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Exploring Parents' Conceptions of Augmented Reality Learning and Approaches to Learning by Augmented Reality With Their Children

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Abstract

With the increasing attention to the role of parents in children's learning, what issues parents consider and how they behave when learning with their children when confronted with the emerging augmented reality (AR) technology may be worth exploring. This study was therefore conducted to qualitatively understand parents' conceptions of AR learning and approaches to learning by AR with their children. A total of 90 pairs of parents and children were invited to participate in an AR book reading activity held in 2015; all of the parents were then interviewed to acquire the research data. Through the phenomenographic method, this study generated several categories of the parents' conceptions of and approaches to AR learning. Further analysis identified the relationships between parents' conceptions and approaches. For example, the parents holding cohesive conceptions (e.g., learning by AR as attaining in-depth understanding) tended to use deep approaches (e.g., offering guidance to connect life experiences with the book content for thorough reading). Based on the findings, a framework of interactive AR book systems for child–parent shared reading is proposed. This study was expected to initiate research in the area of learning by AR in informal learning environments.

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Introduction

In addition to emphasizing what individual learners attain and how they learn, the role of parents in their children's learning with information technology is a notable issue worth exploring. Research has addressed that parents' continuing firm perceptions of and support for learning with information technology could be beneficial for extending student learning from classrooms to home environments (Kong & Li, 2009). A possibility of changing parents' attitudes toward science and technology clubs (after-school clubs) for facilitating students' creative learning was also highlighted in a previous study (Hong, Chen, & Hwang, 2013). Although parents generally expressed less confidence in helping their children to learn with technology, they exhibited positive attitudes toward their children's Internet-based learning (Anastasiades, Vitalaki, & Gertzakis, 2008), educational programmable bricks learning (Feng, Lin, & Liu, 2011), or game-based learning (Bourgonjon, Valcke, Soetaert, Wever, & Schellens, 2011). As far as further engaging parents in their children's learning, it was found that children who wrote programs with their parents performed better than those who worked alone (Lin & Liu, 2012).

With regard to the prospective technology applied in education, it might be important for researchers to endeavor to understand parents' beliefs about how the new technology is currently affecting their children. Augmented reality (AR) is a technique which can blend virtual information with the physical world in real time, further creating a brand new learning experience (Wu, Lee, Chang, & Liang, 2013). With its ability of conveying situational information beyond traditional learning contexts, recent studies have examined the effectiveness of AR applications in terms of students' learning in various educational fields, such as science learning (Chen & Wang, 2015), engineering learning (Gavish et al., 2015), mathematics learning (Lin, Chen, & Chang, 2015), medical learning (Ferrer-Torregrosa, Torralba, Jimenez, Garcia, & Barcia, 2015), or history learning (Chang, Hou, Pan, Sung, & Chang, 2015). Research evidence also indicates that learners tend to possess positive attitudes toward AR-related learning (Bressler & Bodzin, 2013; Lin et al., 2015; Wojciechowski & Cellary, 2013). As there has been little research on children's learning with their parents in AR environments (Cheng & Tsai, 2014; Tscholl & Lindgren, 2016), the investigation of parents' beliefs (e.g., conceptions) about AR learning for their children is still limited. Since parents play an important role in extending children's e-learning from the classroom to the home environment, an understanding of

parents' conceptions of AR learning might be helpful for the implementation of AR learning at home. Moreover, several studies have verified that people's conceptions of learning may guide their approaches to learning (e.g., Chen, 2015; Ellis, 2014). Students' and teachers' conceptions of and approaches to learning have been measured in the past; however, a limited number of studies have examined the same issues with parents as the subjects. This study was therefore conducted in an attempt to explore parents' conceptions of and approaches to learning with their children, especially in the context of AR learning. Based on the understandings of what parents consider AR learning to be and how they learn with their children in AR settings, researchers, educators, or even learning material developers could get more ideas for promoting learning by AR in informal learning environments. Accordingly, this study aimed to answer the following research questions:

1. What are parents' conceptions of AR learning and approaches to learning by AR with their children?
2. What are the associations between parents' conceptions of and approaches to AR learning?
3. What suggestions for supporting AR learning in informal learning environments can be provided?

