CoboChild: a blended mobile game-based learning service for children in museum contexts

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Abstract

Purpose – The purpose of this paper is to develop a blended mobile game-based learning service called CoboChild Mobile Exploration Service (hereinafter CoboChild) to support children's learning in an environment blending virtual game worlds and a museum's physical space. The contextual model of learning (CML) was applied to consider the related influential factors affecting museum learning and to promote children's continuous learning and revisit motivations.

Design/methodology/approach – CoboChild provides a thematic game-based learning environment to facilitate children's interactions with exhibits and other visitors. A practical system has been implemented in the National Museum of Natural Science (NMNS), Taiwan. A questionnaire was used to examine whether CoboChild can effectively fulfill the CML and to evaluate the impacts on museum learning.

Findings – CoboChild effectively fulfilled the CML to facilitate children's interactive experiences and re-visit motivations in the blended mobile game-based learning environment. Most children described the system as providing fruitful playfulness while improving their interpretations of exhibitions and learning experiences.

Practical implications – CoboChild considers the related contextual influences on the effective support of children's learning in a museum, and builds a child-centered museum learning environment with highly integrated blended learning resources for children. CoboChild has been successfully operating in the NMNS since 2011.

Originality/value – This study developed a blended mobile game-based learning service to effectively support children's learning in museum contexts. The related issues are shown to improve the design of blended museum learning services. This innovative approach can be applied to the design of other child-centered services for engaging children's interactive experiences in museums.

Keywords Blended learning, Game-based learning, Mobile learning, Contextual model of learning, Child-centered design, Museum learning

Paper type Research paper

Introduction

Museum learning is an interactive informal learning process motivated by children's interest and fun in discovery through their physical explorations and social interactions in a free-choice learning context (Perry, 2012; Diamond *et al.*, 2009; Falk *et al.*, 2009; Scott, 2013). To facilitate meaningful museum learning experiences and revisit motivation, it is essential to consider the museum's contextual influences in supporting children's effective learning (Falk and Dierking, 2013). Among the museum learning theories, the Contextual Model of Learning (CML) is widely applied and recognized as the most important guideline for designing learner-centered museum services for diverse target visitors within museum contexts (Hou *et al.*, 2014). According to this model, museum learning experience is shaped through continuous interactions among personal,

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sociocultural, and physical contexts over time (Dierking, 2002; Falk and Dierking, 2000). The personal context explains individual differences, including: prior interest, experience, knowledge, learning preferences, and visit expectations; all of these significantly affect children's museum learning behavior and experiences, and thus play a key role in self-directed learning in museum contexts (Falk and Dierking, 2013). The sociocultural context explains that most children learn through their social interactions with others, including conversation and collaborative learning in museum contexts. The physical context describes the object-based learning qualities of museum learning (Speight *et al.*, 2012). Hence, museums should provide children with friendly and intelligent navigation tools to support children freely learning through their interactions with the museum exhibits (Falk and Storksdieck, 2005). Owing to the fact that museum learning is a lifelong learning process, Dierking (2002) later added a time factor to the CML, and highlighted that museum learning is an ongoing process and the result of continuous interactions among personal, sociocultural and physical contexts. Therefore, to promote long-term interactions between children and the museum, it is important to consider the whole contextual influence whereby children's continuous learning and revisiting can be promoted.

The above-mentioned studies show that there is a need for museums to design appropriate services to match children's diverse needs and preferences within museum contexts. More specifically, previous research explains that children of different ages in a variety of visitor groups present various behaviors during their visits (Talboys, 2012). To develop child-centered services for diverse children, many studies highlight that most children prefer highly interactive participation with the museum exhibits and other visitors during their time in the museum (Mayfield, 2005). Except for school field trips, children usually visit museums as part of informal family groups (Dockett *et al.*, 2011). An informal family group typically presents unstructured experiences motivated by their expectations of museum visits (Talboys, 2012). Previous research indicates that most of them are expected to share a joyful experience that would enhance their social relationships with others; therefore, both children and adults expect the museum visits to improve their social interactions and participatory experiences (Land and Zimmerman, 2015). To enhance children's engagements with exhibits, mobile technology has been widely used due to the popularity of mobile devices, such as smart phone, tablets, and wearable devices (Freeman *et al.*, 2016). Many museums have developed mobile applications, such as self-tour service and context-aware mobile guide services to provide multimedia information related to museum exhibits and to support children's self-regulated learning in museums (Chu *et al.*, 2008, 2010; Kanellopoulos, 2011; Lanir *et al.*, 2013; Hwang and Chang, 2015).

With the development of multimedia and communication technology, more and more interactive features are being used with mobile applications to better improve children's engagement in exhibits. For example, previous research found that augmented reality (AR) applications provide children with playful and immersive experiences to promote their learning motivation and their observation of exhibits (Chang *et al.*, 2014; Chiang *et al.*, 2014; Chang *et al.*, 2015; Lu *et al.*, 2014). Besides, many studies have reported that snap-photo service and social networking services encourage children to participate and share their personal experiences (Hussain, 2015; Vassilakaki and Garoufallou, 2014). Despite new interactive technology being increasingly applied in museum services, game-based learning (GBL) service is still one of the most popular interactive applications due to its fruitful interactions and playfulness (Beale, 2011; Chiou *et al.*, 2010; Sintoris *et al.*, 2010; Sedano *et al.*, 2012; Johnson *et al.*, 2015). Blended mobile game-based learning (BMGBL) is a further development in which the ubiquitous learning process involves interplay between the virtual learning space and the physical museum context (Avouris and Yiannoutsou, 2012; Berge and Muilenburg, 2013; Hwang and Chang, 2015). However, most of the previous

