Original article

doi: 10.1111/jcal.12169

Journal of Computer Assisted Learning

Technology-enhanced storytelling stimulating parent–child interaction and preschool children's vocabulary knowledge

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Abstract Preschool children's vocabulary mainly develops verbal through interaction. Therefore, the technology-enhanced storytelling (TES) activity Jeffy's Journey is developed to support parent–child interaction and vocabulary in preschool children. TES entails shared verbal storytelling supported by a story structure and real-time visual, auditory and textual prompts on a tablet computer. In this exploratory study, we investigated how TES influenced parent–child interaction and vocabulary. An experimental pretest-intervention-posttest design was followed with 44 3-year-old children and their parents in the experimental group and 27 peers in the control group. Results revealed that TES stimulated active child involvement and generated parent–child interaction, yet a great variety in TES characteristics both in time spent and usage of prompts was found among participants. Dyads that spent more time on story phases showed more and higher quality parent–child interaction. The usage of prompts was associated with improved parent–child interaction quality. Finally, an effect of TES was evidenced on children's productive vocabulary knowledge. To conclude, this study demonstrates that TES can be considered as a promising context for fostering parent–child interaction and children's vocabulary development.

Keywords parent–child interaction, preschool children, technology-enhanced storytelling, verbal analyses, vocabulary knowledge.

Introduction

Vocabulary knowledge in preschool children is essential for expressing themselves and communicating with others. Before children enter formal schooling, their vocabulary develops mainly through verbal interaction with parents and other family members (Mol & Neuman, 2014; Vygotsky, 1978; Weizman & Snow, 2001). There is a wide variation in the quantity and quality of parent–child interaction which is, amongst other factors, related to sociolinguistic background. In lower socio-economic status (SES) and multilingual ethnic minority families, generally less parent–child interaction is taking place (Bradley & Corwyn, 2002), and the quality is lower as these parents leave less room for active and challenging child participation (van Kleeck, Gillam, Hamilton, & McGrath, 1997). As a consequence, vocabularies of children growing up in these families are found to be smaller and develop at a slower rate (Hoff, 2006).

Teaching parents higher-quality interaction skills via traditional training methods used in family literacy programmes (FLPs) is challenging (Van Steensel, McElvany, Kurvers, & Herppich, 2011). Therefore, we introduce technology-enhanced storytelling (TES) providing real-time support for parent–child interaction via a tablet computer. This approach was shown successful in a previous study where a digital elaboration image including textual and visual prompts fostered parent–child interaction and children's vocabulary (Gremmen, Molenaar, & Teepe, 2016). Elaborating on this, we

Accepted: 31 October 2016

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developed the TES activity Jeffy's Journey. Jeffy's Journey supports shared verbal storytelling of parent and child with real-time support through a story structure and visual, auditory and textual prompts.

We investigated how parent and child engage in TES and how it influences parent–child interaction and children's vocabulary. An experimental pretest-intervention-posttest design was followed with 44 3-year-old children and their parents in the experimental group performing Jeffy's Journey and 27 peers in the control group. In the following literature overview, we first outline the importance of the quantity and quality of parent–child interaction for children's vocabulary. Subsequently, we elaborate on how technology can support parent–child interaction and consequently influences children's vocabulary.

Vocabulary development via parent–child interaction

A rich home language environment, in which parents and children are engaged in activities such as shared book reading, storytelling and game play, is important for children's vocabulary development (Dickinson & Tabors, 2001; Korat, Klein, & Segal-Drori, 2007; Mol & Neuman, 2014). Especially, the parent–child interaction taking place during these activities stimulates children's vocabulary (van Kleeck et al., 1997; Vygotsky, 1978). The more time parents spent on activities with their child, the more interaction is taking place between them and the more opportunities the child experiences to learn new word meaning and to enlarge existing word knowledge (Hoff, 2006).

In addition to interaction quantity, active child participation is important as demonstrated within the dialogic reading context (Mol, Bus, De Jong, & Smeets, 2008; Zevenbergen & Whitehurst, 2003). Active child participation is especially beneficial for the development of productive vocabulary knowledge (Mol et al., 2008), as the child needs to use words in order to acquire productive vocabulary (Sénéchal, Thomas, & Monker, 1995). Parents can use evocative techniques to make their child an active story teller as opposed to a passive listener, for example, by asking open-ended questions to elicit verbal responses and providing feedback (Zevenbergen et al., 2003).

Parents can use and instigate different quality of interaction. They can talk about the here and now by labelling objects and describing characters that are perceptually present (van Kleeck et al., 1997). This contextualized type of interaction can be extended by decontextualized language that is beyond perceptual presence. Decontextualized language includes for example summarizing story content or making predictions about what will happen in the story. The latter type of language is more challenging and demanding and hence considered to be more beneficial for vocabulary development (Hoff & Naigles, 2002; van Kleeck et al., 1997).

In lower SES and ethnic minority families, generally, there are fewer materials such as picture books and games available at homes, resulting in less frequent parent–child activities and parent–child interaction (Neuman & Celano, 2001). Moreover, lower SES parents tend to have a more dominant role during interaction with less active child participation (Hoff, 2006). They are more likely to ask contextualized where-questions and what-questions compared to decontextualized why-questions and how-questions (Bus, Leseman, & Keultjes, 2000; Deckner, Adamson, & Bakeman, 2006). As a result, children growing up in these families have smaller vocabularies (Hoff, 2006; Hoff & Naigles, 2002).

