Smart Toys for Game-based and Toy-based Learning

A Study of Toy Marketers', Preschool teachers' and Parents' Perspectives on Play

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***Abstract*—Over the next years smart Internet-connected toys are expected to grow significantly in numbers. Our study explores smart toys' potential to deliver experiences related to playful learning. One key aspect of toys, such as the CogniToys Dino, Fisher-Price's Smart Toy Bear and Wonder Workshop's Dash Robot are their game-based and toy-based features and functions, which are suggested to have educational outcomes when used in play. Through a comparative investigation of toy marketers', preschool teachers' and the parents' of preschool-aged children's perspectives of smart toys potential—and a comparison to the actual play experiences of preschoolers discovered in earlier stages of research, we demonstrate how the educational potential of contemporary smart toys may be categorized into game-based and toy-based affordances that may be employed for specific educational goals in playful learning.**

Keywords - game-based learning; Internet of Toys (IoToys); play; preschoolers; smart toys.

I. INTRODUCTION

This paper examines the kind of possibilities that the Internet of Toys (or, IoToys) offers for playful learning experiences through their various affordances analyzed through the Playful Experience (PLEX) model introduced by Lucero et al. [1]. We build on the suggested framework to conceptualize the gameful and toy play-like affordances of current smart toys. Our Playful Experience Framework for IoToys validation efforts include an earlier study of play-testing smart toys of the present to see what kind of play experiences these toys prompted in their players (in our case study, preschool-aged children). As a result, the 15 categories of the original framework were further divided into game-based and toy-based play experiences in the Playful Experience for IoToys Framework (See Table 1). This framework functions as a basis for our evaluation of the IoToys suitability for playful learning from the viewpoints of toy marketers, preschool teachers and preschooler's parents.

In earlier stages of our research, we have found that preschoolers use the toys for many kinds of play [2] [3]. This paper focuses on how these play experiences may be categorized into game-based and toy-based experiences, which both contribute to learning. With the previous findings in mind, our goal is to compare the results of the play tests with preschoolers with perspectives on smart toys as communicated by toy marketers, preschool teachers and parents of the preschool children who took part in our play tests. In this way, the paper at hand outlines three perspectives on playful learning related to smart toys: 1) the IoToys marketers' point of view, 2) preschool teachers' point of view, and 3) parents' point of view on the educational possibilities of these contemporary toys.

While some researchers believe that using computers before age seven subtracts from important developmental tasks and other types of learning [4], we believe that the IoToys with their 'hidden' [5], smart and connected technology, represents a medium for children's social and intellectual development. There have been effective attempts at educational technology integration, but school reformers often expect educators to know how to incorporate technology into their teaching. Whereas it may be difficult for educators to realize the potential of new kinds of smart toys to be used in the context of early education, it is important to increase knowledge of the toys' possibilities in the learning context. What is not to be neglected are the parents' attitudes and opinions of using smart toys, as they represent so-called 'edutainment', which may also be consumed when played with in the informal learning environment of the home. When children have a possibility to learn with smart toys, they can, for example, train their language and interaction skills. In this way, both the formal and informal play experiences related to these toys change children's dispositions to learning and behaving.

According to an early definition, a 'smart toy' has been defined *as a device consisting of a physical toy component that connects to one or more toy computing services to facilitate gameplay in the cloud through networking and sensory technologies to enhance the functionality of a traditional toy* [6]. There are three general properties of a smart toys: They are 1) *pervasive* – a smart toy may follow the child through everyday activities, 2) *social* – social aspects and multiplayer participation are becoming a mandatory aspect of interactive IoToys in one-to-one, one-to-many and many- to-many relations [7], and 3) *connected* – contemporary smart toys as IoToys may connect and communicate with other toys and services through networks. For example, the CogniToys Dino can listen and answer to questions raised by children by voice recognition as the toy is connected to IBM Watson's Elemental Path "friendgine", which is a child

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friendly database [8]. Recently, the smart, but previously non-connected toys have evolved into connected playthings, that according to Holloway and Green (2016) mean IoToys, which 1) are connected to online platforms through Wi-Fi and Bluetooth, but can also connect to other toys, 2) are equipped with sensors, and 3) relate one-on-one to children [9].

According to the marketers' of IoToys, toys employed in our study like the CogniToys Dino, Wonder Workshop's Dash and Fisher-Price's Smart Toy Bear offer opportunities for both entertainment and learning. The toys present educational possibilities, particularly in informal situations. For example, the toy markers' promote the toys' capabilities to teach language when played with at home. In the toy marketers' understanding, then, the IoToys offer significant educational benefits and bring with them new possibilities to existing learning technologies [2].

Our interest to explore the potential of the smart toys in a formal learning environment led us to investigate the toys employment in the preschool context. After studying the play experiences of young children between the ages 5-6 years, we wanted to explore how these experiences correlate with the toy marketers', preschool teachers' and parents' perspectives of smart toys' affordances suited for learning. What guided our interest was the understanding that play with smart toys may be viewed from the perspectives of rule-bound (game-like) and open-ended (toy play-like) interaction. In other words, they provide opportunities for both game-based and toy-based learning.

