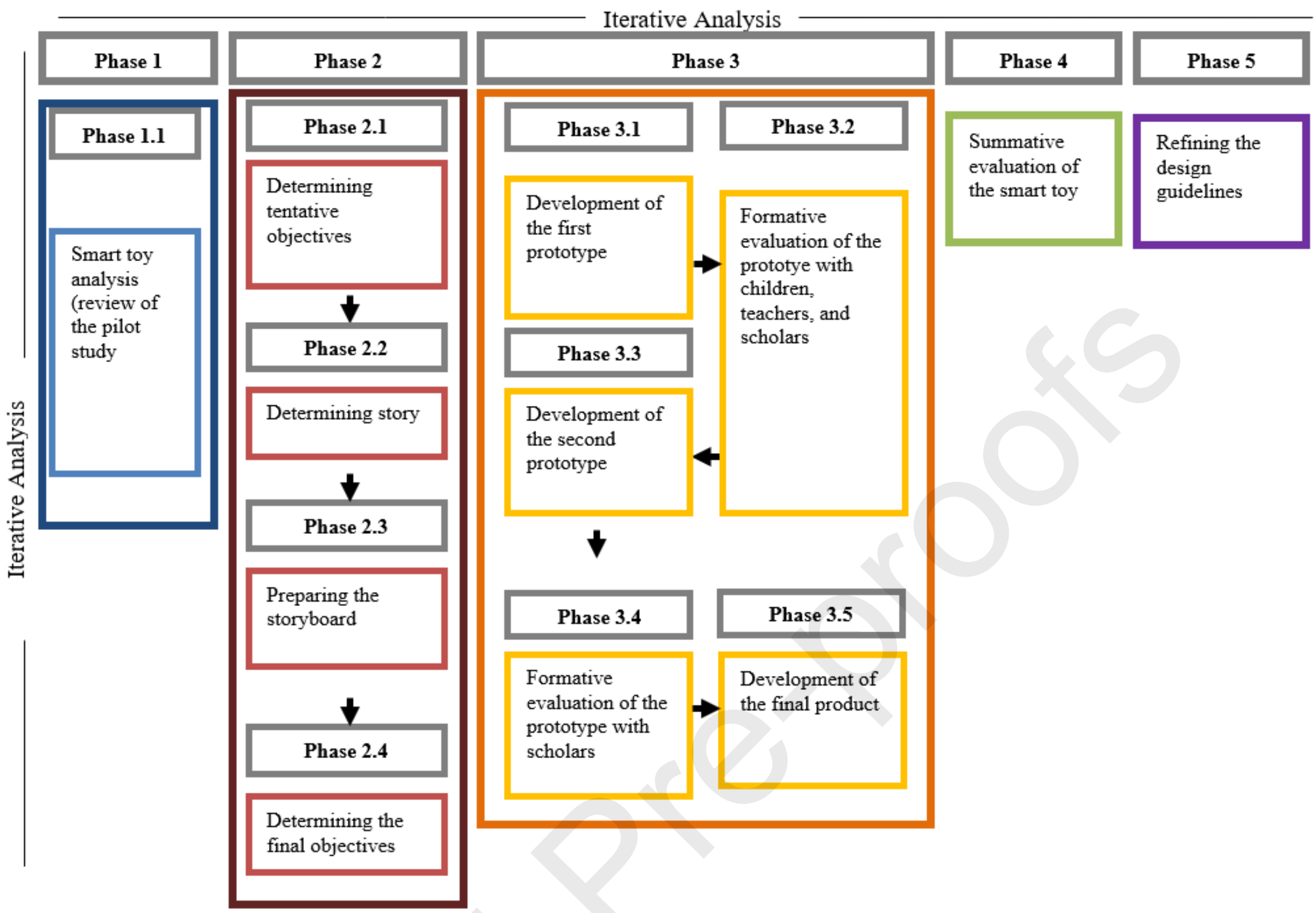


**Fig. 1.** Method based on design and development research models by Reeves et al. (2004) and McKenney and van den Akker (2005).


**Fig. 2.** Screenshot of a scene in a child's room.



**Fig. 3.** Plush toys equipped with RFID tags.


**Fig. 4.** RFID cards with pictures of objects.

**Fig. 5.** RFID reader with the picture of a hand.


**Fig. 6.** Screenshot of the bathroom scene in the second prototype.

**Fig. 7.** Children playing with the smart toy.

**Table 1**

Duration of play for the first prototype

| Gender | Age | Personal Care Skills (minutes) | Cognitive Skills (minutes) | Total Play Time for first prototype (minutes) |
|---|---|---|---|---|
| Male | 38 months | 4.20 | 9 | 13.20 |
| Female | 40 months | 4.15 | 8.30 | 12.45 |
| Male | 45 months | 4.20 | 7.40 | 12.00 |
| Male | 55 months | 4.20 | 6 | 10.20 |
| Male | 56 months | 4.10 | 9.30 | 13.40 |
| Male | 62 months | 3.30 | 6.45 | 10.15 |
| Female | 69 months | 5 | 5.30 | 10.30 |

**Table 2**

Quantitative findings on smart-toy usability

| Gender | Age | Introduction scene (minutes) | Personal care skills scene (minutes) | Cognitive skills Scene (minutes) | Pattern scene (minutes) |
|---|---|---|---|---|---|
| Male | 38 months | 1 | 9.50 | 9.10 | 7.50 |
| Female | 41 months | 3.40 | 3.30 | 6.50 | 8 |
| Female | 47 months | 2 | 4.30 | 5.35 | 5.25 |
| Female | 50 months | 2.05 | 4 | 4.40 | 4 |
| Male | 54 months | 0.15 | 3.05 | 3.20 | 3.45 |
| Female | 61 months | 2 | 2.55 | 4.30 | 3.10 |
| Male | 69 months | 2 | 4.30 | 5.50 | 4.30 |
| Female | 69 months | 2.10 | 2.50 | 3.30 | 3 |
| Male | 69 months | 0.30 | 4.40 | 4 | 2.20 |
| Female | 69 months | 0.30 | 4.15 | 3.40 | 3.20 |

**Highlights**

- A design and development process of a smart toy is proposed.
- Design guidelines related with content, visual design and interaction of the smart toy are provided.
- Smart toys allow children to live powerful interactions since they include the capabilities of both physical and virtual reality.

Conflict of Interest and Authorship Conformation Form

Please check the following as appropriate:

- x All authors have participated in (a) conception and design, or analysis and interpretation of the data; (b) drafting the article or revising it critically for important intellectual content; and (c) approval of the final version.

- x This manuscript has not been submitted to, nor is under review at, another journal or other publishing venue.

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