BMGBL only considered one or two influential factors in the museum context, which limited the positive effects of BMGBL in museum learning (Falk and Dierking, 2013; Hou *et al.*, 2014). More specifically, numerous studies have indicated that the lack of consideration of the influence of personal context makes it difficult to develop proper services matched to children's abilities; in turn, the difficulties of system manipulation and interpretation of museum exhibits negatively affect children's learning in museums (Gutwill and Allen, 2010; Reynolds *et al.*, 2010). Regarding the neglect of the influences of the sociocultural context, previous research has found that the use of BMGBL easily decreased children's interactions with other visitors and with the museum exhibits (Hou *et al.*, 2014). As a consequence, the limited interactions negatively affect the children's construction of knowledge derived from conversations, and the isolated experiences fail to satisfy their need for social interaction (Charitonos *et al.*, 2012). Regarding the neglect of physical context, isolated museum experiences also limit children's exploration and in-depth observation of museum exhibits (Falk and Dierking, 2013; Hou *et al.*, 2014). In other cases, the poor integration of BMGBL and the museum's physical resources negatively affect children's learning due to information overload (Huang *et al.*, 2012). Moreover, previous research has indicated that most of the previous BMGBL neglected the influence of the time factor, making it difficult to continuously improve children's motivations due to the gaps between museum visits, limiting the promotional effect of BMGBL for long-term museum learning and revisiting (Falk and Dierking, 2013; Keskin and Metcalf, 2011).

To overcome the above-mentioned limitations of the previous research, in this study we developed a BMGBL service named CoboChild Mobile Exploration Service (CoboChild) for children, with the aim of integrating the possible approaches to fully consider a museum's contextual influences in BMGBL. CoboChild was designed to fully fulfill the CML to promote children's learning perceptions and motivation in museum learning. A practical system was implemented to realize the service in a natural science museum. Both quantitative and qualitative analyses were performed to identify the support level of the CML and the BMGBL learning experiences. In this way, we expected to fully consider the related influential factors affecting museum learning and to develop a child-centered museum learning environment with highly integrated blended learning resources. By so doing, the service is expected to promote children's learning experiences and long-term interactions with the museum. In brief, this study aims to answer the following research questions:

RQ1. Does CoboChild fulfill the CML to facilitate children's interactive museum experience and re-visiting motivation?

RQ2. Do the children agree that CoboChild is helpful in museum learning?

Research method

The BMGBL approach to fulfilling the CML

In order to fully consider the related influential factors affecting children's museum experiences and to improve the BMGBL design, it is necessary to provide child-centered service with highly integrated blended interactive features and social interactions. In this vein, we propose a BMGBL service named the CoboChild Mobile Exploration Service (CoboChild) with a holistic view of a museum's contextual influences on children's experiences. The service is mainly designed for children in informal family groups in the National Museum of Natural Science (NMNS), which provides a BMGBL environment to facilitate their active participation and social interactions with the others. Considering that BMGBL involves interplay between the virtual and physical contexts, the realization of the CML required modification to a personal context, sociocultural context, blended virtual and physical context, and the time factor in this study. Figure 1 displays the CML realization design of CoboChild.

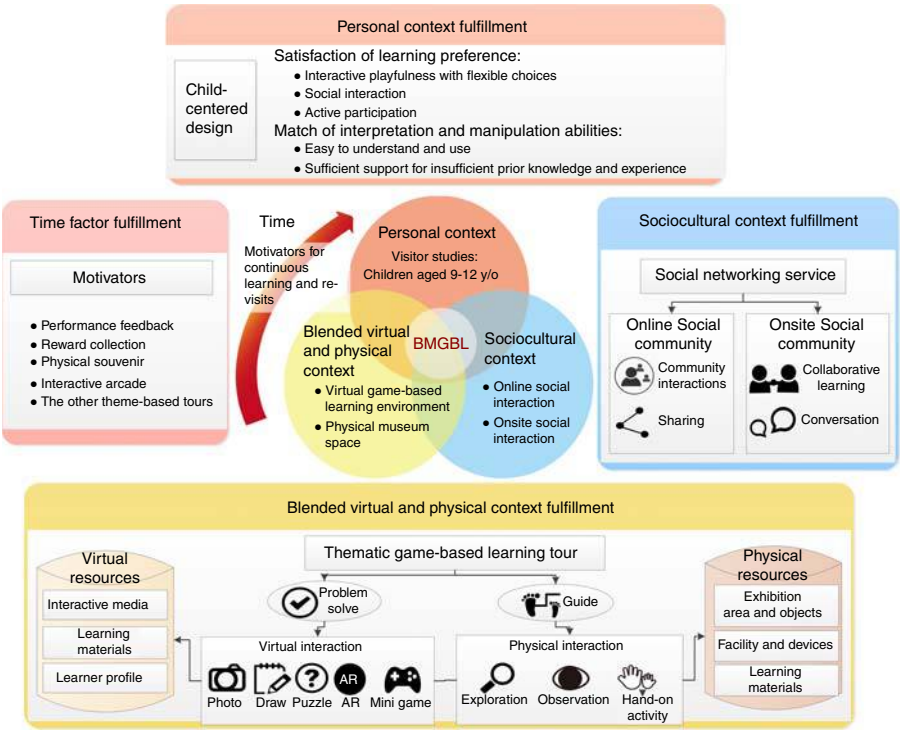

Figure 1.
The CML realization design of CoboChild

Regarding the realization of the personal context, the target users were defined as children aged from nine to twelve years old due to their independent mobile device manipulation ability. Considering each child has different preferences, CoboChild provides various thematic GBL tours and social networking services to support children in choosing a preferred theme and exploring the different parts of the exhibition. The tours were designed based on the exhibition areas, and not only on the playful tour guide function, but also to facilitate the children's engagements and interactions with others. Each tour includes various types of GBL quests with flexible choices for children to freely explore and interact with the exhibits, such as puzzles, drawing, and AR applications. The learning contents and quest design were examined by educational experts to ensure that they matched the children's abilities.