These families need support to engage in parent–child interaction with increased active child participation and high-quality interaction. One way to provide this support is via FLPs that aim to stimulate parent–child interaction via parent meetings during which interaction behaviour is trained (Sénéchal & Young, 2008). A review of Van Steensel et al. (2011) on the effects of FLPs demonstrated only a small mean effect of FLPs on children's vocabulary. It was assumed that high-quality interaction behaviour may be difficult to teach and learn via traditional training methods used in FLPs, such as modeling and role play (Carpentieri, Fairfax-Cholmeley, Litster, et al., 2011; McElvany & Van Steensel, 2009; Van Steensel et al., 2011). Specifically, the transfer of this behaviour to activities in the home context is found be challenging. Therefore, we propose to support parent–child interaction real time during TES.

Storytelling to support parent–child interaction

Storytelling provides an ideal context for active child participation and parent–child interaction and stimulates children's vocabulary development (Mol et al., 2008; Whitehurst et al., 1988). Next to traditional picture books, wordless picture books stimulate storytelling

(Ramos & Ramos, 2011). Wordless picture books elicit active participation as parent, and child creates a story together (Bosh & Durán, 2009). They discuss the relationship between pictures and uncover the story line by encountering different characters and their problems (Dimino, Taylor, & Gersten, 1995). A wordless picture book includes connections between story components and provides background information to create a meaningful storyline (Peterson, 1994). When parent and child engage in storytelling supported by a wordless picture book, they are likely to engage in contextualized parent–child interaction defining the characters and settings. This context also generates decontextualized interaction as the pictures need to be interconnected to create a story.

However, creating a meaningful story requires extensive skills of the parent. The parent needs to ask questions, provide feedback and stimulate the child to actively participate in story creation (Vygotsky, 1978; Zevenbergen et al., 2003). As was reported earlier, these skills may not be evident in all parents. A way to help parents during storytelling is through real-time interaction support. Recent research demonstrates that specific design principles and prompts in technology-enhanced activities stimulate parent–child interaction (Gremmen et al., 2016) and children's vocabulary (Takacs, Swart, & Bus, 2015). Within the storytelling context, Gremmen et al. (2016) conducted a study with a digital elaboration image that included visual and textual prompts (i.e. zoom elements and open-ended questions) for rich parent–child interaction and story construction. Results showed that the prompts stimulated decontextualized parent–child interaction and resulted in higher vocabulary gains compared with a paper condition without prompts.

Korat, Shamir, and Heibal (2013) concluded that parent–child interaction during e-book reading with visual prompts (dynamic visuals and hotspots), auditory prompts (music effects) and textual prompts (highlighted written phrases) encouraged decontextualized language such as sharing personal experiences. In a similar vein, Fisch, Shulman, Akerman, and Levin (2002) showed that including visual prompts, such as choice points that ask users to direct the storyline, encouraged parents' and children's decontextualized language such as making predictions about the story. In contrast, a study of Parish-Morris, Mahajan, Hirsh-Pasek, Golinkoff, and Collins (2013) showed that digital prompts can also distract from story content when they are not congruent with the storyline. Electronic console books with visual and auditory prompts (i.e. puzzles, games, songs and word repetitions) caused interruptions, mid-sentence pauses and other distractions that were detrimental to parent–child interaction quality.

Thus, there is evidence that visual, auditory and textual prompts can support interaction, as long as they are congruent with the story and do not distract from story content or hinder active participation. This was confirmed in a recent meta-analysis on effects of TES on children's vocabularies. Takacs et al. (2015) conclude that multimedia features like animated pictures, music and sound effects were beneficial for children's productive vocabulary and story comprehension, whereas interactive elements like hotspots, games and dictionaries were not.

Another design principle of TES is giving parents and children control of story content and story pace, to encourage active participation and high-quality parent–child interaction. Within the context of shared electronic book (e-book) reading, several studies showed the importance of parents and children being in control of the course of the story. When being in control of the story course, children were more actively participating in story construction (Fisch et al., 2002). In line with this, Kim and Anderson (2008) showed that giving parent and child control of pace the story resulted in more interaction compared with a closed format in which pages were turned automatically. Moreover, they showed that e-books with a voice-over served more as listening materials and involved fewer verbal interactions about the story. A voice over hinders active participation and story creation of parent and child. Therefore, we propose to provide a storytelling format in which parent and child tell the story themselves, and, following previous research, are in control of the story line and story pace, and are guided by prompts that are contingent with the storyline.

Elaborating on the discussed literature, we developed the TES activity Jeffy's Journey. In Jeffy's Journey, the format of shared wordless picture book is integrated, because this has proven to stimulate active participation of the parent and the child (Bosh & Durán, 2009; Ramos & Ramos, 2011). As creating a meaningful story requires extensive skills of the parent, technology was used to support the storytelling process. In the first place, Jeffy's Journey followed three design principles to support the creation of a meaningful story. First, Jeffy's Journey

consisted of storytelling phases, to know, an introduction story, avatar selection and a story creation phase (further explained in the method section). In these phases, the structural elements of a meaningful story (a problem, characters and the relation between events) were outlined (Dimino et al., 1995). Providing the structure of the story was shown to be helpful for creating a meaningful and coherent story (Harris & Schroeder, 2012).

The second design principle was parents and children being in control of the storyline. They could create their own story following the pictures in the introduction story, and they could select the characters of the story in the story creation phase. Following Kim and Anderson (2008), there was no digital narrator or digital voice-over so that dyads could determine the course and pace of the story themselves. As a third principle, we included explicit turn regulation, that is to say, parent and child alternately determined the course of the story by selecting characters. This was included to enforce well-balanced participation of parent and child, and also to prevent a conflict about who was in control of the screen. Turn taking during a technology-enhanced activity facilitates verbal interaction between preschool children (Therrien & Light, 2016), and we assumed the same would hold for parent–child dyads.