Features of AR in This Study

In the field of educational research, increasing efforts have been made to explore how prospective technology applications could support learning or teaching. For example, AR is a notable technology for pedagogical use. Differing from virtual reality (VR), which immerses users in a computer-generated environment, AR technology provides users with a mixed vision, combining the physical world and virtual information in real time. Generally, AR can be classified into two types, image-based AR and location-based AR (Cheng & Tsai, 2013). Location-based AR identifies the user's position by way of a wireless network or global positioning system and accordingly offers virtual information blended with and presented over the physical environment they see. The recent popular mobile game *Pokémon GO* developed by Niantic is a typical example of location-based AR. In contrast, image-based AR uses graphics recognition techniques to detect plane images in the physical world and then provides users with synthetic information or elements overlapping the plane images. AR books, similar to an enhanced version of a traditional three-dimensional (3D) pop-up paper book which can overlap augmented information on the printed pages (Abas & Zaman, 2011; Ramli & Zaman, 2011; Tomi & Rambli, 2013), are a typical image-based AR application. Some studies have investigated how AR books can benefit students, such as by fostering motivation (Ferrer-Torregrosa et al., 2015) or

enhancing performance (Vate-U-Lan, 2012). Due to the fact that AR books could be easily adopted by parents and further used for parent–child shared reading in home environments, this study selected AR books as the learning materials for understanding what parents consider AR learning is and how they learn with their children by AR.

Parents' Views on AR Learning

Despite the increasing work on AR learning issues, research on explorations of parents' views on AR learning is still relatively scarce. In 2013, Cascalesa, Pérez-Lópezb, and Contero explored parents' acceptance of AR technology applied for preschool education. The parents in Cascalesa et al.'s study (2013) considered that the integration of AR into preschoolers' learning could facilitate motivation, creativity, and a degree of satisfaction. According to the parents, the application of AR technology was also positively correlated with their children's learning outcomes such as improvements in reading and writing skills. Similar to the findings of parents' attitudes toward students learning with information technology in previous studies (e.g., Anastasiades et al., 2008; Feng et al., 2011), the parents perceived several benefits in using AR for preschoolers' learning as well. However, the parents' responses in Cascalesa et al.'s study (2013) were not based on their personal experiences of using AR. In this study, we considered that parents may think differently about the role of AR in education when they themselves have personal experiences of AR learning, particularly experiences of engaging in AR learning together with their children.

In a recent study (Cheng & Tsai, 2016), the researchers invited children and parents to read an AR book. They then further examined the parents' conceptions of AR learning. It was found that the parents considered learning by AR as enhancing impressions, fostering motivation, and attaining in-depth understanding. In addition to these positive beliefs, some of the parents negatively perceived learning by AR as obstructing reading or as a substitute for parents. These results indicate that parents do not always hold positive perceptions of learning with technology. When parents participate in the AR learning process, they may perceive a relatively wider spectrum of conceptions of AR learning (Cheng & Tsai, 2016) than just expressing acceptance of the use of AR in their children's learning (Cascalesa et al., 2013). Hence, this study considered that the exploration of parents' conceptions of AR learning could reflect their sophisticated beliefs about the technology applied in education. The limited research to date has preliminarily probed parents' conceptions of AR learning with a small sample size (Cheng & Tsai, 2016). To enhance the applications of AR technology for home education, in this study, we attempted to examine parents' conceptions of AR learning with a large sample size and further generate more constructive categories of parents' conceptions of AR learning.

Conceptions of Learning

To understand learners' beliefs about the nature of learning, several studies have explored the issue through the examination of their conceptions of learning (e.g., Marton, Dall'Alba & Beaty, 1993; Tsai, 2004). An individual's description of what learning purposes and processes are can be defined as his or her conceptions of learning (Benson & Lor, 1999). These conceptions can be deemed as the reflection of the individual's learning experiences. Early research found that students' conceptions of learning can be hierarchically classified into five different categories, namely (a) an increase in knowledge, (b) memorizing, (c) the acquisition of knowledge for retention or use in practice, (d) understanding, and (e) an interpretative process aimed at an understanding of reality (Saljo, 1979). Researchers took the findings of Saljo's studies (1979) a step further and probed students' conceptions of learning in various learning contexts or domains such as science learning (Tsai, 2004), language learning (Drewelow & Mitchell, 2015), history teaching (Voet & De Wever, 2016), and blended learning (Bliuc, Casey, Bachfischer, Goodyear, & Ellis, 2012). Although these studies found similar results regarding the categories of conceptions of learning in order, the conceptions presented in these studies included a variety of content; that is to say, an individual may possess different conceptions of learning in different learning contexts (Marshall, Summer, & Woolnough, 1999). As a result, exploring parents' conceptions of AR learning might facilitate understanding of their beliefs about learning with the aid of AR.