Regarding the realization of the sociocultural context, the social networking services include GBL quests to promote children's social interactions. Considering that BMGBL involves interplay between the virtual and physical contexts, CoboChild improved both the online and onsite social interactions through problem-solving and online sharing activities (Sung *et al.*, 2010; Scott, 2013). The children were encouraged to communicate and collaborate with others to complete the quest. The social networking services provided children with different ways to share their personal experiences with others. The children were free to share and discuss their learning outcomes from the quests, such as with drawings or photos to Facebook. Besides, the service also provided an online social community for the children to share, view, and respond to the others' shared outcomes.

Regarding the realization of the blended virtual and physical context, the museum's physical and virtual resources, which included exhibition areas and objects, learning

devices and facilities, interactive media, as well as digital and real learning materials, were integrated into the thematic GBL tours to support the children's learning. Various GBL quests were designed to promote the children's engagements. For example, photo and drawing gameplay was able to promote the children's in-depth observation of the exhibits, while puzzles and mini games were used to facilitate their exploration, reading of the exhibition descriptions, and experience in the hands-on activities. Besides, the AR quests were designed with interactive functions so that the children can interact with the AR objects, such as closely observing the exhibits or learning more related information. The children were able to take a photo with the AR objects by the screen-grasp function of the AR quest. The children could correct their answers during the gaming process, and they were given different virtual rewards according to their learning performance in the quests.

Regarding the realization of the time factor, CoboChild provided fruitful playfulness and positive feedback to motivate the children's continuous learning and revisiting. The perceived playfulness of the problem-solving game quest satisfied their intrinsic need for fun, and enhanced their motivation for continuous learning (Ryan *et al.*, 2006). In addition, positive feedback, including clear feedback on their quest performance, virtual rewards and physical souvenir collections, was provided to strengthen their motivations for long-term learning and revisiting (Ronimus *et al.*, 2014). Also, CoboChild provides an interactive arcade for children to create individual contents with their collected virtual exhibits and photos; they can share their creations with their friends by e-mail or with Facebook's sharing function. To continuously motivate children to learn and re-visit, thematic game-based learning tours were occasionally provided between museum visits to enhance the children's revisit intention (Keskin and Metcalf, 2011). In this way, a sustainable child-centered museum learning environment with highly integrated BMGBL resources and social interactions was achieved to motivate the children's learning and revisits.

The CoboChild system design

To implement the CoboChild service, a child-centered BMGBL system was used in the NMNS in Taiwan. Figure 2 shows the system framework of CoboChild; it presents a three-layer system framework to fulfill the CML. The top layer provides the user interface of CoboChild, which enables children to interact with the contextual learning services. Currently, the system provides four thematic GBL tours for children to explore in the Life Science Hall, Human Cultures Hall, Micro World Exhibition, and Life on Earth Exhibition. The middle layer shows the contextual learning services, which includes four learning service modules to effectively fulfill each influential factor of the CML. The personal context module provides a child-centered BMGBL environment for each child. Each child's learning behaviors are recorded in the learner management library. The children can access the services and review their learning portfolios and individual contents. The sociocultural context module includes the social networking service and souvenir picture service, which enable children to share their drawings and photos via their mobile device or interactive arcades. The blended virtual and physical context module includes the thematic GBL service and physical exhibition exploration service. The former provides a series of thematic GBL quests for the children, while the latter provides an exhibition area, exhibits, facilities, devices, and related learning materials to support their observations and exploration in the museum. The time factor module includes the quest performance service, virtual reward service, and souvenir exchange service. The quest performance service records and presents the children's performance in each quest. The virtual reward service enables children to collect virtual exhibits and souvenir points; the children can exchange their preferred souvenirs by using the souvenir exchange service. In addition, they can create individual content with their collected virtual exhibits, and share their souvenir pictures with others via the interactive arcade.

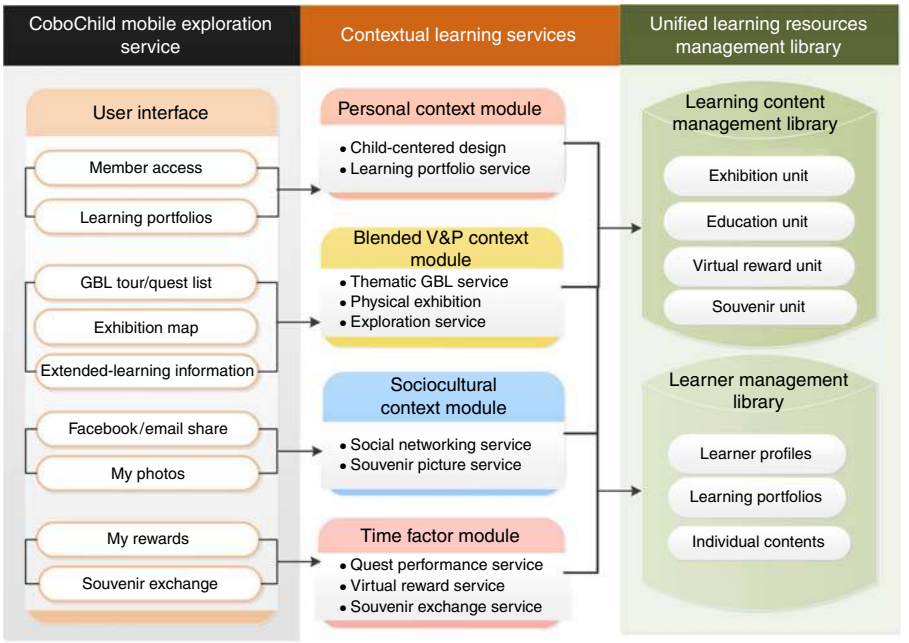

Figure 2.
The system framework of the CoboChild mobile exploration service

The bottom is the unified learning resources management library; it includes the learning content management library and the learner management library to manage the learning resources and each learner's individual learning information, respectively, for the entire learning process. The highly integrated virtual and physical resources are managed in the learning content management library based on a thematic construction structure for each thematic GBL tour. The library comprises the exhibition unit, education unit, virtual reward unit, and souvenir unit. The learner management library comprises learner profiles, learning portfolios, and their individual contents.