In addition to these principles, prompts were added with the purpose to enrich parent–child interaction around the storyline. Visual, auditory and textual prompts corresponding to the storyline were shown to enhance parent–child interaction (Gremmen et al., 2016; Korat et al., 2013). Therefore, prompts such as visual changes, word pronunciations and open-ended question were included to foster contextualized and decontextualized language. In line with the second control principle, prompts were not offered automatically, but parent and child were in control of their implementation. In sum, we assumed that providing a structured storytelling activity accompanied with visual, auditory and textual storytelling prompts would result in active and meaningful storytelling with high-quality parent–child interaction.

Present study

The aim of this study was to explore how parent and child interact during TES. Jeffy's journey is designed following design principles that are derived from research into children's vocabulary development and parent–child interaction. An experimental pretest-intervention-posttest design was followed with 44 3-year-old children and their parents in the experimental group and 27 peers in the control group. Parent–child dyads in the experimental condition did Jeffy's Journey twice. We examined TES characteristics, namely, the time spent on different storytelling phases and the use of prompts. Additionally, we analysed the quantity and quality of parent–child interaction. To establish how the design of Jeffy's Journey influenced parent–child interaction, we looked at their relation with TES characteristics. Finally, we investigated the effects of TES on children's receptive and productive vocabulary. Planning to analyse these particular aspects, the following research questions guided our study:

1. How do parent and child engage in TES?
2. Do the design principles influence active child participation and the quantity and quality of parent–child interaction?
3. What are the effects of TES on children's vocabulary knowledge?

Based on previous research, we expected the design principles of TES to stimulate active child participation and the quantity and quality of parent–child interaction (for example Gremmen et al., 2016; Korat et al., 2013). Furthermore, we expected that storytelling with Jeffy's Journey would facilitate both children's receptive and productive vocabulary. This hypothesis is based on studies that demonstrated the importance of contextualized and decontextualized parent–child interaction for children's receptive and productive vocabulary development (Sénéchal, 1997, van Kleeck et al., 1997).

Method

Participants and design

Four Dutch preschools in multi-ethnic neighbourhoods in middle sized urban areas were approached to participate and all agreed on participation. All parents and children of a preschool were invited to participate. A total of 61 experimental parent–child dyads and 27 control children started the study. Four dyads were excluded because the child was absent during post-test session. Thirteen dyads were excluded because the Dutch language level of parent and/or child appeared insufficient for task

understanding and execution. This resulted in an experimental group of 44 parent–child dyads and 27 controls.

The experimental group consisted of ten fathers and 34 mothers and their child (25 girls and 19 boys) aged 27 to 46 months (M = 39.41, SD = 4.82). Educational level of the parents ranged from no education (2.3%), primary school level (4.5%), high school level (11.4%), vocational education (47.7%), higher professional education (18.2%) to university education (13.6%).

The control group consisted 27 children (17 girls and ten boys) aged 31 to 47 months (M = 41.11, SD = 4.46). Educational level of the parents ranged from no education (7.5%), primary school level (13%), high school level (33.3%), vocational education (37%), higher professional education (5.6%) to university education (1.9%).

A pretest-intervention-posttest control group design was followed with experimental parent–child dyads doing Jeffy's Journey twice within a period of 2 weeks. The receptive and productive vocabulary pre-test and post-test were administered in experimental and control children (N = 71) at the beginning and end of the 2 weeks. Control children did not receive the intervention. All parents gave active consent for their own and their child's participation.

Technology-enhanced storytelling with Jeffy's Journey

Jeffy's Journey is a TES activity carried out on a tablet computer. In the first phase (introduction story), six wordless images demonstrate the elements of the storyline: the main character, problem and setting of the story (Figure 1, phase 1). In Jeffy's Journey, Jeffy is the main character whose suitcase is stolen by a bird while he is waiting at the bus stop on his way to grandma. The bird flies away with the suitcase and drops it over the zoo. The last image of the introduction story defines the problem: it shows a desperate Jeffy, thinking about how to get his clothes back before he can go to his grandmother. By showing one image at a time, we intended parents and children first to label, notice and describe characteristics of characters, objects and the setting (contextualized language). Secondly, for story construction, they need to connect the six images by inferencing, summarizing, predicting, comparing, reasoning and defining the problem (decontextualized language).

In the second phase (avatar selection), parent and child both selected an avatar that was a graphical representation of themselves (Figure 1, phase 2). Avatars indicated a storytelling turn of the parent or the child. Avatars were included to stimulate turn regulated storytelling with well-balanced participation of parent and child. Moreover, turn regulation would prevent a conflict between parent and child on who was in control of the tablet screen. Activation of avatars was technology driven.

In the third phase (story creation), parent and child continued the story of the introduction. In this phase, the main character Jeffy comes alive (Figure 1, phase 3). Supported by visual, auditory and textual prompts, parent and child create Jeffy's story. Jeffy is in the zoo to retrieve his clothes from the animals. Parent and child navigate through the zoo by picking up Jeffy and moving him to visit an animal. When Jeffy visits an animal, an aspect of the animal changes (position, action and colour). For example, the monkeys turn upside down. With this visual prompt, we intended parent and child to notice, label and describe the characters taking part in the story.

