



# Parents' user experiences of augmented reality book reading: perceptions, expectations, and intentions

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## Abstract

Parents play an important role in students' informal learning with technology; however, there is a lack of relevant research, particularly regarding parents' opinions on students' learning with emerging technology such as augmented reality (AR). This study was therefore conducted in an initial attempt to explore parents' user experience (UX) of reading an AR book with their children from the perspectives of perceptions, expectations, and intention. There were 47 pairs of parents and their children invited to participate in a shared AR book reading activity in this study. Each parent was interviewed for qualitatively understanding their UX of reading the AR book, and their intention to use AR books were also quantitatively measured. The results show that the parents exhibited several types of perceived UX (i.e., sense of reality, novelty, playfulness and entertainment, awareness, memory and knowledge, guiding, distracting, and antipathy) and expected UX (i.e., interactivity, portability, sense of touch, vivid animation, value-added, and suitability). The findings further addressed the relationships between the parents' perceived and expected UX and their intention to adopt AR books for their children in the future. Some suggestions for the development and popularization of AR book systems are also proposed.

**Keywords** Augmented reality · User experience · Parent · Phenomenographic method · Reading

## Introduction

Augmented reality (AR), a technique to superimpose computer-generated information upon the physical world in real time, creates a new way for users to access information and further results in unique educational benefits. Due to the technological novelty of AR, the issues with regard to its capability of learning supports have been increasingly explored and discussed in educational technology research during the past few years. For example, some studies have specifically focused on understanding what and how AR technology can help users to read books (e.g., Cheng and Tsai 2016; Gazcon and Castro 2015). AR books, combining the content on the paper book and real-time synthetic information for its

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simultaneous presentation through a screen device, can be considered as enhanced traditional 3D pop-up paper books. Based on the experiences of paper book reading, AR books generally provide additional multimedia information such as 3D elements, video, or audio relevant to the book content for users to read (Gazcon and Castro 2015) and thus create a new reading experience (Lai et al. 2015). Several studies have also reported the advantages of AR books in education such as the enhancement of students' motivation (Ferrer-Torregrosa et al. 2015) and the improvement of reading performance (Abas and Zaman 2011). These studies have generally highlighted the benefits of AR in formal learning situations; however, the research on exploring the role of AR in students' informal learning is relatively rare.

In the social development theory, psychologist Vygotsky argued that socialization and social interaction may influence an individual's consciousness and cognition. He proposed a concept of zones of proximal development (ZPD) and stated it as the distance between an individual's actual ability to independently solve problems and potential developmental ability to solve problems under other capable individuals' help (Vygotsky 1978). In other words, a child could gradually develop cognitive ability or skills that are within his/her ZPD through an adult's encouragement and guidance. Based on Vygotsky's concept of ZPD, parental behaviors regarding shared book reading have been empirically identified its significant impacts on children's language development and literacy skills in previous studies (Li and Fleer 2015; Saracho and Spodek 2010; Sim et al. 2014). That is, in addition to formal education in schools, children's cognitive development could be fostered by family pedagogical practices in informal learning context.

Since parental behaviors play a role in the informal learning happening at home, how parents consider their children's learning with information technology may be a crucial issue for the implementation of informal education, particularly at the stage of preschool or elementary school. With regard to learning by new technology such as AR, a few studies have explored parents' perceptions of AR technology applied for preschool education, and have reported the parents' acceptance of AR learning for their children (Cascales et al. 2013). However, the findings in Cascales et al.'s study (2013) were based on the situation that the parents expressed their perceptions without actual experiences of using AR. When involving parents in an AR learning context together with their children, the parents may consider AR for their children's learning with diverse thoughts in addition to merely expressing their acceptance. For example, in Cheng and Tsai's study (2016), parents addressed multiple conceptions when reading an AR book with their children. To be more specific, while some parents held positively oriented conceptions such as learning by AR as enhancing impressions, as fostering motivation, or as attaining in-depth understanding, other parents possessed negatively oriented conceptions such as considering learning by AR as obstructing reading or as a substitute for parents. These conceptions were generated from the scope of learning by AR. Further exploring parents' thoughts about using AR products through the lens of "user experience" might provide more insights for the development and popularization of AR-related systems for informal learning such as AR books.