Experiment design

Participants

To examine whether CoboChild effectives fulfills the CML, an experiment was conducted to evaluate the children's perceptions of CoboChild. A total of 66 children (35 boys and 31 girls) aged from nine to twelve years old participated in this study (Mean = 11.08, SD = 0.791). Three elementary classes were randomly selected to experience CoboChild during a museum excursion, and to learn about the Micro World exhibition on display at the NMNS in Taiwan. The three classes included a fourth grade class (10 boys and 8 girls), a fifth grade class (14 boys and 11 girls), and a sixth grade class (11 boys and 12 girls).

Experimental procedure and learning scenario

To provide high quality visits, each class was scheduled for the museum excursion on different days. The children were provided with the same learning scenario as the one provided to the informal family groups while using CoboChild in their visits. Figure 3 displays the experiment procedure. The learning activity was conducted in the Micro World exhibition at the NMNS. At the beginning of the experiment, a ten-minute introduction was given to explain the procedure for using CoboChild. After the children

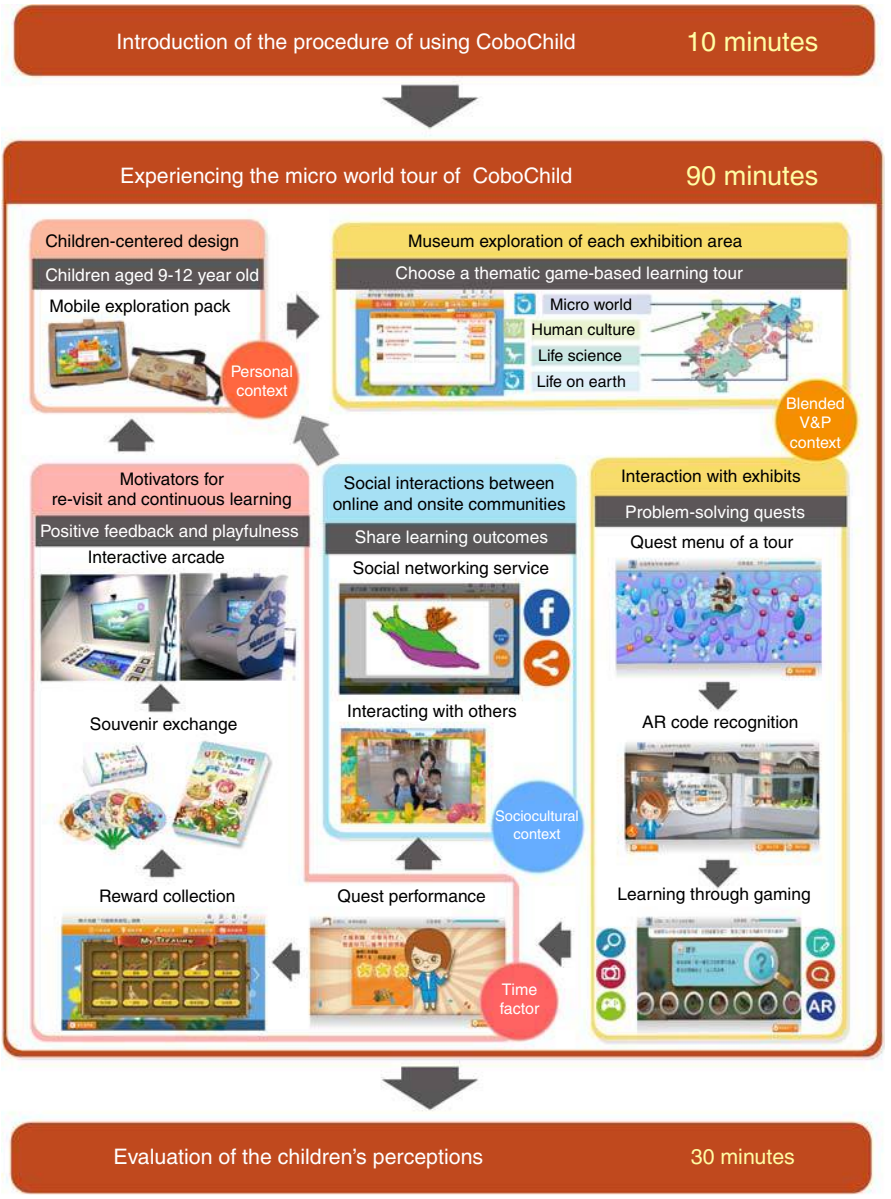

Figure 3.
The experimental procedure of the CoboChild mobile exploration service

logged into the BMGBL system, they were asked to choose the Micro World tour by using the GBL tour list function. The Micro World tour includes 18 different types of GBL quests; they guide children to explore and learn about the Micro World exhibition. Each quest is linked to an AR code; after the introduction prior to the quest, the children can start their quests and learn about the museum exhibits through the AR code recognition. Besides, they can also repeat their preferred quests to improve their performance and to collect virtual rewards.

At the beginning of a tour, an AR quest is designed to engage children in the world of micro creatures. The children were then guided to observe the various creatures and learn about the related knowledge through problem solving and hands-on activities, such as drawing their quests, puzzles, and mini games. Figure 4 displays the interfaces of a GBL quest. Children were asked to observe and find the matching exhibits to solve the puzzles. In order to find the matching exhibits, they had to explore and read the exhibition descriptions to find related clues. After they answered all of the puzzles, they were able to collect virtual rewards, the different suits in this case, and take selfies with their collected suits.

Each child's drawings and photos from each quest were recorded in the learner management library. The children can view and select their individual contents, and share their preferred works with the online community, including Facebook, by using the social networking service (Figure 5). After they finished all of the quests, they could exchange their collected souvenir points for physical souvenirs. The children could also interact with their collected virtual exhibits and take a souvenir picture with the others in an interactive arcade and share those pictures with others (Figure 5). At the end of the tour, 30 minutes were provided for the children to fill out the learning feedback questionnaire in the Classroom Theater near the exhibition. The total time for this experiment was around 130 minutes.