In order to study the perspectives that the different stakeholders around smart toys have, we used three kinds of research material: 1) marketing texts related to the toys under investigation as communicated by IoToys marketers, and 2) a thematic survey to explore preschool teachers' and, 3) parental attitudes, and parents' experiences of digitally enhanced, smart toys in general. We interviewed two preschool teachers and the 14 parents of the altogether 20 preschoolers who participated in our playtests with the help of semi-structured surveys. The participants were asked about a wide range of topics in relation to digitally-enhanced toys, which we here consider to represent smart toys.

In the following section 2, we describe earlier studies to explain how marketers', early educators' and parents' attitudes have been investigated in research focusing on technology use in early education. We then go on to section 3 to explain the methods used in our own study followed by section 4 describing the toys investigated. In section 5, we present and evaluate the results of our study with three perspectives on play with smart toys. We sum up by presenting a framework introducing the game-based and toy-based play experiences potentials of smart and connected toys and end the paper with sections 6 and 7, discussing the results and proposing ideas for future research.

II. RELATED WORK

Attitudes of preschool educators towards the use of information and communication technology (ICT) are currently a major topic of research [10] [11] [12] [13].

One of the reasons for such interest lies in the fact that, as Hoffman, Park and Lin [10] suggest, today's question is how to assist kindergarten and preschool educators by providing knowledge, tools, and strategies required to respond to rapid changes in the learning environment, for example, how to make use of smart toys such as the current connected IoToys in playful learning. But, since there are no systematic studies of the IoToys suitability in the early childhood curriculum, some educators use ICT to a great extent while others do not use it at all [2] [12]. "While parental beliefs appear to play a significant role in children's development, play-learning beliefs remain relatively unexplored in the developmental literature", Fisher et al. write [14]. Consequently, it is of crucial importance for educators to become familiarized with the new tools that for example the IoToys addressed in this paper represent. For example, Chiong and Shuler (2010) discuss that adults keep young children motivated to use apps and smart toys by providing an extra prompt for the child to understand smart toys and games [15]. In other words, the child's capacities to use smart toys and games is influenced by the adult guidance. Thus, we claim that there is a need to recognize the importance of smart toys potentiality in early education to create opportunities for knowledge building and skills acquisition. The preschool teachers who participated in our study are using technology, such as tablets in learning activities. Their attitude toward digital devices and smart toys is positive. However, they are not familiar with smart toys' possibilities in an educational context.

In our earlier study (Ihamäki and Heljakka, 2018) we present the IoToys as a 21st century educational tool. Furthermore, we highlight the toy marketers' views of four IoToys' educational promises by describing the toys' possibilities to be used to offer rich, interactive, innovative and mobile learning experiences to preschool children both in the educational environment as well as in play during leisure time, as suggested by the designers and marketers of the smart toys [2].

Media technology, smart toys, and Internet content have an important role in the everyday life of young children [16]. Skills for understanding and using media are typically learned at home and from peers during the first years of a child's life. Therefore, children learn skills for using media outside of formal education and if granted opportunities, could also use this competence in their early childhood education [17]. For example, in Greece [13] they suggest that in order to successfully integrate ICT in educators' daily practices, it needs to be perceived as a mode of learning that should be embedded in the curriculum.

As the toys may be played with both in preschool as well as in the home, it is also important for the parents of young children to understand their potential. In this study, we try to increase knowledge on how it is important for educators and parents to understand the IoToys as a phenomenon, its products and potentialities, especially from the viewpoint of early learning. What needs to be critically evaluated, then, are the toy marketers' opinion on the capacities of these smart toys and the educational promises used in marketing them and what benefits the toys truly offer to children in terms of *edutainment*, that is, entertainment and education. Further, it is important for preschool teachers and parents to understand what kind of play experiences these smart toys can bring to the preschool context in the name of playful learning.

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The many benefits of playful learning have been presented by Elkind (2007), who states that free, self- initiated, and spontaneous play contributes to the child's healthy, emotional and social development. Elkind stresses that a playful childhood, in fact, is the most basic right for children [18]. As we see it, educators need to remember to think about how their attitudes and opinions influence the employment of new tools such as toys that are available to offer children edutainment by learning through play. It is probable that the educators who have more experience with digital devices and who use digital devices personally, have more positive opinions generally. The educators interviewed for our study perceive digital technology (like iPads) as an useful educational tool that can help children to develop practical competencies and social practices. They also expressed intentions to use new technology in their kindergarten. Finally, it is also important to understand how parents' opinions and attitudes are formed, and how they may have an effect of making these kind of toys available for their young children in the context of home. At the same time, not every parent may have the possibility to offer children the opportunity to play with smart toys at home. However, since some IoToys are already available on the marketplace and their marketers are constantly trying to convince their buyers of their educational power, it is valid to ask whether or not they fulfil these promises for learning. Therefore, it is important to engage both educators and parents in a discussion around IoToys in order to know how they can be used in both unstructured, (toy-like) free play, and structured, (game-like) goal-oriented play.