Approaches to Learning

In general, people's conceptions of learning may guide their approaches to learning, an argument which has been examined and verified by previous studies (e.g., Bliuc et al., 2012; Li, Liang, & Tsai, 2013). Approaches to learning refers to the strategies by which an individual processes his or her learning tasks (Biggs, 1994), and qualitative differences by individuals have been found (Marshall et al., 1999). For students' science learning, it was found that those students who possessed less advanced conceptions of science learning (e.g., learning science as memorizing, testing, or calculating) tend to apply surface-level approaches for achieving extrinsic goals of learning science with simple strategies (e.g., just memorizing the most important content that may achieve high scores in exams instead of understanding it). On the contrary, students holding more sophisticated conceptions of science learning (e.g., learning science as understanding and seeing in a new way) are inclined to adopt deep-level approaches for achieving intrinsic goals of learning science with advanced strategies (e.g., understanding the meaning of the contents in science textbooks and relating new materials to what they already know; Li et al., 2013). Similarly, with regard to teachers' conceptions of and approaches to blended

learning in vocational education, research has shown that those teachers who consider blended learning as student-centered learning (sophisticated conceptions) may be inclined to teach or design instruction which supports deep and meaningful student learning (deep-level approaches; Bliuc et al., 2012). Based on the literature mentioned earlier, it can be speculated that there may be certain associations between parents' conceptions of and approaches to learning with their children, especially in the context of AR learning.

The Purposes of This Study

In sum, the purposes of this study were to examine what parents consider AR learning to be through the lens of an individual's conceptions. Besides, how parents' conceptions of AR learning link to their approaches to learning with their children were explored as well. Subsequently, based on the findings of this study, suggestions for designing AR systems for parents and their children to learn together could be proposed. Also, the examination of AR learning from parents' perspectives may benefit the extension of learning by AR from the classroom to the home environment.

Method

Sample

The participants of this study included 90 pairs of parents and children in northern (45 pairs) and southern (45 pairs) Taiwan. They were recruited based on the purposive sampling method for possibly representing parents' perceptions of AR learning in different areas of Taiwan. The mean age of the parents was 39.31 years old ($SD = 3.92$), ranging from 31 to 50. Among these parents, 73 were females (81%) and 17 were males (19%). Regarding the educational background of the parents, there were 30 parents with a graduate level (33%), 47 with an undergraduate level (52%), and 13 with a high school level qualification (15%). The children's age ranged from 7 to 14 years, with an average of 10.03 ($SD = 1.63$). The proportion of the children's gender is almost equal, with 51% females and 49% males. All of them were primary school students. The parents in this study mostly responded that they were familiar with operating mobile devices such as smart phones or tablet personal computers (PCs), but not with using AR-related applications. The research data were gathered in 2015.

Data Collection

To understand the parents' interpretations of AR learning, the sample parents were individually interviewed by a trained research assistant for collecting the qualitative data. In this study, the parent interviews were conducted in Chinese,

and all the interviews were audio-recorded. Due to the fact that most of the parents did not have any AR learning experience, they were required to read an AR book with their children before the interview. The AR book adopted in this study aimed to introduce the artistic works of the artist YuYu Yang from Taiwan. The content of the paper book was in the form of storytelling with pictures. With the aid of AR technology, users can read more details about the artistic works. To be more specific, by focusing on the pictures of the paper book with the camera of a mobile device, the augmented information could be superimposed upon the physical book and presented in the form of interactive 3D objects or videos to describe the artistic works in the book (e.g., sculptures or engravings). Notably, the augmented information did not represent the story but provided scaffolding to help readers better understand or appreciate the artist's creative concepts. On average, each child–parent pair spent about 30 minutes reading the AR book. All of the parents were interviewed after the reading activity to reveal how they felt about learning with the aid of AR, and what strategies they perceived themselves as having used during the process of the AR book reading with their children. The interview questions for the parents are as follows:

- Conceptions of AR learning
  1. According to the reading experiences, please describe what *AR learning* is in your understanding.
  2. How would you introduce *AR learning* to your friends?
  3. Do you think the AR technology can benefit children's learning? Why?
- Approaches to AR learning
  1. What did you do during the process of the AR book reading with your child?
  2. Why did you apply these approaches or strategies in the reading activity?

Data Analysis

To analyze the qualitative data, the parent interviews were fully transcribed as verbatim text. Two researchers subsequently examined and analyzed the verbatim transcripts based on the phenomenographic method, which has been used in previous studies (e.g., Tsai, 2004). Within the interpretivist paradigm, phenomenography is a qualitative research approach used to investigate individuals' different understandings of reality in which people experience something or think about something. The method is focused on variations of experience rather than variations of individuals. It usually involves data collection of small and purposive samples of subjects through interviews. By sorting subjects' perceptions (from the interview data) into specific categories of experience, the phenomenographic method can form the underlying structure based on these categories and reveal probable conceptions of experience related to the

phenomenon (Åkerlind, 2005). Accordingly, this study considered phenomenographic analysis as an appropriate qualitative method to understand the phenomenon with regard to parents' perceptions of AR learning.

To analyze the parents' interview responses, first, the most important sentences in the verbatim transcripts were marked to extract the main ideas about parents' conceptions of and approaches to AR learning. The two researchers then summarized the similarities and differences between the parents' conceptions of AR learning, as well as approaches to AR learning, by comparing the main ideas. By examining the consistencies and differences across the interview data, different categories of conceptions of and approaches to AR learning can be qualitatively constructed. The researchers discussed and classified the parent interview data into the generated categories in agreement. Through the phenomenographic method, the parents' responses could be classified into hierarchical categories to depict their conceptions of and approaches to AR learning, and the qualitative relationships between the categories could be further identified by cross-tabulation analysis.