Figure 4.
The interface design of the fourth quest of Micro World tour

Figure 5.
The interface design of the social networking services in CoboChild

Measurements

To answer the research questions in evaluating children's perceptions of the realization of CML and the CoboChild design in museum learning, both quantitative and qualitative approaches were used to collect children's subjective feedback on CoboChild. A learning feedback questionnaire was used to evaluate the children's perceptions of CoboChild after they experienced CoboChild (Cronbach's $\alpha = 0.89$). There were two sections to evaluate: the support levels of the CML and the children's evaluations of CoboChild design in museum learning. The support levels of the CML included 25 assessment questions using a five-point Likert scale from 1, "strongly disagree" to 5, "strongly agree." The questions were designed based on the CML theory, and are shown in Table I. In particular, the personal context

CML fulfillment	Mean	SD	*t*
Personal context	3.79	0.57	4.09***
1. The pre-quest introduction helps me to better understand the knowledge of the exhibits for each quest	4.03	0.84	5.13***
2. The quests are too difficult to finish. (reverse question)	2.82	1.16	−4.77***
3. I have sufficient abilities to finish all of the quests	3.95	1.00	3.70***
4. CoboChild is able to create individualized museum experiences for me	4.06	0.93	4.92***
5. The learning content is easy to understand	3.64	1.08	1.03
6. The manipulation of CoboChild is intuitive and easy to learn	3.45	1.07	−0.35
7. In general, I like learning with CoboChild in the museum	4.18	0.91	6.09***
Sociocultural context	3.81	0.62	4.11***
8. I prefer to finish the quests with my friends and family together	4.08	0.950	4.925***
9. CoboChild encourages me to interact and discuss with others in the museum	4.11	0.825	5.967***
10. Learning with CoboChild decreases my interactions and conversations with others in the museum. (reverse question)	2.59	1.457	−5.070***
11. I am able to meet more friends by using the social networking services with CoboChild	3.73	1.103	1.674
12. I like to use the social networking service so that I can share my experiences with my friends	3.80	1.011	2.435*
13. The social networking service supports me to enhance my relationships and interactions with others through sharing and discussion	3.76	1.024	2.044*
Blended virtual and physical contexts	3.83	0.60	4.46***
14. The various kinds of gameplay can improve the playfulness in museum learning	4.05	0.935	4.738***
15. I know the goal of each quest to finish the quests	3.67	0.934	1.450
16. I know the learning goal of each quest to learn the thematic knowledge of the exhibits	3.80	0.769	3.201**
17. I know my learning performance and rewards of each quest	4.05	0.935	4.738***
18. The virtual rewards improve my exploration in museums to get more rewards	4.05	0.919	4.823***
19. CoboChild improves the attention to the exhibits in the museum	4.00	0.961	4.228***
20. CoboChild guides me to observe the exhibits and find more details	4.05	0.983	4.506***
21. CoboChild encouraged me to explore and discover the knowledge of the exhibits	4.06	0.892	5.104***
22. I seldom read the exhibition descriptions and observe the exhibits when I learn with CoboChild. (reverse question)	3.26	1.232	−1.599
Time factor	4.03	0.80	5.33***
23. I would like to revisit and experience the other thematic learning tours with CoboChild	4.08	0.917	5.10***
24. I would like to learn more related knowledge of exhibits after learning with CoboChild	4.05	0.885	5.01***
25. I would like to learn the prior thematic knowledge before my next visit to have better learning performance with CoboChild	3.95	0.999	3.70***

Notes: $N = 66$. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Table I.
The one sample *t*-test result of the fulfillments of CML

(Cronbach's $\alpha = 0.65$) included seven questions to examine whether the service can satisfy children's learning preferences and provide proper learning quests matching their interpretation abilities and manipulation skills. The sociocultural context included six questions (Cronbach's $\alpha = 0.78$) to assess children's perceptions of online and onsite social interactions. The blended virtual and physical context (Cronbach's $\alpha = 0.81$) consisted of nine questions to evaluate children's perceptions of the virtual interaction design and physical interactions. The last part, the time factor (Cronbach's $\alpha = 0.82$), involved three questions to evaluate the children's learning and revisit motivations to promote long-term museum learning experiences after their visits, i.e. the continuous learning motivation after onsite visits, the pre-visit learning motivation before revisiting, and their revisit motivation to experience the other thematic GBL tours after their visit. For each category, a reverse question was designed to ensure that the students were not guided to respond in a particular direction. The Cronbach's α value of each category is from 0.65 to 0.82, which shows the reliability of the questionnaire.

Regarding the children's evaluation of the CoboChild design in museum learning, three open-ended questions were used to collect more detailed feedback from the children. They were asked whether CoboChild is helpful in regard to museum learning, and to explain their reasons. They were also asked to describe their satisfaction with, and preferences, regarding the service design, such as the specific functions or gameplay design. The following questions were asked:

(1) What is your most favorite and most disliked design of CoboChild? Why?

(2) Are you satisfied or unsatisfied with CoboChild? Why?

(3) Do you think CoboChild is helpful in museum learning? Why or why not?

Data analysis

The children's responses to the questionnaire were collected and filtered before the data analysis stage. The Predictive Analytics Suite Workstation 18.0.0 (PASW Statistics) was used for the statistical analysis. To evaluate whether CoboChild fulfilled the CML to enhance children's interactive experiences, a one-sample t-test was applied with a test value of 3.5 as the agreement level. The significance level was $\alpha = 0.05$ for each statistical analysis. Besides, children's subjective feedback on the first and second open-ended questions was used to explain the quantitative results. To evaluate whether CoboChild is helpfulin museum learning, the children's subjective feedback on the third open-ended question was encoded and analyzed using Grounded Theory. The experiment results are presented in the following section.