III. METHOD

Häkkinen et al. (2003) suggested a multi-method approach that is process-oriented and takes into account different contextual aspects [19]. Our case study uses this approach in order to provide a holistic and complimentary description of the smart toys' possibilities for playful learning. Our study builds on the knowledge from the previous stages of our research: By using the findings of our study with preschoolers interested in the various play patterns IoToys as contemporary smart toys afford [3], and asking how this information from the play tests carried out with the IoToys correlates with smart toy marketers', preschool teachers', and parents of preschoolers' perspectives on play with digitally-enhanced toys, we set out to formulate a comprehensive understanding of how different stakeholder's views on smart toys address affordances related to playful learning. In other words, we analyze smart toy marketers' envisioned play experiences of three IoToys and compare these with preschool teachers' and parents' general attitudes towards smart toys and their educational potential. We examine the following research questions:

RQ1 (targeting the toy marketers): What kind of promises related to play experiences are the toy marketers giving for the IoToys, as reflected in their marketing texts (i.e. on websites and other advertising materials)?

RQ2 (targeting the preschool teachers): What kind of opinions do the preschool teachers' have regarding the play experiences related to smart toys used for playful learning in the preschool environment?

RQ3 (targeting the parents). What are the parents' opinions and observations of their children's play experiences with toys with digital dimensions, such as smart toys?

In order to analyze the viewpoints of toy marketers, preschool teachers and parents of preschool children who participated in the playtests in an earlier study [2] [3], we have collected three kinds of research materials: First, toy marketer's descriptions on three IoToys through websites, digital and printed marketing materials, second, a semi-structured survey for preschool teachers and third, a semi-structured survey for the parents of the preschool children.

The toys under investigation fulfil the criteria of IoToys, they are 'smart', and their connectivity usually occurs through mobile devices or some cases, smart toys contain their own computer (e.g., the CogniToys Dino and Fisher-Price's Smart Toy Bear.) The toys were chosen based on their age-appropriateness, gender-neutrality as character types of toys, and their availability on Amazon US (in August 2017). Also one reason for selecting these IoToys was the awards they have received. For example, the CogniToys Dino has received the Silver Honor 2016 Parent's choice award.

To analyze the research materials, we have used content analysis. The goal of content analysis is to provide knowledge and understanding of the phenomenon under study [20]. It provides the researcher with the possibility to make a close reading of the data through a systematic classification process of coding and identifying themes and patterns. Researchers immerse themselves in the data to allow new insights to emerge [21]. The method is also described as inductive category development [22].

The motivation to use three sets of research materials enriches the holistic view of adult perspectives on smart toys: The marketing materials help us to understand aspects of learning and contextualize and elucidate marketer motives in relation to the IoToys promises for learning. The preschool teachers' interviews inform us about the constraints and possibilities for using smart toys, such as IoToys in the context of early learning. Further, these interviews enable the articulation of aspects of learning with smart toys and help us to contextualize and elucidate individual attitudes and behavior, based on personal motives and perceptions in relation to use smart toys in the early education curriculum. We pursued those situational and contextual aspects of Finnish preschool that were identified by participants during our interviews. By using a semi-structured, thematic survey to explore parental attitudes, opinions and earlier experience of smart toys, we were able to draw parallels between ideas on toys' capacities to 'teach' at home. Next, we describe the rich material in our case study to illustrate the possibilities for playful learning with three contemporary smart toys.

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A. Educational promises of the smart toys in our study: The marketers' perspective

We have chosen three smart toys (that also fulfil the criteria for IoToys), for which we have collected marketing materials to analyze the marketers' perspective of their educational affordances. All of these smart toys connect to the Internet via Wi-Fi. The connected toys employed in this study are *hybrid playthings*, which means that they are both physical artefacts and objects, which also function as portals to digital devices and socially shared content [3].

Our study employs toys that represent 'edutainment', and that according to their marketers, cater both to enjoyment and opportunities for learning: CogniToys Dino, Wonder Workshop's Dash and Fisher-Price Smart Toy Bear. These smart toys are briefly described in the following, based on their marketing texts:

CogniToys Dino

Amazon.com describes the CogniToys (by Elemental Path) as an educational toy, which includes stories, games, jokes and fun facts. Educational subjects including vocabulary, math, geography, science, which make children to engage more within an educational play based on their academic needs. The CogniToys Dino will constantly evolve because it is a cloud-connected, Wi-Fi enabled character allowing for the play experience to repeatedly improve and update automatically. The toy is said to engage children with a wide variety of content by encouraging learning and play using interactive dialogue. The CogniToys offers "FUNdemental Part of the CogniToys Experience", where each Dino comes with "a variety of custom modules to engage children in educational play including problem-solving challenges, geography games, historical fun facts and more" [23]. According to a marketing text published by Kickstarter, the CogniToys Dino "creates an atmosphere of fun, playful education! Built into the play experience is a number of custom modules that engage the child in educational play. As the interaction increases so will the challenge of the educational content continuing to become more challenging as the child learns" [24].