Results

The Categories of Parents' Conceptions of AR Learning

By analyzing the qualitative variations in the parents' interview data through the phenomenographic method, this study found several major categories of conceptions of AR learning as indicated by the parents. Specifically, the parents' conceptions of AR learning can be classified into eight hierarchical categories. That is, they considered AR learning as (a) increasing presence, (b) drawing attention, (c) fostering motivation, (d) extending content, (e) attaining in-depth understanding, (f) enhancing interaction, (g) obstructing reading, and (h) diminishing imagination. The descriptions of the parents' responses for the eight categories are presented as follows, from positive (1 to 6) to negative (7 to 8). Note that the positive categories of the parents' conceptions of AR learning are listed from the less advanced to the more sophisticated levels.

a. Increasing presence (called *presence*)

In this category, the parents considered learning by AR as being for the purpose of increasing presence. To be more specific, they think that AR technology can allow learners to read books from 3D aspects and therefore create the feelings of reality by AR. For example, some of the parents' responses are extracted below:

> *P11: My child could actually observe the artistic work from various aspects as he wanted. I think AR can provide the perceived reality for him to appreciate artistic works.*

P55: I think AR can offer opportunities of seeing artistic works for those people who can't visit art galleries.

b. Drawing attention (called *attention*)

Differing from learning with the aid of a computer, in this category, the parents thought that learning with new technology such as AR can attract their children's attention and can even help their children to remember what they have read in the AR book. For example, the parents stated that:

P29: In my opinion, reading the text in the book may be boring. Learning by AR can enhance the impressions of the content with those 3D virtual objects. It's appealing for children, and even for adults as well.
P68: Learning by AR with the 3D presentation is attractive for children. The way of learning is quite different from learning by using a mouse. AR learning can create more experiences of engagement. Also, children would understand the appearance of the artistic works better and remember them more easily.

c. Fostering motivation (called *motivation*)

The parents' responses classified into this category represented their interpretation that learning with the aid of AR can foster children's willingness to read. The children may have more motivation to explore the content of the book. For example, the parents responded that:

P16: We can be personally on the learning scene when reading with the aid of AR. The learning experience could induce our curiosity to go into the field to see the artistic works.
P60: Integrating AR technology into traditional reading experiences can overcome the boredom that children may perceive when reading paper books. I think that, with the aid of AR, it can push children to learn actively. At least, children are willing to open books to read.

d. Extending content (called *content*)

In this category, the parents' responses represented the consideration of AR learning as using technology to offer relevant knowledge while their children engaged in learning such as reading AR books. They perceived learning by AR as extending learning content. For example, the parents

stated that:

P14: I think that, in addition to the content of the book, there was complementary information provided by the smart device. If children's textbooks can be presented in this way, I think it would be better for their learning.
P57: I think the application of AR learning is good. Learning by AR can extend children's learning because the AR book system would provide much relevant information for them to read, just like somebody else is commenting on the book beside them.

e. Attaining in-depth understanding (called *understanding*)

According to the responses of the parents which were classified into this category, learning by AR was conceptualized as attaining more in-depth understanding of the learning materials. They thought that AR learning can provide opportunities for children to read the content of the paper book more carefully. Children could have thorough comprehension of the learning content. For example, the parents responded that:

P12: I found that AR technology could help my child to read the content and observe the pictures in the book carefully. Instead of turning over the pages quickly, the details of the book content could be noticed, as well as the story described in the book.
P39:Learning by AR can help us to understand the rationale of the artistic work. That is, with the aid of AR, we could know about why the artist created the work, what messages he wanted to transmit, and what techniques he used in the creation.

f. Enhancing interaction (called *interaction*)

In this category, the parents considered that AR technology could create interactive environments for learning. Specifically, in addition to the interaction between parents and their children, AR learning allows learners to interact with the learning materials and provides opportunities for learners to explore the learning content. For example, some of the parents' responses are extracted below:

P52: In the learning activity, I can either interact with my child or let her read the AR book herself. My child's exploration of the book can also be fostered with the aid of AR. I think that learning by AR can help children to gain more knowledge regarding the book.
P56: We can interact with each other in the process of the AR book reading. For example, I can instruct my child to view the work from several perspective angles or far and near distance. He can also operate the AR book by himself. In my opinion, the interaction resulting from AR learning could motivate children to learn.

g. Obstructing reading

In contrast to the positive conceptions of AR learning perceived by the parents, in this category, the parents were concerned that their children's attention was attracted by the AR technology rather than by the text in the paper book. Learning by AR may even interrupt their children's reading and further have a negative effect on their learning. For example, the parents stated that:

P13:I think AR learning is kind of a new way to learn; however, I am concerned about the situation that AR technology would obstruct children's reading.
P36:I found my child playing with the tablet PC for AR. Hence, I am worried about the situation that my child may pay less attention to book text reading.
P43:I think that children did not want to read the book in more detail; on the contrary, they concentrated on the tablet PC and were eager to explore what else to play on it.

h. Diminishing imagination

In this category, the parents considered that learning by AR may diminish children's imagination originating from traditional text reading. Learning by AR may have negative effects on children's reading because of the novelty of the technology. According to the parents' responses, the reality provided by AR also inhibited children's opportunities to think creatively. Some of the parents' responses are given below as examples:

P09:I don't think learning by AR is good for my child. Reading the text in the paper book can help children to understand the meaning of the content. Also, their imagination can be enhanced by reading.
P37:Reading paper books could help my child to develop a rich imagination. Seeing the real objects with the aid of AR may not be helpful for creative thinking.
P87:Books with too many fancy effects may not lead readers to read the books carefully. In my opinion, reading can cultivate children's imagination due to the presentation of the text and pictures in the books.

The Distributions of the Categories of Parents' Conceptions of AR Learning

To understand how the parents perceived AR learning, the interview data were analyzed by quantitative content analysis according to the eight categories generated earlier. The frequency and proportion of each category were then

Table 1. The Distributions of the Categories of Parents' Conceptions of Augmented Reality Learning.

Categories	Description	*n*	%
(1) Presence	Parents considered learning by AR as being for the purpose of increasing presence	17	19%
(2) Attention	Parents considered learning by AR can attract children's attention	15	17%
(3) Motivation	Parents considered learning by AR can foster children's willingness to read	9	10%
(4) Extending	Parents considered AR can offer relevant knowledge while children engaged in learning	14	15%
(5) Understanding	Parents considered learning by AR can attain thorough understanding of the learning materials.	17	19%
(6) Interaction	Parents considered AR technology can create interactive environments for learning (e.g., interaction between parents and children or interaction between learners and learning materials).	7	8%
(7) Obstructing reading	Parents considered learning by AR may even interrupt children's reading and further have a negative effect on their learning.	5	5%
(8) Diminishing imagination	Parents considered learning by AR may diminish children's imagination originating from traditional text reading.	6	7%

AR = augmented reality.

calculated. According to Table 1, in general, there were no specific conceptions of AR learning that predominated. It was found that 19% of the parents perceived learning by AR as creating presence for users ($n = 17$) and as attaining in-depth understanding of book content ($n = 17$). Meanwhile, 17% of the parents ($n = 15$) considered learning by AR as capturing users' attention because of its new technology features which differ from those of a traditional computer interface. Also, the conceptions regarding learning by AR as providing relevant knowledge for extending book content were held by a similar proportion of the parents ($n = 14$, 15%). With regard to the positive-oriented conceptions, relatively fewer parents perceived AR learning as fostering motivation ($n = 9$, 10%) and enhancing interaction ($n = 7$, 8%).

In addition, it should be noted that there were 11 parents who possessed negative-oriented conceptions of AR learning. They considered that learning by AR may have negative effects on learners' concentration on book reading ($n = 5$, 5%) and may diminish readers' imagination regarding the text because of the presence provided by AR ($n = 6$, 7%). A previous study indicated parents' acceptance of AR learning due to its benefits for children's motivation and creativity (Cascales et al., 2013). However, the findings were based on a situation in which the parents did not have actual personal experience of using AR for learning with their children. Taking this a step further, this study engaged parents in the AR learning context so as to understand their conceptions in more depth. In addition to positive conceptions, this study found that parents may have negative conceptions when confronting AR learning. Even though the frequency of the categories of negative conceptions was relatively low, the results may address the bottleneck of AR book reading at the present stage of AR learning development.

The Categories of Parents' Approaches to AR Learning

To understand what strategies the parents perceived themselves as using during the process of the AR book reading with their children, the phenomenographic method was adopted to analyze the parents' interview responses. The results show that there were six hierarchical categories of the parents' approaches to AR learning generated by the phenomenographic analysis. Specifically, the parents utilized approaches including (a) accompanying, (b) assisting, (c) instructing, (d) prompting, (e) guiding, and (f) discussing to read the AR book with their children. In the following, we present descriptions of the parents' responses for the six categories listed from surface to deep levels.

a. Accompanying

In this category, the parents responded that they accompanied their children to read the AR book without other strategies or interventions. Some of the parents' responses are extracted below as examples:

P06:My child likes to read by herself; therefore, I kept up with her. Sometimes she would wait for me if I read more slowly.
P32:I think I can't teach him anything. Hence, I would not intervene in his reading process and allow him to learn himself.