Experimental results

The fulfillment of the CML

Table I displays the one-sample t-test results which evaluate the support level of the CML. As shown in Table I, most children had positive feedback on the CML realization design ($p < 0.001$). Regarding the realization of personal context, the children agreed that the CoboChild satisfied their preferences (Mean = 4.18, $p < 0.01$). Besides, learning with CoboChild was able to create individualized museum experiences (Mean = 4.06, $p < 0.01$). In the qualitative results of the children's feedback, a sixth-grade girl explained that the diverse quests design of CoboChild brought her an interesting and playful museum learning experience. Another fourth-grade girl stated that she liked CoboChild very much because CoboChild enabled her to learn through playing. The children's feedback showed that the GBL quest design highly satisfied their learning preference for playful interactions. Besides, most children believed they have sufficient ability to finish the quests, which showed that CoboChild

matches the target children's interpretation abilities and manipulation skills (Mean = 3.95, $p < 0.01$). The aforesaid results show that CoboChild fulfilled the personal context matching the children's abilities and preferences. However, there is no significant difference in the evaluation of the ease of understanding and use ($p < 0.01$). Some children explained they encountered internet ($N = 1$) or system problems ($N = 13$), such as internet disconnection and irregular logout. Many children ($N = 16$) stated that they repeated the quest many times to achieve the quest's requirements. The children's feedback showed that the unstable system and quest difficulty may influence the children's perceptions of the ease of understanding and use.

Regarding the realization of the sociocultural context, most children agreed that CoboChild can enhance their on-site and online social interactions ($p < 0.001$). Most children prefer to finish the quests with their friends; they help each other to finish the quests together. A sixth grade girl explained that CoboChild enabled her to learn, and to explore the exhibition with her friends, which made museum learning more interesting. Another fifth grade boy stated that he enjoyed finishing the quests together with his friends. The results showed that CoboChild encouraged children's conversations and social interactions with each other. Regarding the online social interaction, many children ($N = 15$) appreciated that CoboChild enabled them to share their experiences with their friends and family by using the social networking service. However, a few children ($N = 3$) worried that their account information might be hacked while using the social networking services with a public tablet; the lack of confidence in keeping their account secure limited their online social interactions.

Regarding the realization of blended virtual and physical contexts, the children highly appreciated the playful interactive design of CoboChild ($p < 0.001$). The various types of GBL quests effectively encouraged them to actively participate in learning. A fourth grade boy described learning with CoboChild as being like "an adventure in a museum." Figure 5 shows the children's learning activities with CoboChild. As shown in Plate 1, the children actively participated in the learning activities with their peers. The different GBL quests engaged them in active interactions with the exhibits, such as hands-on activities, observations, and reading of the exhibit's descriptions. Despite CoboChild providing fruitful

Plate 1.
Children participating in museum learning with CoboChild

playfulness to encourage children to observe the exhibits and explore the exhibition area, the children complained that some quests were too difficult to achieve the requirements, which brought them negative perceptions in repeating the quests. More specifically, many children prefer to compete with other children. To finish the quests as fast as possible, they tend to skip the introduction prior to the quest, so they did not learn the required knowledge to achieve the quest's requirements. The results showed the need to provide more hints during the quest, and the importance to prevent children from skipping important information and failing to finish the quest.

Regarding the realization of the time factor in promoting children's motivation, most children showed their willingness for continuous learning and revisiting after experiencing the CoboChild ($p < 0.001$). Learning with a tablet, which is very different from the traditional field trip, brings the children a fresh new experience. The engaged joyful experiences make a deeper impression of museum excursion. Hence, the positive experiences highly motivated children in regard to continuous learning and revisiting. Besides, they were motivated to build on their prior knowledge of the other themes before experiencing further CoboChild tours. Thus, in answer to the first research question, CoboChild can effectively fulfill the CML to facilitate interactive museum learning experiences and revisit motivation.

The children's evaluation of CoboChild in museum learning

Regarding the second research question which examines whether CoboChild is helpful in museum learning, Table II demonstrates the qualitative results of the children's evaluation of CoboChild design in museum learning. As shown in Table II, most children ($N = 48$) highly appreciated the fact that CoboChild has a positive effect on museum learning. Many ($N = 16$) described that the fruitful GBL quests significantly improved the playfulness of the museum learning, which reduced their learning stress ($N = 3$). The playful interactions motivated children to actively engage in the learning activities ($N = 3$). Besides, CoboChild integrated fruitful learning resources to support their learning ($N = 6$), such as GBL quests, animations, and videos. Therefore, many children believed CoboChild helps to enhance learning the thematic knowledge of exhibits due to the improved motivations and fruitful learning materials ($N = 10$). Moreover, the participatory experiences with joy significantly improved their impression of the museum visit ($N = 5$). In spite of the advantages of CoboChild, some children ($N = 12$) were not sure whether it improved their learning, while a few ($N = 6$) did not feel that CoboChild is helpful in museum learning. This may be due to the fact that CoboChild has both strengths and weaknesses which affect learning. Despite CoboChild's advantages in improving the playfulness and social interactions in museum

Table II.
The qualitative results of the children's perceptions in using CoboChild

Perceptions	Evaluation of learning perceptions
Positive ($N = 48$)	Improved playfulness ($N = 16$)
	Reduced learning stress ($N = 3$)
	Improved motivation ($N = 3$)
	Support learning effectively ($N = 10$)
	Improved impression ($N = 5$)
	Fruitful and new learning resources ($N = 6$)
	I don't know ($N = 5$)
Negative ($N = 6$)	Museum is impossible to be replaced. Cobochild has its limitations ($N = 2$)
	May focus on playing and ignore learning with exhibits ($N = 1$)
	No significant perceived improvements ($N = 1$)
	I don't know ($N = 2$)
Neutral ($N = 12$)	I don't know ($N = 12$)

Note: $N = 66$

learning, children described some issues in the CoboChild design which negatively influenced their perceptions. More specifically, many children ($N = 16$) stated that they had difficulties to achieve the quest's requirements. The children explained they spent too much time in repeating at a quest, which irritated them a lot. Moreover, some children ($N = 14$) encountered internet or system problems, such as disconnected internet and irregular logging out. The frustrations in dealing with the system issues negatively influenced their learning with CoboChild. The results also indicated the need to improve the system's stability and internet roaming issues to improve the quality of CoboChild service. Moreover, a few children found some limitations in CoboChild ($N = 2$). A sixth-grade girl explained that children with insufficient skills in manipulation may hardly learn well with CoboChild, one of its limitations in improving museum learning. Another sixth-grade girl indicated that some children may focus on their competition to finish the quests and ignore learning. The children's feedback showed that most children agreed that CoboChild is helpful in museum learning; however, there is a need to improve the system issues and support children in their manipulations.