The definition (ISO 9241-210) of user experience (UX) is "a person's perceptions and responses that result from the use or anticipated use of a product, system or service." The perceptions of UX involve an individual's experiential or affective feelings that address the meaningful and valuable aspects of the interaction between humans and computers. UX involves a consequence of a person's internal state (e.g., motivation or mood), the characteristics of the designed system (e.g., usability or functionality), and the context within which the interaction occurs (Hassenzahl and Tractinsky 2006). Moreover, the ISO

definition of UX may elicit the ideas that, while an individual's perceptions of "use" of a system stand for the concept of perceived UX, his/her perceptions of "anticipated use" of a system indicate the concept of expected UX. The research viewpoints by previous studies also show that, in addition to the evaluation of perception of UX (e.g., Okimoto et al. 2015; Rehrl et al. 2014), users' expectations of the usage of products or information systems is another essential element for measuring UX (e.g., Olsson et al. 2013; Olsson 2014). In other words, UX could be analyzed from the two aspects including users' perceptions and expectations. Compared to the investigation of parents' conceptions of AR learning, UX could be a broad range of perspectives depicting parents' subjective experience resulting from interaction with AR technology such as AR books.

Studies on the UX of AR prototypes or applications have mostly examined users' perceptions from evaluative aspects (Dhir and Al-kahtani 2013; Rehrl et al. 2014). In general, users' perceived usability (e.g., ease of use), task performance (e.g., time duration to use), or emotional responses (e.g., pleasure) were utilized as the indicators for the quantitative evaluation of UX in AR scenarios. In addition to the work on the evaluative measurement of UX, little surveys have been qualitatively conducted to reveal UX as a phenomenon (Irshad and Rambli 2014). For example, one study interviewed customers in a shopping mall to explore the expected UX of mobile AR services for business purposes (Olsson et al. 2013). Several characteristics of UX and requirements that affect and facilitate the mobile AR experiences were identified in their study. Through the contextual interview analysis, the users' expectations described in Olsson et al.'s study (2013) can holistically illustrate users' contextual feelings in mobile AR environments; and the categories of UX can further be the basis to create metrics for measuring the actual UX. Therefore, it is considered that the adoption of qualitative measurements in this study could be appropriate to reveal the phenomenon of parents' subjective thinking about AR books for their children's informal learning.

In addition, to foster the usage of AR books for children's learning in informal contexts, the parents' attitudes toward the adoption of AR books should play a dominant role. Previous studies have implied the relationships between UX factors and behavioral intention to use information technology (Deng et al. 2010), as well as AR applications (Wojciechowski and Cellary 2013). The purposes for achieving satisfying UX are stimulating customers to use products or services (Olsson et al. 2013). Accordingly, this study was also interested in probing what factors of perceived and expected UX may lead to parents' continual usage intention to adopt AR books for their children's informal learning. Therefore, this study was situated in the context of child-parent AR book reading, and the research questions are summarized as follows:

1. What are parents' perceptions of their UX of AR book reading?
2. What are parents' expectations of their UX of AR book reading?
3. What are the relationships between parents' UX of AR book reading and their behavioral intention to use AR books in the future?

## Method

### Tool

This study adopted an AR book, namely "*The adventures of Yuyu: Yuyu Yang artistic journey (published in Taiwan)*," as the learning material for understanding the parents'

UX. Through storytelling with pictures, the purpose of the AR book was to introduce the work of an artist Yuyu Yang in Taiwan. To read the AR book, tablet PCs or smart phones with a camera were required. While focusing on the specific images on the paper book with the mobile device, virtual elements including 3D models with narration, videos, and interactive objects designed for extending the content of the book (e.g., detailed descriptions of Yuyu Yang's artistic work) are superimposed on the pages in real-time. In addition to the paper book reading, users can turn the mobile device to inspect different aspects of the augmented 3D objects along with narration for presenting the artistic work in more depth. Figure 1 demonstrates the usage of the mobile AR book.

## Participants

There were 47 pairs of parents and their children from different regions of Taiwan invited to participate in this study. The participants all agreed to be involved in the research. Whereas the mean age of the parents was 36.28 (ranging from 24 to 57) years old, the mean age of the children was 6.48 (ranging from 4 to 9) years old. A total of 96% of the parents had experience of using smartphones or tablet PCs, indicating that they were familiar with the operation of mobile devices. Notably however, about 75% of the parents responded that they had not seen or used AR applications before. It can therefore be supposed that most of the parents' responses to the UX of the AR book reading may not have been affected by their prior experience of AR technology.