Wonder Workshop's Dash

Wonder Workshops' Dash's own website includes an educational part, on which educational benefits for using for Wonder Workshop's Dash in educational programs are introduced. The website describes how the Dash robot will "grow with students and it is easy for beginners to get started and then scaffolds learning through a meaningful curriculum." It is supportive of 21st century skills, by "encouraging students to continue building critical thinking, creativity, communication, and collaboration skills for tomorrow's job market" [25]. As the website for Wonder Workshops' Dash mentions, "play is a powerful teaching tool". Dash has its own comprehensive curricular resources for teachers to help students' practice computational thinking [26].

While the company sells Dash directly to families, it has also seen Dash and sidekick toy, Dot, to become part of schools' curriculum and coding clubs over the years. According to Kolodny, some 8,500 schools are using Dash and Dot around the world today [27].

Fisher-Price's Smart Toy Bear

Fisher Price's Smart Toy Bear is described as "an interactive learning friend as unique as your child" that comes without a screen. The toy responds to what the player says, and remembers things. It takes cues from its player, then invites play, talk, movement, imagination and learning. The Smart Toy is also able to recognize images with 9 'Smart Cards' included, which the player can choose to play activities like listen to stories, play games and 'go on adventures'. As the Smart Toy is constantly updated it is said to encourage social-emotional development, imagination and creativity: "Your Smart Toy learn new activities every month" [28].

A. Preschool teacher survey interviews

The importance of digital technology competencies of early education teachers is publicly recognized and supported in most countries around the world. One study from Mainland China showed that educators' educational level and ICT-related training were found most important in determining whatever they use digital technology in their teaching [12]. According to Konca et al. it is important to support educators' positive attitudes towards digital technology, but also their suggestion on using digital technology in kindergarten [11]. The research that investigated intentions of 50 early childhood educated teachers from University of Athens, Greece, using digital game-based learning, revealed that kindergarten educators in Greece generally have very positive views about the digital technology use and who owned a computer at home had more positive opinions. These educators perceive digital games as a useful educational tool for kindergarten environment [13].

In this study, we have used a semi-structured, thematic survey to explore two preschool teachers' views on smart toys and their use in the preschool context. The teachers have informed that the children in their group each have their personal tablet at preschool, which they are allowed to use in supervision for a limited time per day. Out of the 20 preschool-aged children (5-6 years of age), who took part in our play tests in previous stages of our research, we have asked how many of them have a mobile phone of their own. Of the children that participated in our study, 10 reported owning a mobile phone. The teachers were asked about the use of digital media and toys in the preschool context in general, their ideas on smart toys, and their opinion regarding the affordances of these toys that relate to playful learning.

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B. *Parental survey interviews*

Previous studies have demonstrated that the extent to which parents' guide their children's media use, digital games and toys, and the strategies they apply, are related to demographic variables, such as the parent's age, gender, and education or income level. In addition, the parent's own media use and skills, and family context variables, such as family size, marital status and the number of media screens at home are important as well [29]. Furthermore, parents who are less skilled in using media and digital devices themselves may find it more difficult to install parental controls on the devices, games and smart toys or to discuss the media content critically with their children as compared to media literate parents [30]. Indeed, researchers have shown that parents' mediation strategies are in accordance with their views on various effects of media content on children. Parents who feel that media offers educational or entertainment opportunities more often co-use the media, digital devices and smart toys with their child, or actively discuss the content [31]. Many parents feel that through media use their young children develop their physical, cognitive and emotional capacities, a wide range of media skills, defined as the child's knowledge and understanding of the role of media and technology in society [32].

In our study, we have conducted survey interviews concerned with parents' perspectives on digitally enhanced toys such as smart toys on a general level, the play of their children with these toys, and these toys' capacity to cater for playful learning. We have used a semi-structured, thematic survey to explore parental attitudes, opinions and earlier experiences of smart toys. We have used a thematic survey to explore parental and kindergarten teachers' attitudes and parent's experiences of digitally enhanced toys in general. Thematic survey focuses on mainly on investigating the following questions:

- Does your child play with the (digitally-enhanced) toy alone or in the company of other children?
- Do you think that playing with this kind of a toy teaches the child new skills?
- Does the child simultaneously use (other) mobile devices when playing with the toy?
- Does your child play with the toy in any of the following ways: nurses the toy; uses the toy in narrative play (gives the toy a role and lines of speech in play); explores the toys' mechanical features; tries to teach the toy new skills; uses the toy as a bedtime companion?

We have recruited the parents of 20 preschool-aged children (altogether 14 parents, both male and female), the survey interviews with whom the interviews were carried out in October 2017 [2] [3].

The parents' were asked about their attitudes to children's use of digital media and toys in general, their opinions on digitally-enhanced toys such as smart toys, and their observations on their children's play with smart toys related to solitary and social play, learning experiences, use of mobile devices as extensions of toy play, play patterns demonstrated by their children, and the importance of the toys' various playful affordances.

IV. RESULTS

Next, we report the results of our study, organized around three perspectives on play with smart toys: the promises of playful learning as described by the smart toy marketers, the preschool teachers' attitudes and opinions on smart toys, and the parental perspective concerning this type of toys.