At each animal, parent or child (depending on who's turn it was) could select visual, auditory and textual storytelling prompts. The emotion, word, swop and question prompts were expected to instigate elaborate character descriptions and more in depth storytelling. Firstly, the emotion prompt caused the change of a character's emotion to happy, sad or angry. This visual prompt was expected to stimulated decontextualized parent–child interaction about the point of view and feelings of a character. Secondly, the word prompt pronounced a word. This auditory prompt provided phonological input and was used to instigate contextualized parent–child interaction about the label, location and meaning of a word. The swop prompt made a character do something funny. This visual prompt could encourage contextualized language about the character's characteristics and actions and decontextualized language about why the character was acting in that way. In the parent's turns, the word prompt was replaced by a question prompt. With this textual prompt, a story-related question popped up, for example, 'Which animals did we visit so far?'. Contextualized question were about colours, shapes, counting or sounds of a character, whereas decontextualized questions asked for making a prediction or summary of the story, or connecting the storyline to personal experiences. All prompts could be used unlimitedly. Going from one animal to another, parent and child created the story of Jeffy retrieving his clothes, with elaborate descriptions of the animals that took his clothes.

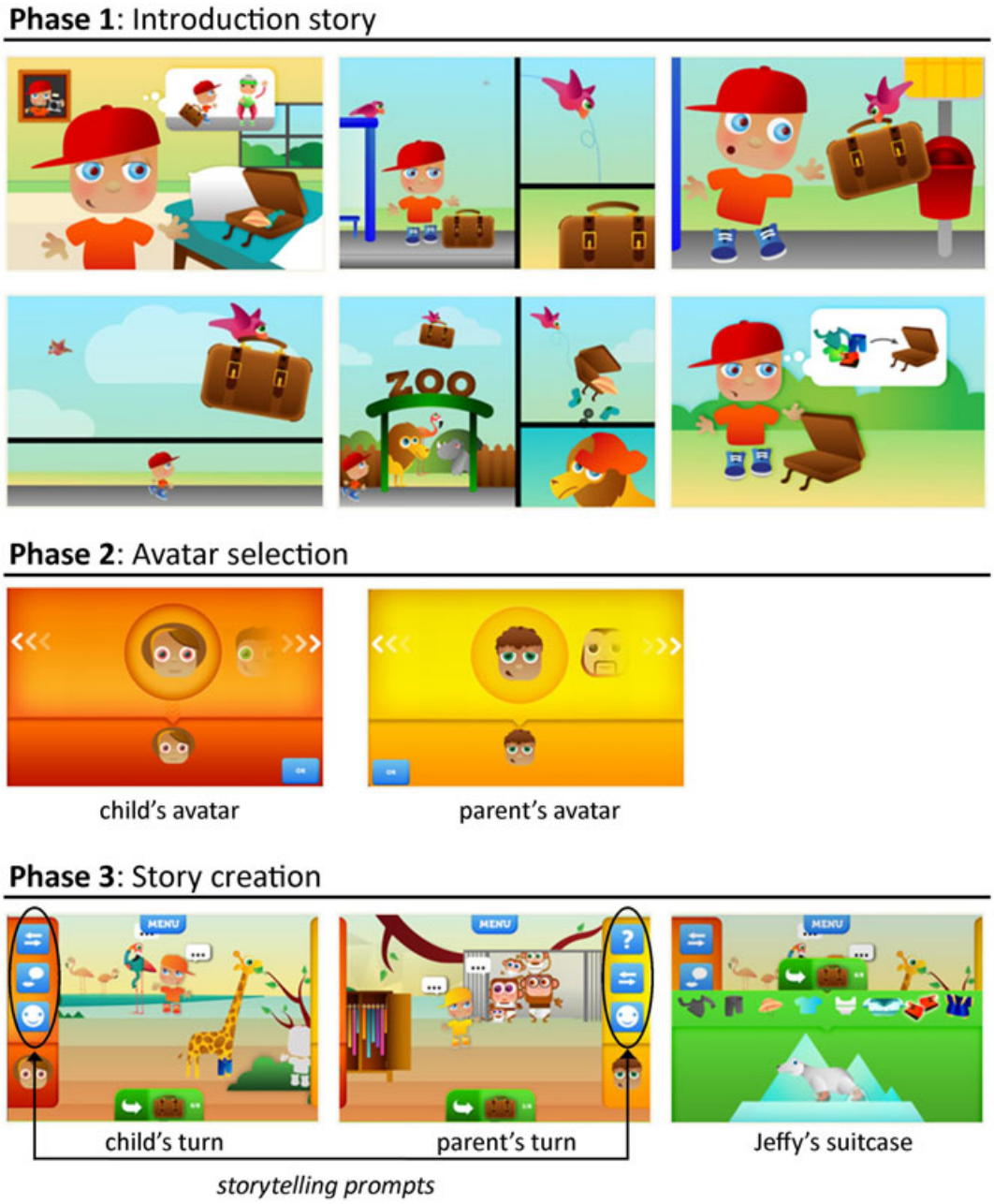

Figure 1 Technology-enhanced storytelling with Jeffy's Journey. [Colour figure can be viewed at wileyonlinelibrary.com]

The retrieved clothes were stored in Jeffy's suitcase that could be viewed at all times (Figure 1, Jeffy's suitcase). It showed which items were collected at which animal and which items were still missing. The suitcase was provided to repeat story elements and to elicit decontextualized interaction as summarizing (what did Jeffy already find) and predicting (where does Jeffy still needs to go). When all eight garments were collected, an overview of the suitcase was provided in order to summarize, look back and conclude the story.

Measures

Technology-enhanced storytelling characteristics

Technology-enhanced storytelling characteristics were derived from log files in which all technical aspects of

storytelling were tracked. Each performance, for example, the moment parent and child started and finished the introduction, was displayed with a time stamp; and from this time spent on, storytelling phases was derived. Use of storytelling prompts was also derived from the log files, as the system tracked which storytelling prompts were used and how often. These characteristics were used to investigate associations between technology use and the quantity and quality of parent–child interaction.