b. Assisting

According to the responses of the parents which were classified into this category, it was revealed that some acted as facilitators to assist their children

in holding the paper book, operating the mobile device, or narrating the content of the book. It should be noted that, in this category, the parents did not intervene in their children's reading. For example, some of the parents stated that:

P39:To see the augmented information quickly, I helped him to focus the paper book with the camera of the iPad. Sometimes, he may skip the pages with more text content; and I would help to narrate the content.
P47:I was worried that she may not hold the iPad stably; hence, I always held the iPad during the reading activity. When we turned to the pages with AR information, either she would control the paper book or I would operate the iPad to read the AR book. I think she kept her mind on the AR book reading activity.

c. Instructing

In this category, the parents acted as instructors to demonstrate how to operate the AR book system. Some of the parents tended to explain the content of the book. Despite the parents' instruction in this category, they still encouraged their children to read the AR book actively. For example, some of the parents responded that:

P31:I explained the content of the book for my child for instructing how the artistic work was made. He would read the AR information and compare it with what I said.
P87:Firstly, I would demonstrate how to read the AR book with the iPad, such as narrating the content of the book and operating the iPad to see the AR elements from different angles; then, he would read the book by himself.

d. Prompting

The parents responded that, in this category, they may provide prompts or hints to help their children pay attention to reading the AR book in detail. Also, some of the parents would propose questions to get their children to think about the content of the AR book. For example, some of the parents stated that:

P13:I usually reminded my child to notice the details in the book. For example, I would ask him to pay attention to the artistic work and further ask him questions about its appearance (e.g., size).
P36:When finishing a learning topic, I would ask questions about the augmented information for my child to think about. For example, what is engraving? How is it made? If my child cannot answer my questions, I would provide more hints for my child to get a better understanding.

e. Guiding

In the process of the AR book reading, the parents' responses in this category indicated that they guided their children to connect life experiences with the content of the book. From the parents' guidance, the children could read the AR book in more depth. For example, some of the parents responded that:

P11:I would guide him to see the pictures in the book; then, I also asked him some questions to connect with his life experiences.
P38:When he could not understand the augmented objects, I had to provide guidance to link what he had seen before. For example, I reminded him to recall Taroko Gorge when he observed the virtual artistic work in the AR book.

f. Discussing

In this category, the parents discussed the content of the AR book with their children during or after the reading activity. They considered that experience sharing would be helpful for facilitating their children's integration of and reflection on the content learned earlier. For example, some of the parents stated that:

P55:During the process of the AR book reading, I expected that my child could learn actively. Hence, I would not interfere in my child's learning. When we finished reading the AR book, I shared what I had seen previously with my child and discussed with him to facilitate reflection on and integration of the learning content.
P74:Actually, we enjoyed reading the AR book. During the reading activity, we discussed the book content together. In my opinion, this kind of interaction may help my child to remember our discourse or the content of the book.

The Distributions for the Categories of Parents' Approaches to AR Learning

Similar to the analysis of the parents' conceptions of AR learning, the interview data regarding approaches to AR learning were also analyzed and classified into the six categories by quantitative content analysis. The results in Table 2 show that the most common approach to AR learning used by the parents was *assisting*. Specifically, 30% of the parents ($n = 27$) acted as facilitators to help their children hold the paper book or operate the mobile device but did not interfere with their children's reading. The second highest frequency of the approaches which the parents applied were *accompanying* ($n = 16$, 18%) and *discussing*

Table 2. The Distributions of the Categories of Parents' Approaches to Augmented Reality Learning.

Categories	Description	*n*	%
(1) Accompanying	Parents accompanied their children to read the AR book without other strategies or interventions.	16	18%
(2) Assisting	Parents assisted their children in holding the paper book, operating the mobile device, or narrating the content of the book, but did not intervene in their children's reading.	27	30%
(3) Instructing	Parents demonstrated how to operate the AR book system or tended to explain the content of the book for the purpose of encouraging their children to learn actively.	10	11%
(4) Prompting	Parents provided prompts to help their children pay attention to reading the AR book in detail or proposed questions to get their children to think.	13	14%
(5) Guiding	Parents guided their children to connect life experiences with the content of the book for reading the AR book in more depth.	8	9%
(6) Discussing	Parents discussed the content of the AR book with their children during or after the reading activity for the purposes of facilitating their children's integration of and reflection on the content learned previously.	16	18%

AR = augmented reality.

($n = 16$, 18%). In the hierarchical categories, whereas the approach *accompanying* indicates the most surface-level strategy, the approach *discussing* represents the deep-level strategy. To some extent, these results may imply that the parents in this study did not show certain preferences for utilizing the surface-level or the deep-level strategies to read the AR book with their children. Compared with other approaches to AR learning by the parents, the approach *guiding* was not commonly applied ($n = 8$, 9%). This result may indicate that the parents in this study were not used to providing guidance for connecting life experience with book content when reading with their children, particularly in the AR learning context. For AR learning system designers, this finding might also raise practical implications regarding what mechanisms of reading guidance could be enhanced in the future.