Toy marketers' perspective on smart toys

We begin by highlighting several aspects of marketers' ideas on smart toys and their suitability to be used in playful learning, which helps to set the context of this study. We concentrate on three IoToys, which represent the most recent evolution of smart toys. These smart toys have won several awards and are named 'children's best toys' [23]. In their communication marketers, have used words like 'future technology', 'future education' and they have also given the picture that these are 'dream toys for children' with which they also can learn for example languages, pronouncing skills and mathematical skills. These marketing texts are also directed towards parents' in the extent to which they give a promise of learning opportunities to children. The marketers also use examples of how many kindergartens already have used for example the Dash robot in kindergarten.

'Educational value' is frequently is used as a marketing concept for the connected toys of the present. In particular, the usage of the word "smart" occurs in high frequency to describe the level of intelligence in the toy that will transfer to its user. For example, on the website for the CogniToys Dino it is explained that that the toy could teach mathematics like addition, subtraction and division. The CogniToys Dino also offers digital games, with educational potential, like 'Math Mouse', 'Capital Quest', 'Country Quest', and so on [33]. The marketers describe the smart toys to learn and grow alongside children. Further, they believe that the toys can be used as educational tools for example in kindergarten. For instance, the toy marketer for Wonder Workshop's Dash claims that their products and apps may teach students from kindergarten and up how to code. They offer six apps; students can for example tackle a series of challenges and in- app puzzles that introduce the concept of coding. The marketer describes the Wonder App 'to use machine programming and an original visual design to advance young students' understanding of computer science'. Again, the Blockly app is a block-based coding app that introduces children to programming [27].

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The Fisher-Price Smart Toy Bear is marketed as an educational toy, which children can learn important concepts with through engaging in interactive play. Children can train their smart toy to recognize their voice through embedded voice recognition features, or to respond to their commands with a selected option. For example, the developers claim that the smart toy adapts to developmental changes while remembering the child's name, favorite colors', foods and more. The toy suggests adventures that they should 'go on adventures together', along with stories and games [29].

In sum, as smart toys, the IoToys chosen for our study have, by their marketers, been given promises regarding various play experiences that are believed to have values for use in education [2] [3]. From the perspective of the Playful Experience Framework (or PLEX), the study demonstrated, how the toy marketers' ideas on the IoToys on the one hand correlated with the experiences categorized in the PLEX framework, and thus in both areas of play experiences: game- based and toy-based play experiences as categorized by the authors (See Table 1). The five most frequently occurring play experiences communicated in the analyzed marketing texts (websites, packaging), are listed in the following:

1. Challenge (game-based PLEX); Content related to educational subjects, coding and games
2. Humor, relaxation, thrill (toy-based PLEX); Storytelling, jokes
3. Fellowship (toy-based PLEX); Collaboration
4. Exploration (toy-based PLEX) 'Go on adventures'
5. Discovery (toy-based PLEX); Content related to play by image recognition through 'Smart Cards'

However, some differences could be detected in the envisioned play experiences of the IoToys: For example, the CogniToys Dino and Wonder Workshop's Dash included more game-based affordances for playful learning (challenge, competition, completion and control), whereas the Fisher- Price's Smart Toy Bear seemed to afford more toy-based play experiences for playful learning (for example, through humor, relaxation and sympathy).

Preschool teachers' perspective on smart toys

Hannaway and Steyn (2017) propose that teachers' use of digital technology influence their pedagogy and the ways knowledge is created in the classroom [34]. Again, teachers' attitudes toward digital technology use of young children are informed by the children's age: Mertala (2017) studied Finnish trainee teachers' perceptions of the role of digital technology in early year education and concluded that technology-related concerns for the youngest children were related to the children's physical health, whereas for older children it was their intellectual health [35].

The interaction with smart toys is generally not seen as very appealing from an educational perspective [36]. According to Ruckenstein (2010), the Nordic discourse on digital toys often constructs these toys as unnatural intrusions into the lives of small children [37]. As the category of smart toys has evolved and developed rapidly into more pedagogically informed devices, we were interested in preschool teachers' attitudes and opinions on these digitally-enhanced toys. The preschool educators' (n=2) perspective in this study allowed us to consider the differences that formal and informal learning environments may provide to the connected toys' usage as playthings. The teachers' informed us that the preschool currently uses learning games, but limits their use to a certain time of the day. The two female educators interviewed for our study identified toys such as Storyteller Yano and Tamagotchi to represent toys with digital enhancements and dimensions. Both interviewees considered the educational affordances of the smart toys to be highly important. Out of the play patterns described in our survey the teachers listed the narrativizing of the toy (i.e. storytelling with it) to be the most important. According to the research materials collected from the surveys, the teachers' attitude towards educational technology was positive, as they claimed that "technology could be used even more in preschool". However, a comment made by one of the preschool teachers supports Ruckenstein's thinking of digital toys as 'intrusions' in the early education context [37]: "I see that digital toys are more suitable in the domestic environment than in the kindergarten" (preschool educator, 29 years in the profession). From the perspective of the PLEX Framework, preschool teachers considered *control* ("the player is able to teach the toy new skills") as a game-based experience related to smart toys to be important for playful learning. Again, the toy- based play experiences of *exploration, expression, nurture* and *relaxation* were marked as important facets of smart toys' dimensions in terms of playful learning. Together, the five most prominent play experiences were listed in the following order of importance in reference to playful learning by the teachers:

1. Expression (toy-based PLEX); narrativizing theory
2. Nurture (toy-based PLEX); nurturing of the toy
3. Control (game-based PLEX); teaching the toy new skills
4. Exploration (toy-based PLEX); exploring the toy's mechanical features
5. Relaxation (toy-based PLEX); using the toy as a bedtime companion)

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Parents' perspective on smart toys

We have used a thematic survey to explore parental attitudes and experiences of digitally enhanced toys. Although the 14 parents of the 20 preschoolers who participated in our play tests were interviewed about a wide range of topics in relation to digitally enhanced toys in general (to be presented in the subsequent stages of our research), this study focuses mainly on investigating the following questions:

- Do you think that playing with a digitally-enhanced (smart) toy teaches the child new skills?
- Does your child play with the toy in any of the following ways: Nurtures the toy; uses the toy in narrative play (gives the toy a role and lines of speech in play); explores the toys' mechanical features; tries to teach the toy new skills; uses the toy as a bedtime companion?

Altogether, 14 parents (n=11 female, n=3 male) from different socio-demographic backgrounds participated in our semi-structured survey. Ten of the parents reported their child as owning some kind of toy with digital dimensions. Half of the parents considered their child as learning something while playing with digitally enhanced toys. The most popular play pattern the parents reported their child as carrying out with the toy was exploring the toys' mechanical features (9 children), and the second most popular play pattern was to use the toy in narrative play (7 children). The third most popular pattern on the list of play patterns children carry out with toys with digital dimensions was to nurture the toy and use it as a bedtime companion (6 children).

Considering the educational features of the digitally enhanced toys, the parents who answered these questions reported the most important feature as the toys' capability of teaching the child to how to count and how to be self-expressive, teaching good manners, and taking other players into consideration. The toys' ability to teach their players to read, ask questions, and be self-expressive (e.g., to come up with stories) were considered somewhat important by the parents. The majority of parents (8/14) answered that the toy's educational aspect is its most important aspect. We consider this to represent the toy-based play experience of *challenge*. Together, the five most prominent play experiences were listed in the following order of importance in reference to the perspective of parents to playful learning:

1. Challenge 8/14 (game-based PLEX)
2. Expression, exploration 7/14 (toy-based PLEX)
3. Relaxation 6/14 (toy-based PLEX)
4. Fellowship 3/14 (toy-based PLEX)
5. Nurture 2/14 (toy-based PLEX)

V. EVALUATION

In this study, we have explored play experiences related to playful learning experiences of smart toys from the marketers, teachers and parents' perspectives, which we analyzed through the PLEX Framework. We suggest that these play experiences can best be evaluated from the perspective of using smart toys in early education, and by dividing them further into game-based and toy-based learning experiences, which suit different learning goals. We have found that from the perspective of toy marketers', play experiences that are connected with contemporary smart toys, or IoToys, relate most to the play experiences of *challenge*, which we consider an experience best understood as a play experience for game-based learning. In other words, toy marketers suggest that activities such as learning of educational subjects, coding and playing of games are meaningful for the players. Other play experiences envisioned by the toy marketers are the experiences related to storytelling and telling of jokes, which we interpret as the toy- based play experiences of humor, relaxation and thrill. Other play experiences accentuated in the toy marketers' perspective are the play experiences of fellowship, exploration and discovery, which relate to the IoToys under scrutiny in terms of their affordances of pursuing collaboration between players, 'going on adventures' with the smart toy to explore new content communicated by the toy, and finally, enable the player to discover new play ideas by triggering interaction between the toy and the player by the use of image recognition through 'smart cards'.

According to preschool teachers *control* ("the player is able to teach the toy new skills") as a game-based experience related to smart toys and the toy-based play experiences of *exploration, expression, nurture* and *relaxation* were marked as important facets of smart toys' dimensions in terms of playful learning. Finally, the parents listed the toys ability to educate—the game-based play experience of *challenge*, to be a key aspect of smart toys in terms of playful learning. The toy-based play experiences of *exploration, expression, nurture* and *relaxation* were marked as important facets of smart toys' dimensions in terms of playful learning. For all detected play experiences of smart toys, see the following Table 1.

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TABLE I. THE GAME-BASED AND TOY-BASED PLAY EXPERIENCES POTENTIALS OF SMART AND CONNECTED TOYS, PARENTS' AND TEACHERS' PERSPECTIVES, TOY MARKETERS' PERSPECTIVES, AND RESULTS OF THE PLAY TESTS IN OUR EARLIER STUDY.