Discussions

In brief, the above-mentioned results demonstrate that CoboChild can effectively support the CML to create interactive museum experiences and promote children's motivation. CoboChild not only provides proper services matching children's abilities to support their learning in the museum, but also provides a flexible learning environment with a diverse gameplay design to satisfy different children's learning preferences. The thematic learning activities and social networking services promote the children's active participation and social interactions. Moreover, the diverse gameplay design enhances the playfulness of museum learning, which in turn satisfies the children's intrinsic need for fun in order to motivate their learning (Ryan *et al.*, 2006; Hung *et al.*, 2014; Sintoris *et al.*, 2010). Therefore, the improved engagement is helpful to enhance the personal connections with museum exhibits and others, thereby creating a meaningful museum experience and strengthening children's positive perceptions and motivation in museum learning (Simon, 2010; Dockett *et al.*, 2011; Shih *et al.*, 2011; Yiannoutsou and Avouris, 2012).

The aforementioned results show that BMGBL is a suitable approach for promoting museum learning for children. Most children were satisfied with the CoboChild design and believe that CoboChild is helpful to support their learning in museums. However, the internet problems and unstable system negatively affect children's perceptions. Many young children do not have sufficient ability to deal with the encountered system problems by themselves; therefore, the system problems may negatively influence the results of the ease of manipulation. Similarly, Chu (2014) reported that young children or children from remote areas usually have less prior experiences in using mobile devices. Previous research indicates that children with insufficient prior experience in using mobile devices may encounter more difficulties in their manipulations, which negatively affects their perceptions and motivation (Russell-Rose and Tate, 2013; Hsu *et al.*, 2016). The results indicate that the use of digital technology only has a positive effect with the appropriate design to avoid the negative manipulation effects (Bowen *et al.*, 2008). Besides, there is a need to support children in their manipulations to minimalize the negative effects of system issues.

Another issue is the application of social media in improving social interactions. From the results of this study, many children enjoy sharing their experiences by using social media; this supports the previous research findings that the application of social media can improve children's perceptions and social interactions with others (Drotner and Schrøder, 2013; Russo *et al.*, 2008; Scott, 2013). However, a few children worry about the account security issues and are demotivated to use the social networking services. This may due to

the reason that the children with less prior experiences of using social media may have lower motivation and self-efficacy in sharing their experiences by social media (Lee and Ma, 2012). On the other hand, we found that many children prefer to share their experiences with social networking services. However, they have less awareness to protect their account security in using the social networking service. For example, they did not log out after using the social networking services, and in turn, the others could easily get their personal information. The aforesaid issues show the need to improve children's awareness of the risks in using social media, and to avoid the potential risks in using social networking services with public devices. Currently, more and more museums have launched mobile apps that offer self-tour services for the visitors (Johnson *et al.*, 2015). By using the visitor's own devices, it is helpful to avoid the related issues in using public devices.

Regarding the fulfillment of the time factor in promoting children's motivations to continue learning and re-visiting, previous research indicates that the post-visit social interactions play a key role in repetitive visits (Charitonos *et al.*, 2012). Therefore, many museums apply social media to enhance the connections between the public and museums, and to promote the post-visit social interaction engagements in museum communities (Simon, 2010). The aforementioned results show that CoboChild has the potential to promote children's repetitive visits by using the social networking services. Moreover, CoboChild provides the souvenir exchange service to promote children's repetitive use of CoboChild and collect the souvenir points for physical souvenirs. However, attempting to continually provide updated learning resources and attractive physical souvenirs for children is a challenge for museums in regard to financial funding and multi-disciplinary collaborations. To deal with this issue, there is a need to develop a well-designed enterprise business model for long-term museum management. Three issues are considered to develop a sustainable enterprise business model for CoboChild. Firstly, previous research indicates the importance of museum branding to promote the values of museums for long-term museum management (Scott, 2013). To build the museum brand, there is a need to provide unique services to match the target visitors' needs. Moreover, it is important to continually provide high-quality learning contents so that the visitors can repeatedly use the service and re-visit. Considering that museum learning is an ongoing process from pre-visit, and on-site visit to post-visit stages, we are endeavoring to extend CoboChild to a theme-based BMGBL service before, during and after children's visits. In this way, CoboChild can support children's constructing the prior-knowledge of exhibitions before they visit, and the museum can actively motivate children to re-visit after their visits by providing post-visit services, such as recommendation service and community learning service. By so doing, we expect to build a virtuous museum learning environment and retain our loyal customers.

The second issue is to develop a self-sufficient model for long-term operation, for example, to provide related products and paid services for museum members (Wallace, 2016). Cooperating with local schools, industries and government also brings benefits for museums for long-term museum management, i.e. financial support or development support for establishing new services and learning contents. Last but not least, there is a need to construct a reliable, unified, and scalable content management system. In this way, it is possible to continually extend the contents and services for the visitors, and the model can be successfully implemented and sustained in museums.