## Instruments and procedure

To explore the parents' UX of the AR book reading, this study invited the parents to freely read the book together with their children. Before the child–parent shared reading activity began, a trained research assistant briefly introduced the research process and the usage of the book. Only when the participants understood how to operate the mobile AR book did the reading activity begin. In general, they read the book for approximately 20–30 min. When the participants finished the AR book reading, the parents were individually interviewed to qualitatively understand their UX through the lens of their perceptions and expectations regarding the AR book reading. The average duration of each parent interview was close to 10 min. Several semi-structured interview questions were utilized for revealing the parents' perceived UX and expected UX after trying the experience. The sample questions are: *please describe your feelings when you read the AR book* (perceived UX) and *what do you expect to experience when reading an AR book* (expected UX)?



**Fig. 1** Demonstration of the mobile AR book utilized in this study

Moreover, to examine the parents' intentions to adopt AR books for their children to learn, this study adapted a scale (*intention to use*) in a recent study evaluating students' attitudes toward AR learning (Wojciechowski and Cellary 2013). It is rated on a five-point Likert scale (from 1, "strongly disagree," to 5, "strongly agree"). The reliability coefficient for the scale was 0.94, indicating a satisfied internal consistency.

## Data analysis

The interviews were undertaken in Chinese and audio-recorded, as well as fully transcribed. To present the parents' UX when engaging in the AR book reading, this study adopted the phenomenographic method to examine the verbatim transcripts of the parent interviews. Through phenomenography analysis, the understandings of reality in which people experience can be revealed. Previous studies have used the methodology to analyzing and further classify students' conceptions of learning into specific categories (Tsai 2009). Also, some studies on exploring UX have adopted the phenomenographic method to outline differences in users' technological understandings of virtual product prototypes (Kaapu and Tiainen 2010). Therefore, analyzing the interview data by the phenomenographic method may be helpful for revealing variations in the parents' UX of the AR book reading.

As for the implementation of the phenomenographic analysis in this study, for each parent's interview transcripts, the researchers firstly marked the most important sentences that could represent their main idea of experiencing the AR book reading. The content-specific consistencies and differences across the interviewed parents' responses were then explored and summarized by comparing the selected sentences. Following previous steps, the qualitatively different categories of the UX of AR book reading perceived and expected by the parents can be generated by the researchers' discussion in agreement. According to the generated categories, the parents' interview data were further analyzed by quantitative content analysis. Moreover, to understand the qualitative associations between the parents' UX and their intention to use in the context of AR book reading, the quantitative data of their intention were firstly classified into bipolar categories (i.e., weak and strong) and were then used for cross-tabulation analysis with the categories of their UX.

## Results

### Perceptions of UX

Through the phenomenographic analysis, this study identified eight categories of the parents' perceptions of their UX of the AR book reading. The description and examples of the parents' interview responses for these categories are presented in Table 1.

Using the eight categories as the coding scheme, this study further coded the interview data by quantitative content analysis for depicting the parents' perceived UX from a holistic aspect. Notably, the parents' responses regarding their UX of AR book reading generally involved multiple perceptions and therefore overlapped among the various categories. Taking one parents' responses for example: "*It is a fresh experience to operate the virtual artistic objects in 3D; and we can see the work from different angles. The way to read the book can offer us more understanding of the artistic work.*" Her responses to the interview questions represent the perceptions that the AR book was capable of presenting the artistic work in 3D form and was helpful for her child to acquire knowledge about the

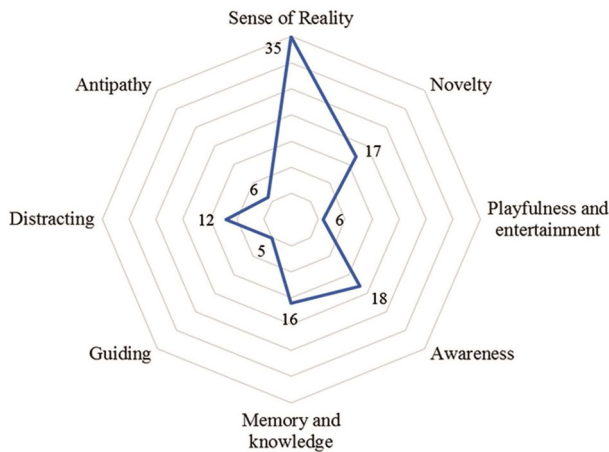
**Table 1** The category of the parents' perceptions of UX