	Playful Experience	Parental and preschool teachers' perspectives on Play Experiences	Toy marketers' perspectives on Play Experiences	Results of play-tests in our study
Play experiences for gameplay and game-based learning	Challenge	Importance for the parent that the toy is educational: 8 parents out of 14 parents most important PLEX 2 parents out of 14 parents second important PLEX 1 parents out of 14 parents third important PLEX	"CogniToys offers game challenges like, "Dog Quiz game, Math Mouse, Ocean Quiz, Animal Expert, Capital Quest" etc." (www.CogniToys.com)	Children's abilities are tested by the IoToys' demanding tasks. (Wonder Workshop's Dash)
	Competition	Parents or preschool teachers did not mention this PLEX in our survey.	"Wonder Workshop's Dash has League Robotics Competitions to build teamwork and community spirit" (www.makewonder.com)	Children can contest with their earlier experiences with IoToys. (Wonder Workshop's Dash)
	Completion	Parents or preschool teachers did not mention this PLEX in our study.	"Program Wonder Workshop's Dash to be a musical performer with Xylo. Used with the Xylophone accessory, kids can program Dash to play their favourite song or make new tunes of their own." (www.makewonder.com)	Finishing a major task, like listening to the IoToys' story. (Fisher-Price Smart Toy Bear, CogniToy Dino)
	Control	Play experience detected by the parents: The child aims to teach the toy new skills, 4 parents out of 14 parents reported this PLEX. Teachers evaluated this to be the 3rd most important PLEX of all.	"CogniToys offers General Command Prompts: Let's play a game, tell me a story, tell me a joke, Play a Song etc." (www.CogniToys.com)	Commanding IoToys with an IPad. (Wonder Workshop's Dash, Fisher-Price Smart Toy Bear, CogniToy Dino)
Play experiences for open-ended play and toy based-learning	Discovery	Parents or preschool teachers did not mention this PLEX in our study.	"Wonder Workshop's Dash has more than 600 built-in-tutorials, challenges and projects, the apps let children explore programming at their own pace." (Wonder Workshop's Dash Robot – Apple)	Children's imaginative play with IoToys presents a way of playing what the designer never even thought, like using the IoToys as a lamp. (Wonder Workshop's Dash)
	Exploration	Play experience detected by the parents: The child explores the mechanical features of the toy: 7 parents out of 14 parents reported this. Teachers evaluated this to be the 4th most important PLEX.	"CogniToys update automatically as new content becomes available." (www.CogniToys.com)	Investigating an object or situation with the IoToys. (Wonder Workshop's Dash, Fisher-Price's Smart Toy Bear, CogniToys Dino)
	Expression	Play experience detected by the parents: The child narrates the toy: 8 parents out of 14 parents reported this Teachers evaluated this to be the 1st most important play experience.	CogniToys expresses itself like green light in his/her mouth means "I am ready to play", blue lights mean I am talking, yellow light means I am listening and so on". (https://vimeo.com/158246191)	Children make creative things by coding. (Wonder Workshop's Dash)
	Fantasy	Play experience detected by the parents: the child anthropomorphizes the toy: 2 parents out of 14 parents reported this PLEX.	"Wonder Workshop's Dash makes robotics as delightful as finger painting. A picture-based coding language built for kids, children create detailed behaviours for Dash, creating the robot pet, pal or sidekick of their dreams." (www.makewonder.com)	An imagined experience, e.g. the "IoToy can teach me to fly". (Fisher-Price's Smart Toy Bear, CogniToys Dino)
	Fellowship	Importance for the parent that the toy enables social play: 3 parents out of the 14 parents most important PLEX 7 parents out of the 14 parents second important PLEX 1 parents out of the 14 parents third important PLEX	"The Fisher-Price Smart Toy Bear is an interactive learning friend with all the brains of a computer, without the screen! The more your child plays with Smart Toy, the more this remarkable furry friend adapts to create personalized adventures the two of them will love! Sounds like the start of a true friendship!" (www.momvstheboys.com 2015)	IoToys like the Dash Robot has their own community to share experiences of one's own toy with others. (Wonder Workshop's Dash)
	Humour	Parents or preschool teachers did not mention this PLEX in our study.	"The CogniToys Dino tells jokes, for example: "Punny yodeling joke: "Knock knock." "Who's there?" "Little old lady." "Little old lady, who?" "Wow! I didn't know you could yodel!" (www.pinterest.co.uk/cognitoys/)	IoToys give children fun and joyous experiences by telling children stories and jokes. (Fisher-Price's Smart Toy Bear, CogniToys Dino)
	Nurture	Importance for the parent that child nurtures the toy: 2 parents out of the 14 parents most important PLEX 1 parents out of the 14 parents second important PLEX 9 parents out of the 14 parents third important PLEX Teachers evaluated this to be the 2nd most important PLEX	"Fisher-Price's Smart Toy Bear of content really allows children to communicate with the Smart toy, which offer unique personalized content and nurturing them through play". (www.smartoy.com)	Children want to take care of their IoToys. (Fisher-Price's Smart Toy Bear)
	Relaxation	The child uses the toy as a bedtime companion: 6 parents out of the 14 parents reported this. Teachers evaluated this to be the 5th important PLEX	"Fisher-Price's Smart Toy bear climb under the covers and enjoy bedtime stories, soothing music or nature sounds to help wind down after a long day". (www.smartoy.com)	Children comment that the IoToy can read them a bedtime story. (Fisher-Price's Smart Toy Bear, CogniToys Dino)
	Sensation	Parents or preschool teachers did not mention this PLEX in our study.	"CogniToys are smart devices in toy form, tailored just for kids to provide an educational and entertaining experience without the need for a screen". (www.CogniToys.com)	Children think that IoToys are exciting as they stimulate the senses and give children feedback. (Fisher-Price's Smart Toy Bear, CogniToys Dino)
	Sympathy	Parents or preschool teachers did not mention this PLEX in our study.	"Fisher-Price's Smart Toy Bear: it's never-ending fun that encourages social-emotional development, imagination and creativity with your child". (www.smartoy.com)	Children can share emotional states with their IoToys. (Fisher-Price's Smart Toy Bear, CogniToys Dino)
	Thrill	Parents or preschool teachers did not mention this PLEX in our study.	"Fisher-Price's Smart Toy Bear surprise means to explore a mysterious cave, soar on a magic carpet, rescue a pod of dolphins and more adventures." (www.smartoy.com)	Children's excitement derives from to taking risks with the IoToy, e.g. by listening to a ghost story told by the toy or risk-taking in reference to coding with the IoToys. (Fisher-Price's Smart Toy Bear, CogniToys Dino)