Parent–child interaction

Parent–child interaction was transcribed from the videotaped TES sessions. All utterances were coded following the van Kleeck et al. (1997) adapted version of the four levels of abstraction coding scheme, which we also used in the study of Gremmen et al. (2016). Following van Kleeck et al. (1997), we distinguished story-related utterances, procedural-related utterances and interaction-related utterances. Unintelligible utterances and non-responses were not coded (see the Appendix for the complete scheme and examples).

Story-related utterances were comments and questions about the storyline. Story-related utterances were further coded on their quality by the four levels of abstraction. These levels describe to which extent an utterance refers to contextualized information that is perceptually present or to decontextualized information that is beyond perception. The first two abstraction levels included contextualized utterances, whereas the third and fourth level contained decontextualized utterances. Procedural-related utterances included utterances on functional aspects of TES and the tablet. Interaction-related utterances involved utterances that parents and children used to support each other, give feedback or engage to complete the task.

For each dyad, interaction of two TES sessions was transcribed and coded. Due to technical issues, sound quality of some videos was of insufficient quality for being transcribed and coded. Only dyads of which both videos were suitable were coded. In total of 27 dyads, both videos were suitable, resulting in 54-coded transcripts. Coding was carried out by the first author and two trained research assistants. All videos were transcribed, and subsequently, each utterance received a single code. The first two transcripts were coded and discussed by all coders. Subsequently, four transcripts were double coded, in order to determine inter-rater reliability. Inter-rater reliability (Fleiss' K) on the main categories (i.e. interaction, procedural and story-related utterances) was $K = .77$ and on the sub-categories of story-related utterances $K = .77$, which was sufficient to continue coding (Fleiss, 1981).

Vocabulary knowledge

We designed a task-specific vocabulary test consisting of 30 words. Referents of all 30 words were perceptually present in TES, and attention was drawn to the target words by the prompts. All 30 vocabulary items were assessed both productively and receptively, following the age appropriate testing format of the Peabody Picture Vocabulary Tests (Schlichting, 2005). In the productive vocabulary task, children were shown a picture of the target word, and simultaneously, they were asked to complete a sentence in which the target word was left out (for example: "When you go to sleep, you wear your ... [pajama's]?"). For each correctly completed sentence, one point was assigned with a maximum of 30 points. All other responds than the target word were assigned a zero score. Internal consistency of this task was sufficient (Cronbach's $\alpha = .89$). In the receptive task, children had to select the picture of the target word out of three distracters (perceptual, phonological and semantical). Each correctly selected item was assigned one point, resulting in a maximum score of 30 points. Internal consistency of the receptive task was sufficient (Cronbach's $\alpha = .85$).

Procedure

Parents were recruited and informed about the study via an information brochure. Firstly, productive and receptive vocabulary knowledge (the former first) tests were administered in all 71 children. Next, the 44 experimental dyads did TES with Jeffy's Journey on a tablet computer, twice in separate intervention sessions. Subsequently, all 71children were post-tested on productive and receptive vocabulary knowledge. In an addition, parents filled out a background questionnaire. The entire study took place within a period of 2 weeks.

Intervention and test sessions were conducted by the first author and trained research assistants. Test administrators first spent time with the children in the preschool so that children could become familiar with them. Children were tested individually in a quiet room in their

preschool. Test sessions took approximately 10 min per child. At the beginning of the intervention sessions, parents received verbal instruction on TES. The test administrator clarified an instruction sheet explaining the goal of the activity. The parent was allowed to keep the instruction sheet during the activity and was informed not to ask for help during storytelling. Intervention sessions were video-recorded and took approximately 10 min per session ($M = 9.57$, $SD = 2.20$).

Data analyses

In order to answer our first research question, we calculated means and standard deviations for the TES characteristics time spent on different storytelling phases and use of storytelling prompts. Also, means and standard deviations of the quantity and quality of parent–child interaction were calculated. Calculations were carried out on data of the two intervention sessions together. For answering our second research question, we explored Pearson's correlation matrixes, in which we associated the TES characteristics with parent–child interaction quantity and quality. For the final question, we ran separate Multiple Regression Analyses on receptive and productive vocabulary tests, with post-test scores as dependent variables and pre-test scores and condition (0 = control, 1 = experimental) as independent variables. Testing was carried out at $p < .05$.

Results

Technology-enhanced storytelling characteristics and parent–child interaction

Descriptive statistics of TES characteristics and the quantity and quality of parent–child interaction are presented in Table 1. Over two sessions of TES, dyads spent on average four and a half minutes on the introduction story in which they discussed the characters, setting and problem of the story. They spent half a minute on the second phase in which they selected their avatar for turn regulation. With over 15 min, parents and children spent most time on the story creation phase. In this phase, which was the core of the activity, they created the story and tried to solve the problem that was introduced in the introduction story. Large standard deviations indicate that there was a great variety in the time parent–child dyads spent on each phase.

Table 1. Technology-enhanced Storytelling Characteristics and the Quantity and Quality of Parent–Child Interaction

	Mean	*SD*	Min.	Max.
Time spent on storytelling phases[a]				
Phase 1: Introduction story	04:28	02:11	00:24	09:36
Phase 2: Avatar selection	00:38	00:26	00:10	02:09
Phase 3: Story creation	15:10	03:31	08:41	26:15
Use of storytelling prompts[b]				
Emotion prompt	9.64	10.34	0	43
Swop prompt	5.09	6.85	0	26
Word prompt	4.41	5.72	0	19
Question prompt	1.68	2.58	0	12
Child utterances[c]				
Interaction-related	12.15	10.58	0	34
Procedural-related	37.07	25.92	3	118
Story-related	57.93	47.23	7	251
Contextualized	47.89	35.21	7	176
Decontextualized	10.04	14.74	0	75
Total utterances	127.07	70.70	22	366
Parent utterances[c]				
Interaction-related	29.15	23.43	3	91
Procedural-related	121.00	56.23	24	214
Story-related	134.30	81.16	11	394
Contextualized	108.67	57.43	11	256
Decontextualized	25.63	29.47	0	138
Total utterances	298.19	137.18	56	679

[a]$n = 44$. [b]$n = 22$. [c]$n = 27$.