Category	Description	Example
1. Sense of reality	Reading the AR book as seeing the real artistic work in a three-dimension, and even being where the work is	"...The book includes many 3D objects for us to observe in different aspects. I had feelings about seeing the work in a museum..."
2. Novelty	Feelings about the novelty of the presentation of AR books, particularly for the 3D elements or virtual information overlapping from the paper book	"...I am surprise to see the popup objects. I even cannot imagine what a form of book can be designed as it..."
3. Playfulness and entertainment	Emotionally expressing their joy, amusement and playfulness that arise from a brand-new experience of reading	"...The reading experience of AR book is fresh and special. It is interesting and playful to read a book in this way..."
4. Awareness	Considering the AR book to increase children's awareness about the content of the book and to draw their attention to read	"...Reading books with AR technology is attractive for children. Their attention to the book reading is also increased..."
5. Memory and knowledge	Considering reading with the AR book as helpful for memorizing the content, as well as for understanding the knowledge about art (or artists)	"...The AR book can lead my child to immerse into the context of the storybook and help him to memorize the content..."
6. Guiding	Considering that the AR technology can support the parents to guide their children to read the paper book in more depth	"...The pop-up information provided by AR technology such as the explanation of the artistic work can give me more ideas to guide my child to read the book..."
7. Distracting	Feelings about interrupting their book reading due to the usage of the AR technology	"...My child was easily attracted by the mobile device and looked forward operating it..."
8. Antipathy	An antipathy toward allowing their children to use electronic devices after they experienced in reading the AR book	"...I am worried about the possible injury on eyesight by continuingly focusing on screen..."

content of the book. This parent's perceptions of the UX were then classified into the two categories of (1) *sense of reality* and (5) *memory and knowledge*, and hence were counted twice. As a result, a total of 115 coded perceptions of UX were generated from the parents' interview data by the trained research assistants. A radar chart (Fig. 2) was also drawn to present the distribution of the parents' coded perceptions of their UX with regard to AR book reading in the eight categories.

As shown in Fig. 2, the UX of *sense of reality* was mostly perceived by the parents (frequency = 35), signifying that reading by AR technology strongly conveyed the experiences of seeing real objects and immersing oneself in real places. Besides, the perceptions of *novelty* (frequency = 17), *awareness* (frequency = 18), and *memory and knowledge* (frequency = 16) were also expressed by some parents in this study. The results indicate that, in addition to affective perceptions, the parents considered the AR book as beneficial for children's cognition attainment. Relatively speaking, the parents exhibited fewer perceptions of *playfulness and entertainment* (frequency = 6) and *guiding* (frequency = 5), probably due to the fact that the AR book was not integrated with a gamified mechanism or instructional guidance. In addition to the positive perceptions of UX, some parents expressed negative attitudes toward the AR book. Among the negative perceptions, the





**Fig. 2** Radar chart of the parents' perceptions of UX

feelings about interrupting book reading due to the usage of the AR technology were frequently expressed (*distracting*, frequency = 12) by the parents. On the other hand, the parents held relatively fewer perceptions of dislike for children's usage of electronic devices (*antipathy*, frequency = 6). To sum up, with regard to the UX of the AR book reading in this study, the parents expressed more emotional perceptions (e.g., *sense of reality* and *novelty*) than cognitive (e.g., *awareness* and *memory and knowledge*) and negative (e.g., *distracting* and *antipathy*) perceptions.

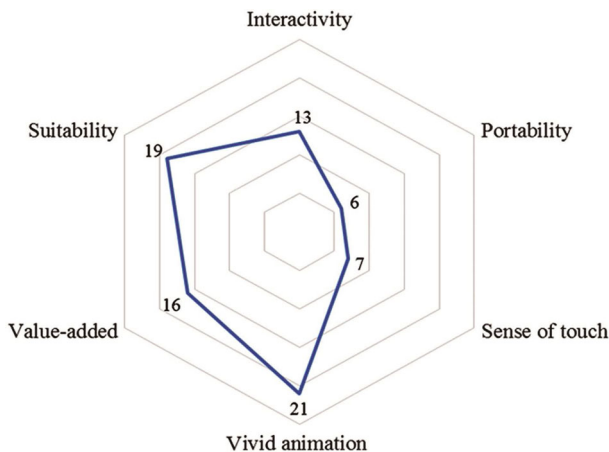
## Expectations of UX

In addition to understanding the parents' perceptions of UX, their UX of the AR book reading from the perspective of expectations were explored. The results from the phenomenographic analysis show that there were six categories of expected UX generated. Table 2 presents the description and examples of the parents' interview responses for the categories.