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VI. Discussion

The IoToys have been on a high growth in numbers for some time now. Simultaneously, parents want to take a more active role in their children's education and give them tools for that. The IoToys as an emerging category of smart toys, seems to deliver both entertainment and education, offer opportunities for free play and connect children to play games, and make activities by learning new skills, like mathematics and languages. Toy companies work to keep children and parents engaged, offering new ways to both play and learn. Playing with contemporary smart toys connected to the Internet, future play can be shaped as children may connect with others, in the online and offline domains, public and private spaces and in formal and informal learning environments. In other words, children's playing is no longer confined to the physical space but extends to virtual realms, which means that the IoToys offer opportunities to engage in the kinds of transmedia and trans-domain practices. These practices transform the toy to operate as a kind of boundary object [38], enabling the children to transverse different domains and practices with ease. For example, the Fisher-Price Smart Toy Bear learns how the child plays and recommends new activities because of its connection to the Internet through Wi-Fi.

In our study, we have presented three different perspectives on play with smart toys: Toy marketers' suggestions on the IoToys' potential for playful learning, preschool teachers' views on smart toys suitability to be used in the early learning context, and parents' attitudes towards smart toys based on their observations of children's play in the domestic sphere. All these stakeholders have understood that play evolves, and modern technology can help a child feel more empowered, capable and they can learn with toys. Still the question of how to make use of these contemporary smart toys in early education can be raised. The preschool teachers' attitudes will influence their teaching activities when using digital devices, games and smart toys in their education. Clearly, more research is needed to understand how preschool teachers could use for example the IoToys for learning. It is also important to remember that these toys function as entertainment, and children playing with the smart toys in home environments may not understand all their educational features. Like many studies have shown, when parents are more involved with their children's education they also want toys to teach something to their children. Therefore, the parental perspective on what is considered important in terms of play experiences that may contribute to playful learning should be studied and acknowledged even more.

VII. Conclusion and future research

The results of our study present that marketers have seen the educational potential of contemporary smart toys, and are using that in their communication. Moreover, they also reference early education parties, which have used their smart toys as a part education.

Despite their complex technological systems, smart toys designed for the mass market come in relatively affordable prices for consumers of the Western world and are in this way more likely to enter the domestic playscapes of young children. Although, at many times, digitally-enhanced toys are still considered to fit informal learning environments such as the home better than the formal educational context of preschool, we believe that the ongoing digitalization development will eventually also introduce more preschools with more connected toys. We believe, that contemporary smart toys are bridging play and learning in positive ways, and could be used even more as a part of informal and formal learning. Therefore, it is beneficial for both educators and parents of young children to know the various possibilities these playthings afford both in terms of different play experiences. In future stages of our research, our aim is to conduct a longitudinal study with both preschoolers, their parents and their teachers in order to find out more about the play experiences the contemporary smart toys afford.

In our study we explored smart toys' potential to deliver experiences related to playful learning. One key aspect of toys such as the CogniToys Dino, Fisher-Price's Smart Toy Bear and Wonder Workshop's Dash Robot are their game-based and toy-based features and functions, which are suggested to have educational outcomes when used in play.

We hope this paper to have highlighted the three perspectives on play with smart toys from the viewpoints of toy marketers', preschool teachers and parents. As our results have shown, preschool teachers are generally positive towards the IoToys, but are not necessary sure about how to use them in education. This means that early educational professionals must be more informed about new technologies affordances for playful learning. Furthermore, as our findings show, parents are generally welcoming to smart toys into their children's lives as well, because they offer new modes of playing and learning, yet do not really know their potential. These modes for playful learning could therefore be evaluated based on play experiences related to smart toys' as game-based and toy-based affordances, as presented in our paper. In this way, their suitability could be better considered to be used for playful learning in different learning situations and contexts.

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