During the story creation phase (third phase), dyads had access to storytelling prompts: an emotion, swop, word and question prompt. Half of the group used the storytelling prompts ($n = 22$). The emotion prompt was, with an average of 9.64 times, applied most often and used by 81.8% of the dyads. The question prompt was used least (1.68 times on average) and used by 50% of the dyads. The swop and word prompt were used to the same extent (5.09 and 4.41 times on average) and used by 72.7% and 63.6% of the dyads, respectively. Overall use of storytelling prompts differed highly across parent–child dyads. The storytelling prompts were not used at all by 9.1% of the dyads.

Next, we explored parent–child interaction during the two TES sessions. Table 1 presents interaction quantity indicating the type of utterances parents and children made (interaction-related, procedural-related and story-related) and the quality of the story-related utterances (contextualized versus decontextualized). The table demonstrates that children were actively participating during TES. They made a substantial contribution to the interaction, with 127.07 mean utterances being 30% of the total

conversation utterances. Most utterances were story related. The relative amount of story-related contributions of parents and children was similar for both parent and child, with 45% of their total utterances. Parents talked relatively more about the procedure (40%), whereas children showed a smaller percentage of procedural talk (29% of their contributions). The interaction-related utterances were 9.8% of parental talk and 9.6% percent of children's talk. This indicates that parents guided the procedural aspects of TES but that story creation was carried out conjointly. When looking at the interaction quality, conversations were characterized by contextualized language with about 80% of the story-related utterances. There was also decontextualized language with around 20%. A wide range on all types of utterances shows that there were large differences among dyads in the quantity and quality of interaction during TES.

The influence of design principles on parent–child interaction

In order to understand how TES influenced parent–child interaction, we investigated the associations between TES characteristics and parent–child interaction, see Table 2. In the introduction story (phase 1), wordless pictures were used to generate interaction about the character, setting and problem. This phase was positively associated with the overall interaction quantity of both parents and children, indicating that there were many utterances in this phase. Moreover, the introduction story related to interactional-related and story-related utterances of children. For parents, this phase was positively related to all type of utterances, yet the strongest to story-related utterances. This indicates that during the introduction story parents and children together created the storyline and that parents guided the procedural aspects TES and their collaboration. Positive relations were found between the introduction story and contextualized and decontextualized language use of the parent. In this phase, the parent used contextualized language with character descriptions such as 'This is Jeffy and he is at the bus stop' and decontextualized language with reasoning like 'When you are at the bus stop, you have to wait for the bus'. The second game phase avatar selection) was a procedural phase in which turn regulation was introduced. Time spent on this phase positively related to procedural utterances of parents and children with discussions about choosing an avatar. For example, the parent said: 'You can click here to select the boy', to which the child replied: 'Ok, I click here'.

The third game phase (story creation) was the most important phase during which parent and child created the actual story with the main character Jeffy. They were supported by storytelling prompts. Time spent on this phase was related to the overall interaction quantity of parents and children. This indicates that the story creation phase stimulated interaction between parents and children. Moreover, this phase was strongly associated with story-related utterances of the child and parent, and also with the parent's procedural-related utterances. This indicates that parent and child together created the story. In this story creation process, the child was equally active as the parent, whereas the parent provided additional procedural guidance. With regard to interaction quality, this phase strongly related to both contextualized language and decontextualized language of parents and children, with stronger relations to decontextualized language use. Using decontextualized language, the parent asked the child for example: 'Should we take this jacket for Jeffy?', to which the child replied: 'Yes, take it off'. Subsequently, the parent started reasoning: 'When it is getting colder, he will have to wear it. Otherwise he will feel cold'.

During this third phase, storytelling prompts aimed at generating contextualized and decontextualized parent–child interaction were available. The emotion and question prompt were positively associated with the parent's and child's story-related utterances and also with the parents' interaction-related utterances. Moreover, these prompts were positively associated with both contextualized and decontextualized language use, with a stronger relation to decontextualized language. For example, the emotion prompt resulted in decontextualized language making identifications with the character, like: 'We do not want him to be sad, right? And also not to be angry'. In another example, the question prompt led to interaction with the parent asking a summarizing question like: 'Which animals did we already visit?', to which the child replied: 'The owl with the feathers'. Thus, the emotion and question prompt indeed supported high-quality interaction when used.