As with the quantitative content analysis of perceptions of UX, the parents' responses to the expected UX were coded according to the six categories of expectations. Similar to the parents' exhibited perceptions, they also expressed multiple expectations and therefore overlapped among the various categories. Through a series of quantitative content analysis, a total of 82 coded expectations were yielded from the parents' interview data by the trained research assistants. A radar chart (Fig. 3) was then illustrated to present the distribution of the parents' coded expectations of UX with regard to AR book reading in the six categories. Figure 3 presents that the frequency in the categories of *vivid animation* (frequency = 21), *value-added* (frequency = 16), and *suitability* (frequency = 19) were higher than the frequency in the other three categories. The results indicate that, with regard to using AR books in the future, the parents may possess more content-oriented expectations than function-oriented expectations. That is, compared with the expectations of more interactive operation (*interactivity*), slimmer mobile devices to read with (*portability*), or even a sense of touch to feel the contents (*sense of touch*), the parents in this study preferred that AR books should include more vivid animation regarding the book

**Table 2** The category of the parents' expectations of UX

Category	Description	Example
1. Interactivity	Expecting AR books to include more interesting designs for users to interact with the virtual elements or information (e.g., using gestures to manipulate the augmented 3D objects)	"...I expected to experience in more interaction with the objects overlapped upon the paper book. For example, when I click on it, more action or information will show on..."
2. Portability	Expecting to read AR books with more slight and portable devices (e.g., wearing an AR glass or holding a lighter mobile device with larger screen) for an ease of control	"...It will be cool if we can see the AR information through wearable devices, such as high-tech glasses or something..."
3. Sense of touch	Expecting the AR technology to provide a sense of touch (e.g., actual feelings of touch stainless steel) for users when reading AR books	"...It might be an imagination running wild that I can have physical sense of touch when I tried to touch the augmented objects. For example, when touching the engraving work, a sense of touching wood will come up to me..."
4. Vivid animation	Expecting AR books to include more vivid animation regarding the book story to fulfill the content of the virtual information within the AR book	"...When I saw the 3D artistic work upon the paper book, my expectation is that the 3D objects will present more vivid animation corresponding to the content of narration..."
5. Value-added	Expecting AR books to integrate value-added learning materials into the paper book (e.g., a craft of cutting paper for increasing the children's impression of the artistic work)	"...It would be great if more value-added learning materials were included in the paper book. For example, I suggested to include a craft of cutting paper in the picture book for children to practice after the reading activity..."
6. Suitability	Expecting the content of AR books to draw on their children's interests or needs (e.g., interesting topics, life-relevant materials, or abstract knowledge)	"...My child was not interested in the art topics. I expected that more scientific or biological materials could be designed for the topics of AR books in the future..."

**Fig. 3** Radar chart of the parents' expectations of UX



content (*vivid animation*), integrate value-added learning materials into the paper book (*value-added*), or develop more content relevant to children (*suitability*).

### The relationships between perceptions of UX and intention to use

As mentioned previously, the parents held multiple perceptions of UX, and these perceptions overlapped among the various categories. The analysis of qualitative associations between the parents' perceptions of UX and their intention to use AR books in the future cannot be implemented unless their main perceptions are identified. Therefore, in this study, we firstly classified these categories into three dimensions. Specifically, the categories of *sense of reality*, *novelty*, and *playfulness and entertainment* were classified into the emotional dimension; the categories of *awareness*, *memory and knowledge*, and *guiding* were classified into the cognitive dimension; while the categories of *distracting* and *antipathy* were classified into the negative dimension. Subsequently, all of the parents' responses were examined again by the trained research assistants in this study to determine what the major perception of each parent was based on the key idea which appeared with the highest frequency in the three dimensions. As a result, there were 25 parents' responses coded into the emotional dimension, 10 parents' responses coded into the cognitive dimension, and 12 parents' responses coded into the negative dimension. To further understand the relationships between perceptions of UX and intention to use, the quantitative data of the parents' intention to use should be converted to a nominal scale. Accordingly, the parents' mean scores in the scale of *intention to use* (mean = 3.63) were utilized as the threshold value to classify their scores into bipolar categories (i.e., weak and strong). Hence, the qualitative relationships between perceptions of UX and intention to use can be analyzed by cross-tabulation analysis.