The Relationships Between Parents' Conceptions of and Approaches to AR Learning

To explore the relationships between the parents' conceptions of AR learning and their approaches to learning by AR with their children, in this study, we classified the categories of conceptions and approaches into several major dimensions for further cross-tabulation analysis. Regarding the conceptions, past studies generally found hierarchical conceptions of learning by students and further classified them into two types, that is, cohesive and fragmented conceptions (e.g., Marton et al., 1993; Quinnell, May, & Peat, 2012). Whereas cohesive conceptions refer to more sophisticated thoughts about how knowledge is constructed, fragmented conceptions reflect less advanced thoughts about how knowledge is memorized. To a certain degree, the eight categories of conceptions of AR learning found in this study corresponded to previous studies. For instance, the conceptions of learning by AR as drawing attention to help learners memorize the learning content can be deemed as fragmented conceptions. The conceptions of learning by AR as enhancing interaction for offering opportunities to explore the learning content can be considered as cohesive conceptions. Differing from the positive-oriented conceptions found in previous studies, in the context of AR learning, in this study it was further found that the parents had negative-oriented conceptions such as obstructing reading. Accordingly, we classified the eight categories into three dimensions of conceptions of AR learning. To be more specific, learning by AR as increasing presence, drawing attention, and fostering motivation were classified into the dimension of fragmented conceptions, whereas learning by AR as extending content, attaining in-depth understanding, and enhancing interaction were classified into the dimension of cohesive conceptions. On the other hand, learning by AR as obstructing reading and diminishing imagination were classified into the dimension of negative conceptions.

In terms of approaches, several studies have examined students' approaches to learning via the two broad types of surface and deep approaches (e.g., Chin & Brown, 2000; Li et al., 2013). While surface approaches to learning usually refer to simple strategies such as memorizing fragmented knowledge, deep approaches refer to advanced strategies such as connecting prior knowledge with present learning content for attaining thorough understanding. In this study, the parents' approaches including accompanying their children and helping their children's reading with simple assistance with the operation of the device did not involve much intervention in the children's reading. Therefore, in this study, the approaches of accompanying and assisting were deemed as surface approaches. On the other hand, the approaches of instructing, prompting, guiding, and discussing involved more intervention by the parents with the aim of helping their children integrate their ideas and reflect on their learning process; accordingly, these four approaches were considered as deep approaches which the parents used to read the AR book with their children.

Table 3. The Relationships Between Parents' Conceptions and Approaches.

		Surface approaches	Deep approaches	Total
		(1) Accompanying (2) Assisting	(3) Instructing (4) Prompting (5) Guiding (6) Discussing	
Fragmented conceptions	(1) Presence (2) Attention (3) Motivation	27 (30%)	14 (16%)	41 (46%)
Cohesive conceptions	(4) Extending (5) Understanding (6) Interaction	13 (14%)	25 (28%)	38 (42%)
Negative conceptions	(7) Obstructing reading (8) Diminishing imagination	3 (3%)	8 (9%)	11 (12%)
Total		43 (48%)	47 (52%)	90 (100%)

Note. $\chi^2 = 10.03$, $p = .007$.

According to the cross-tabulation analysis in Table 3, the results of the chi-square analysis indicated significant associations between the parents' conceptions of and approaches to AR learning ($\chi^2 = 10.03$, $p < .01$). As shown in Table 3, the parents possessing fragmented conceptions tended to utilize surface approaches ($n = 27$, 30%) rather than deep approaches ($n = 14$, 16%) to reading the AR book with their children. That is, the parents who considered learning by AR as being for the purposes of creating presence or drawing attention were inclined to let their children read the AR book on their own, or provided a little help with the operation. On the other hand, for those parents who held cohesive conceptions, it was found that they tended to utilize deep approaches ($n = 25$, 28%) rather than surface approaches ($n = 13$, 14%) to reading the AR book with their children. These results indicate that the parents perceiving learning by AR as possibly extending learning content, attaining thorough understanding, or enhancing interaction had the tendency to engage more in the AR book reading process with their children. From the parents' perspective, the application of the strategies such as providing prompts to encourage the children to pay attention to reading the AR book in detail, or discussing the book content with their children during or after the reading activity may be beneficial for acquiring in-depth understanding of the book.