The swop and word prompts showed weaker relations with parent–child interaction and were not associated with story-related interaction. The swop prompt was only related to interaction-related utterances of the child. A surprised reaction with the only verbal expression of 'Ohh!!' or 'Ahh!' was characteristic interaction for the

Table 2. Associations Between Technology-enhanced Storytelling Characteristics and the Quantity and Quality of Parent–Child Interaction

	Time spent on storytelling phases (n = 27)			Use of storytelling prompts (n = 13)			
	Phase 1: Introduction story	Phase 2: Avatar selection	Phase 3: Story creation	Emotion prompt	Question prompt	Swop prompt	Word prompt
Child utterances							
Interaction-related	.53**	.22	.22	.44	.59*	.59*	.38
Procedural-related	.23	.53**	.21	.17	.26	.04	.07
Story-related	.40*	.05	.57**	.80**	.85**	.22	.55
Contextualized	.37	.00	.51**	.78**	.83**	.22	.52
Decontextualized	.39	.16	.61**	.81**	.86**	.20	.61*
Total utterances	.51*	.31	.53**	.65*	.77**	.19	.46
Parent utterances							
Interaction-related	.54**	.08	.33	.60*	.66*	.23	.53
Procedural-related	.48*	.51**	.49**	.47	.51	.32	.34
Story-related	.55**	.15	.56**	.76**	.80**	.38	.53
Contextualized	.53**	.11	.47*	.70**	.73**	.42	.45
Decontextualized	.47*	.20	.62**	.81**	.86**	.28	.62*
Total utterances	.59**	.28	.56**	.70**	.75**	.35	.52

*$p < .05$. **$p < .001$.

functioning of this prompt. Finally, the word prompt was related to decontextualized language of both parents and children. For example, the parent's reaction on the word prompt was 'Jacket, you also have a blue jacket'. This above indicates that there are clear relations between the design principles and parent–child interaction that is generated during TES.

Effects of technology-enhanced storytelling on children's vocabulary

The last question investigated the effect of TES on children's vocabulary. Children's receptive and productive vocabulary knowledge scores are presented in Table 3. Multiple Linear Regression Analysis on receptive vocabulary knowledge (0 = control, 1 = experimental) demonstrated that the pre-test score significantly explained the post-test score (R^2 = .710, β = .83, $t(68)$ = 12.21, $p < .001$) and that there was no added value of condition ($\Delta R^2 = .002$, $\beta = .05$, $t(68) = .67$, $p = .507$). This indicates that the experimental group and control group made similar growth on receptive vocabulary knowledge and that there was no significant effect of TES. The analysis on productive vocabulary knowledge demonstrated that the pre-test score again significantly explained the post-test score ($R^2 = .809$, $\beta = .89$, $t(68) = 17.19$, $p < .001$) and that there was a significantly added value of condition ($\Delta R^2 = .012$, $\beta = .11$, $t(68) = 2.09$, $p = .041$). This indicates that there was a significant effect of TES on productive vocabulary knowledge showing that the experimental group learned more words compared with the control group.

Discussion

The purpose of this explorative study was to investigate how the TES activity Jeffy's Journey influenced parent–child interaction and vocabulary of preschool children. An effect of TES was evidenced on children's productive vocabulary knowledge. We explain this effect by elaborating on the design principles of TES and how they influenced parent–child interaction during the activity.

Technology-enhanced storytelling significantly improved children's productive vocabulary knowledge. This result is partially in line with our hypothesis and theory on vocabulary learning. The effect confirms that productive vocabulary acquisition takes place when children are encouraged to retrieve words in interaction with a parent (Hoff, 2006, Sénéchal, 1997). The fact that TES did not affect receptive vocabulary knowledge could be explained by the incremental view of learning (Nagy & Scott, 2000). Vocabulary knowledge exists on a continuum where receptive vocabulary knowledge can be seen as a precursor for productive vocabulary knowledge (Stahl & Stahl, 2004). Receptive vocabulary test scores demonstrate that around one third of the words were already receptively known at pre-test. TES has contributed to a more complete understanding of the already receptively known word meanings. This might explain the

Table 3. Descriptive Statistics on Pre-test and Post-test Scores of Experimental (n = 44) and Control (n = 27) Children's Receptive and Productive Vocabulary

	Receptive vocabulary				Productive vocabulary			
	Pre-test		Post-test		Pre-test		Post-test	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Experimental group	21.32	4.76	22.11	4.84	12.93	5.87	15.59	6.15
Control group	18.11	6.02	18.59	7.25	11.70	5.80	13.07	6.01

gain found on productive knowledge, but not on receptive knowledge.

The effect on productive vocabulary knowledge can be clarified further by the design principles of TES and their influence on active participation and the quantity and quality of parent–child interaction. The combination of the design principles (structured storytelling via different phases, turn regulation, control of the storyline and the visual, auditory and textual prompts) stimulated active participation of both parent and child. Firstly, the three storytelling phases (introduction story, avatar selection and story creation phase) each had their specific contribution to parent–child interaction. During the introduction story, dyads use story-related utterances to define the characters, settings and the problem of the story. In this first phase, parent and child also used interaction-related language to enhance their collaboration, which appears important at the beginning of a collaborative activity. Selecting an avatar was expected to be a procedural aspect of the activity on which least time was spent. Indeed, this phase lasted on average half a minute and only resulted in procedural-related talk. Dyads spent most time on story creation, which was the most important phase. During this phase, parent and child together constructed the story using story-related language with the parent guiding the procedural aspect. Moreover, this phase generated high-interaction quality with both contextualized and decontextualized language. This analysis of story phases indicates that each storytelling phase has its specific relation to parent–child interaction. Moreover, it shows that parent–child interaction can be directed by the design of a storytelling phase. Thus, providing the structure of the story by different storytelling phases was helpful for generating active child participation and creating a meaningful and coherent story. This result is in line with previous research showing that a story structure is helpful for story creation (Harris & Schroeder, 2012).

The second principle of parents and children being in control of the storyline and story pace was included to stimulate active participation. During TES, parents and children were both actively participating with children being responsible for on average 30% of the total utterances and parents for 70%. Moreover, almost half of their interaction was about the storyline. This confirms findings of previous research showing that control of the course of story events and the story pace, and the absence of a voice-over generates active story construction (Fisch et al., 2002; Kim & Anderson, 2008).