As shown in Table 3, the qualitative relationships between the parents' perceptions of UX and their behavioral intention reach a significant level ( $\chi^2 = 6.80, p < .05$ ). That is, the parents who held stronger emotional or cognitive perceptions may be inclined to continue using AR books. Notably, the results in Table 3 present that negative perceptions of UX such as distracting reading by AR technology or feeling antipathy toward electronic devices may not facilitate the parents' willingness to use AR books in the future.

### The relationships between expectations of UX and intention to use

As with the analysis of the parents' perceptions of UX, the categories of their expectations were firstly classified into two dimensions. That is, while the categories of *interactivity*,

**Table 3** The cross-tabulation of the parents' perceptions of UX and intention to use

	Intention to use		Total
	Weak	Strong	
Perceptions of UX			
Emotional	11	14	25
Cognitive	2	8	10
Negative	9	3	12
Total	22	25	47

$$\chi^2 = 6.80^*, p < .05^*$$

*portability*, and *sense of touch* were classified into the function-oriented dimension, the categories of *vivid animation*, *value-added*, and *suitability* were classified into the content-oriented dimension. Then, the trained research assistants in this study examined all the parents' responses and discussed them to determine what the major expectation of each parent was based on the key idea which appeared with the highest frequency in the two dimensions. Accordingly, while 20 parents' responses were classified into the function-oriented dimension, 27 parents' responses were classified into the content-oriented dimension. After converting the quantitative data of the parents' behavioral intention to a nominal scale, the results of the cross-tabulation analysis in Table 4 show that there were significant relationships between the parents' expectations of UX and intention to use ( $\chi^2 = 7.52$ ,  $p < .01$ ). To be more specific, the parents expecting to enhance content-oriented materials in AR books (e.g., providing more vivid animation to fulfill the content of the augmented information, including value-added learning materials such as paper cutting craftwork for increasing children's attention, or developing more life-relevant content of AR books in accordance with children's needs or interests) tended to show strong intention to use them in the future. On the other hand, according to the parents' expectations, the enhancement of functions of AR books (e.g., including more interactive mechanisms, using smaller media devices, or even providing a sense of touch for users when reading AR books) may not be helpful for increasing their behavioral intention for adopting AR books in the future.

## Discussion and conclusion

Parents play an important role in students' informal learning with information technology; however, there is a lack of relevant research, particularly with regard to parents' opinions on students' learning by emerging communication technology such as AR (Cascales et al. 2013; Cheng 2017). This study was therefore conducted in an initial attempt to explore parents' UX of reading an AR book with their children from the perspectives of perceptions, expectations, and intentions. The diverse categorical UX generated in this study can further be the basis to create metrics for measuring actual UX. In addition to illustrating parents' contextual feelings of reading in AR environments from a holistic viewpoint, the findings of this study were anticipated to provide more insights for the development and popularization of AR book systems in the field of informal education.

The parents in this study not only expressed emotional perceptions (e.g., *sense of reality* and *novelty*) and cognitive perceptions (e.g., *awareness* and *memory and knowledge*) of UX, but also exhibited negative perceptions of UX (e.g., *distracting* and *antipathy*). Moreover, the results of this study showed the evidence that the parents' emotional and

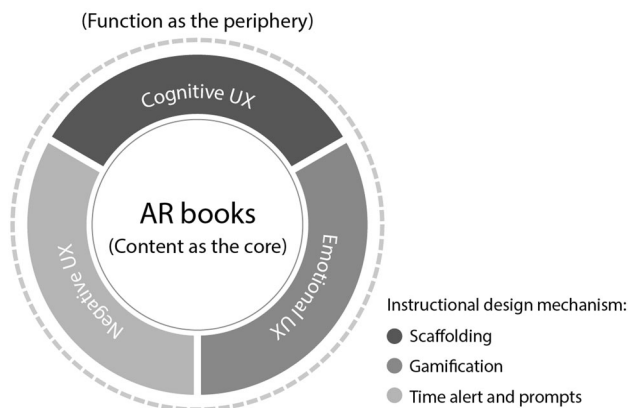
**Table 4** The cross-tabulation of the parents' expectations of UX and intention to use