The aforementioned results found in the AR learning context correspond to previous studies which were situated in other learning contexts for indicating the

positive relationships between students' conceptions and approaches (Bliuc et al., 2012). In addition, it is also interesting to note that, for the parents who held negative conceptions of AR learning, they were inclined to use deep approaches ($n = 8$, 9%) rather than surface approaches ($n = 3$, 3%) to learning with their children. Although some parents in this study considered learning by AR as hindering children's reading or even diminishing their imagination regarding the content of the book, the negative conceptions were probably involved in more critical thinking rather than simple considerations of the limitations of AR book reading. The associations between negative conceptions and deep approaches such as instructing, prompting, guiding, and discussing were identified in this study, accordingly.

Discussion and Conclusion

The present study qualitatively explored parents' conceptions of AR learning and their approaches to learning by AR with their children through the phenomenographic method. Associations between the parents' conceptions of and approaches to AR learning were also found. Specifically, the parents possessing more sophisticated conceptions (e.g., learning by AR as attaining in-depth understanding) tended to utilize deep approaches (e.g., offering guidance to connect life experiences with the book content for thorough reading) to reading the AR book with their children, and vice versa. It is notable that the parents who held negative conceptions of AR learning (i.e., obstructing reading and diminishing imagination) were inclined to apply deep approaches to reading with their children. We speculated that the negative conceptions were involved in critical thinking and related to deep-level strategies. However, in the current stage, the parents' perceptions of the shortcomings of AR learning still need to be improved. The parents in this study stated that the possible reasons for interrupting the AR book reading were the operation of one hand for controlling the mobile device and the other for flipping the paper book. Another possible reason was the novelty effect which drew the children's attention to the mobile devices, distracting them from actually reading the book. As a result, it is suggested that wearable devices (e.g., AR glasses) might reduce the interference of the mobile devices (e.g., tablet PCs) in AR book reading. Reading AR books using wearable devices may create more intuitive user experiences and may also reduce users' attention to the hardware.

In addition, to enhance children's and parents' reading by AR technology, a mechanism for the design of child–parent shared AR books is also proposed. To be more specific, the deep approaches to AR learning including instructing, prompting, guiding, and discussing found in this study can be the basis of the mechanism. For each learning topic of the AR book, the proposed design would first provide hints regarding the operation of the AR book or the instruction of the book content to engage the readers in the activity of child–parent shared

book reading. Subsequently, the prompts with regard to the current learning topic and the guidance for connecting life experiences with the book content are offered. Finally, the AR book raises open-ended issues regarding the current learning topic for parents and their children to discuss with each other. Through the sequence of instructing → prompting → guiding → discussing (IPGD) strategies, the understanding of each learning topic could be enhanced by continuing the interaction between the children and parents.

Moreover, the parents in this study considered that learning by AR may diminish their children's imagination originating from traditional text reading. It is therefore further proposed that features of social sharing and learning process recording be integrated in the phase of discussing the IPGD strategies. That is, in addition to the supply of open-ended issues during the phase of discussing, the proposed mechanism also allows users to actively ask questions on the built-in social network to increase knowledge building. The features of learning process recording allow users to reexamine their reading process in the AR book system via the recorded discourse among users. This feature of the proposed mechanism might foster parents' and children's reflection on what they have learned, and integrate it with their prior knowledge. It is considered that the proposed mechanism of AR books with the IPGD strategies could lead parents who hold less advanced conceptions of AR learning to use more sophisticated approaches to learning with their children. The aforementioned framework is expected to be helpful for future studies regarding the design of AR books.

With the increasing attention to the role of parents in children's learning (e.g., Bourgonjon et al., 2011; Hong et al., 2013), this study further addressed what parents considered and how they behaved as learning with their children when confronted with the emerging AR technology. The findings of this study are also expected to initiate the research on learning by AR in informal learning environments. Moreover, several categories of conceptions of and approaches to AR learning were identified from the parents' perspectives. Similar to past studies (e.g., Li et al., 2013) situated in science learning contexts, it was found that, in the context of AR learning, the parents' conceptions of AR learning were also related to the approaches they used to read with their children. Notably, the purposive sampling conducted in this study may have resulted in potential limitations of uncontrolled background variables (e.g., parents' gender and education level). Also, involving child–parent pairs in the AR book reading activity for the first time may have engendered novelty effects of new technology usage. To eliminate these potential limitations, large scale quantitative research is suggested to reexamine the results of this study. Specifically, based on the generated categories of conceptions and approaches in this study, future work could verify the correlations between users' conceptions of and approaches to AR learning through quantitative measurements. The causal relationships

among conceptions, approaches, and learning outcomes could be further examined based on a structural model. It might be interesting to include other variables such as self-efficacy (Issaieva, 2016), motivation (Rabanaque & Martinez-Fernandez, 2009), or technology literacy (Hohlfeld, Ritzhaupt, & Barron, 2013) in the discussion of users' conceptions of and approaches to AR learning. In addition to the exploration of parent subjects, it is also suggested that future studies on AR learning examine other cohorts of research samples such as high school students, college students, or teachers.

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