The third principle, explicit turn regulation in which parent and child alternately determined the course of the story, stimulated well-balanced story creation. Parent and child equally participated in story creation, both with 45% of their contributions being story-related language. This study adds to the existing knowledge that turn regulation facilitates verbal interaction between preschool children (Therrien & Light, 2016) by showing that turn regulation also stimulates well-balanced participation of parent and child.

Next to three design principles that facilitated active participation during story creation, storytelling prompts were included to support interaction quality and rich interaction around the storyline. We found that the use of visual and textual storytelling prompts related to the quality of parent–child interaction. The emotion and question prompt generated contextualized and decontextualized language. The emotion prompt resulted in discussions about the character's feelings in relation to the story. The textual question prompt provided a question about the storyline. Even though this prompt was used limitedly, when it was used, it generated high-quality story-related interaction. Surprisingly, the auditory word prompt did not generate story-related interaction. It might be that providing a single word does not result in the expected labelling behaviour as single words might be too isolated for this storytelling context.

This prompt could be improved by providing a word incorporated within a sentence, so that it becomes more integrated in the story (Takacs et al., 2015). The swop prompt was also not related to story-related language, yet it elicited interaction-related language of the child. It might be that this prompt, which made a character do something funny, was too complex to connect to the storyline. In line with findings of Gremmen et al. (2016) and Korat et al. (2013), the current study confirmed that prompts aligned with the story encouraged active verbal participation and facilitated high-quality story-related language. Prompts that were more difficult to connect to the storyline did not result in story-related language (Takacs et al., 2015). This in-depth evaluation of parent–child interaction during storytelling phases adds to the existing knowledge on how technology can support parent–child interaction.

Exploring the parent–child interaction during TES also showed a great variety among dyads. This variety was found both on the time spent on storytelling phases, the use of storytelling prompts and the quantity and quality of parent–child interaction. This suggests that the TES context stimulates different behaviour. This finding is in line with the variety found on the time spent on EC book reading (Parish-Morris et al., 2013) where a wide range on reading time was revealed (5.27 to 30.37 min). Possibly, this variation relates to sociolinguistic background of parents and children, such as educational level of the parent or language level of the parent and child, or to experience with digital activities in general. However, as the design of this study did not allow us to explore what underlies this variation, these explanations are highly speculative and should be investigated in depth in a follow-up study.

This study has some limitations. A first limitation is that we included a no-treatment control group, resulting in a weak comparison group. Future research should therefore consider comparing variations of the TES context or relating this context to, for example, the context of shared e-book reading or a non-digital storytelling context. Also, in this study, we did not address differences between the first and second time of TES. Further research should be conducted to examine the development of storytelling characteristics and parent–child interaction over time. In addition, it is advisable to include a training phase to provide dyads with the opportunity to get acquainted with the TES context. As it was our goal to investigate how the TES context influences parent–child interaction and children's vocabulary, future research could investigate whether interaction skills acquired within this context are being transferred and applied during other activities or daily routines. In line with that, it could be investigated how TES influences parent–child interaction when combination with traditional parent–child interaction training methods used in FLPs.

To conclude, this study shows that TES characteristics stimulate the quantity and quality of parent–child interaction and affect productive vocabulary knowledge of preschool children. After only two storytelling sessions, positive effects on children's productive vocabulary development were evidenced. The relations between TES characteristics and parent–child interaction showed that specific elements of TES generated contextualized and decontextualized parent–child interaction. Therefore, TES can be considered as an effective learning context for both parent and child.

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Appendix

Coding Scheme for Coding Parent–Child Interaction Based on van Kleeck et al. (1997)

Main category	Definition	Examples of parent–child interaction	Technology-enhanced storytelling
Interaction related	Utterances to support each other, give feedback or engage to complete the task.	P: very well, you already know a lot!C: yes! P: now we are telling a story, later you can play. C: ok.	Introduction story
Procedural related	Utterances about functional aspects of the activity and tablet.	P: look, this is how you pick up Jeffy.C: I take Jeffy here. P: don't click on that button. C: click here?	Story creation
Story related	Utterances about the content of the story.		
Contextualized	(1) Utterances about perceptually present entities, focussed on labelling, locating and noticing entities.	P: where do you see the polar bear?C: here! *points* P: the tablet said underware. C: underware. P: ohh, did you see that? C: ohhh!	Polar bear changes position Word prompt Swop prompt
	(2) Utterances about perceptually present entities, focussed on entities' characteristics and actions, recalling information and completing sentences.	P: and now the suitcase is …?C: empty. P: the bird takes the suitcase. C: yes, bird suitcase. P: how many monkeys do you see? C: one, two, three…four!	Introduction Introduction Question prompt
Decontextualized	(3) Utterances beyond perceptual presence, focused on summarizing story content, defining words, providing a point of view of a character, comparing similarities and differences, providing judgements about story content and associating different images.	P: you also have a nice suitcase.C: yes I have a new suitcase, blue. P: which animals did Jeffy visit so far? C: ehmm, the bird and the lion! P: he is looking angry, ggrrrr! C: I don't make him angry.	Looking in suitcase Question prompt Emotion prompt
	(4) Utterances beyond perceptual presence, focused on making predictions about story content, describing and solving a problem and explaining concepts.	P: what is the bird going to do?C: taking the suitcase. P: what can Jeffy do now he has al his clothes? C: sleep over at grandma's house! P: the suitcase is empty, it needs to be filled. C: yes, otherwise we cannot go camping.	Introduction Jeffy at last animal Looking in suitcase
Non-codable	Unintelligible utterances, filler words when they were the only word of a sentence	Hmmm, uhuh	
Non-response	Denials and refusals to participate	I don't knowNo	