	Intention to use		
	Weak	Strong	Total
Expectations of UX			
Function	14	6	20
Content	8	19	27
Total	22	25	47

$$\chi^2 = 7.52^{**}, p < .01^{**}$$

cognitive perceptions of UX may relate to their intention to adopt AR books for their children in the future. On the contrary, the negative perceptions of UX may decrease their willingness to use AR books. The findings may provide implications for the development of AR books applied in informal learning contexts; that is, instructional designers can consider highlighting the characteristics of AR books which can enhance learners' emotional and cognitive perceived UX. Notably, parents' negative perceptions of UX including the feeling that AR interrupts book reading and antipathy toward electronic device usage should also be paid attention to. With regard to the parents' expectations, they possessed both function-oriented and content-oriented expectations of UX. In this study, the parents generally expressed more content-oriented than function-oriented expectations. It was also found that, rather than the function-oriented expectations, the content-oriented expectations were associated with the parents' inclination to adopt AR books for their children in the future. The results may encourage instructional designers of AR books to emphasize the development of book content beyond the focus on fancy functions.

Based on the abovementioned findings, this study further proposed the guidance for the development of AR books from the perspective of UX. As shown in Fig. 4, users' content-oriented expectations of UX are the core of the development issues that should be noticed. Due to the fact that the significance of users' content-oriented expectations was highlighted, the developers are suggested to firstly focus on satisfying users' content-oriented expectations of UX. For example, developing more suitable content of AR books to meet students' needs or interests, designing vivid animation for representing book content, and integrating value-added materials into paper books for students to learn in more depth could be considered. Secondly, the developers should pay attention to the perceptions of UX from users' emotional, cognitive, and negative aspects. It is noted that, in this study, the parents' perceptions including *playfulness and entertainment* (emotional dimension) and *guiding* (cognitive dimension) were relatively weak. These results may imply the possibility of integrating a gamified mechanism for fostering learners' perceived playfulness or of incorporating scaffolding methods for facilitating reading guidance. In order to respond to the parents' negative perceptions of UX (e.g., *distracting and antipathy*) which probably diminish their intention to adopt AR books in the future, it is suggested that adding a 'reading time alert' function to remind readers to rest for a while during the process of reading AR books might be helpful for dispelling the concerns of technology



**Fig. 4** A framework for guiding the development of AR books

antipathy. Providing more prompts by AR book systems for redirecting readers' attention back to the book content could eliminate the perceptions of obstructing reading by AR technology. The periphery of Fig. 4 represents the developers' consideration with regard to users' function-oriented expectations of UX. The parents expected AR books to integrate more functions to provide readers with rich interaction for experiencing the augmented information. Some of them anticipated reading AR books with more ease of control, and even imagined experiencing actual feelings of touching the virtual objects. Reading AR books with recently developed wearable devices (e.g., AR glasses) may help meet the expectations of portability. In spite of that, meeting the needs of function-oriented expectations should not be the priority when engaging in developing AR books.

With regard to future work, quantitative measurement of parents' UX of AR book reading could be considered. Although some of the parents' UX in this study were identified as emotional perceptions (e.g., playfulness and entertainment), their emotional responses to the usage of the AR book were not explored in more detail. Accordingly, it is suggested that emotion evaluation tools could be utilized for capturing and interpreting users' emotions in the future. For example, users' emotional responses can be examined by physiological response measurements such as heart rate variability testing or the detection of the electrical activity of muscles in order to reveal the progressive emotional variation during the process of AR book reading. When finishing AR book reading activities, users can respond to self-reported instruments to represent their emotional states. In addition, some of the parents subjectively perceived that the AR book may interrupt reading. Including the measurement of eye movement in future studies could provide objective research evidence to verify the learners' UX of reading distraction posed by AR books.

In conclusion, the characteristics of the parents' perceived and expected UX found in this study can be the basis for the practical design of AR books in the future. With greater consideration of parents' UX, the acceptance of adopting AR books for their children to learn may be increased, and the industry of learning by AR might be boosted when parents possess more positive attitudes toward it. Moreover, reading by AR technology could enhance the interaction between parents and their children and further foster informal learning.

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## Compliance with ethical standards

**Conflict of interest** The author declares that he have no conflict of interest.

**Ethical approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed consent** Informed consent was obtained from all individual participants included in the study.

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