Conclusions and future work

In this study, a BMGBL service named CoboChild was developed for children aged nine- to twelve-years old; it considered the influential factors of a museum context to develop a sustainable BMGBL environment for children. Regarding the first research question, most of the children agreed that CoboChild can facilitate their interactive experiences and re-visit motivation through fruitful thematic game-based learning tours and social interactions,

which highly satisfied the children's preference for interactive playfulness. Besides, CoboChild provided fruitful motivators, including interactive playfulness and positive feedback, which show the potential to improve children's long-term learning and revisiting. In fact, CoboChild has been widely appreciated by numerous young visitors since 2011, with approximately 1,200 children revisiting the museum and continuously using the service every year. Regarding the second research question, most of the children agreed that CoboChild significantly enhanced the playfulness and interpretation of the museum exhibitions, which motivated their active engagement in museums, so CoboChild is clearly helpful in museum learning.

In brief, in this study we developed a benchmark project to fully consider the interactions among all the key factors in a museum context, effectively fulfilling the CML to promote children actively engaging in museum learning. The results show the BMGBL approach is a potential way to effectively motivate children's continuous learning and revisiting. Considering the positive effects of the BMGBL approach, it has the potential to be applied in the development of future services for different target groups, such as the students of higher education and general public groups. By doing so, museums can provide adaptive learning services to effectively support diverse visitors' learning in museum contexts.

This study contributes to both game-based learning and the museum management communities. With respect to the game-based learning community, the results highlight the need to provide children with a flexible learning environment with proper support and fruitful gameplay designs to enhance their museum learning experiences. In terms of the museum management community, a BMGBL environment with playful interactions for children was developed in this study, which effectively supports the CML and improves the design of the BMGBL. The improved engagements and social interactions have the potential to motivate children's long-term learning and revisiting. CoboChild provides a new learning model which enables children's learning with blended learning resources between the physical and virtual museums.

Despite the study providing fruitful results for BMGBL applications in a museum context, there are some limitations in this study. Firstly, this study was a short-term study. Hence, there is a need to conduct long-term studies to examine the time influence on promoting the effect of CoboChild. Because of the schedule issues and the school's expectations in using BMGBL rather than a traditional field trip, there was no control group in the experimental design. Regarding the second question, there are limited perceptions by which to evaluate the effects of CoboChild on museum learning. More specifically, children may have difficulties in explaining their ideas due to the limited understandings of museum learning. Hence, the detailed information regarding museum learning can be provided to support children better evaluating the effects of CoboChild on museum learning. As well, the learning performance of CoboChild is still undefined. To evaluate whether CoboChild is better than the traditional museum learning method, comparisons regarding children's learning perceptions and performance can be considered in future studies. Moreover, there is a need to investigate the evaluations by the teachers and museum staffs to better define the effects on museum learning.

This study also raised some issues to be considered in future studies. Regarding the realization of a personal context, a personalized approach with flexible choices was adopted in CoboChild to satisfy the children's diverse learning preferences. However, considering individual differences in learning preferences and needs, customized services can be developed in future studies to better support the diverse range of children's learning in museums.

Regarding the realization of a sociocultural context, the use of social media shows a positive effect in promoting online social interaction. However, to provide children with a

safe environment with the social networking services, there is a need to improve children's awareness of security protection in using public tablets. In addition, collaborative or competitive learning quests, can be developed to better enhance the on-site social interactions among children in future developments.

Regarding the realization of blended virtual and physical context, there is a need to provide the children who have less prior experience with sufficient manipulation support. Besides, the internet and system problems should be solved to avoid the negative effects in children's perceptions.

Regarding the realization of the time factor, it is important to develop a well-designed enterprise business model in regard to the sustainable development of museum services for long-term museum management. Membership marketing is highlighted to provide unique services matched to their specific needs. Besides, there is a need to integrate the online pre-visit and post-visit services with the onsite BMGBL service to effectively promote a virtuous cycle and long-term museum learning experience.

References

Avouris, N.M. and Yiannoutsou, N. (2012), "A review of mobile location-based games for learning across physical and virtual spaces", *Journal of Universal Computer Science*, Vol. 18 No. 15, pp. 2120-2142.

Beale, K. (2011), *Museums at Play: Games Interaction and Learning*, Museums etc., Edinburgh.

Berge, Z.L. and Muilenburg, L. (2013), *Handbook of Mobile Learning*, Routledge, New York, NY.

Bowen, J., Bradburne, J., Burch, A., Dierking, L., Falk, J., Fantoni, S.F., Gammon, B., Giusti, E., Gottlieb, H. and Hsi, S. (2008), "Digital technologies and the museum experience: handheld guides and other media", Altamira Press, New York, NY.

Chang, K.E., Chang, C.T., Hou, H.T., Sung, Y.T., Chao, H.L. and Lee, C.M. (2014), "Development and behavioral pattern analysis of a mobile guide system with augmented reality for painting appreciation instruction in an art museum", *Computers & Education*, Vol. 71, pp. 185-197.

Chang, Y.L., Hou, H.T., Pan, C.Y., Sung, Y.T. and Chang, K.E. (2015), "Apply an augmented reality in a mobile guidance to increase sense of place for heritage places", *Educational Technology and Society*, Vol. 18 No. 2, pp. 166-178.

Charitonos, K., Blake, C., Scanlon, E. and Jones, A. (2012), "Museum learning via social and mobile technologies: (How) can online interactions enhance the visitor experience?", *British Journal of Educational Technology*, Vol. 43 No. 5, pp. 802-819.

Chiang, T.H., Yang, S.J. and Hwang, G.J. (2014), "An augmented reality-based mobile learning system to improve students' learning achievements and motivations in natural science inquiry activities", *Journal of Educational Technology and Society*, Vol. 17 No. 4, pp. 352-365.

Chiou, C.K., Tseng, J.C., Hwang, G.J. and Heller, S. (2010), "An adaptive navigation support system for conducting context-aware ubiquitous learning in museums", *Computers and Education*, Vol. 55 No. 2, pp. 834-845.

Chu, H.C. (2014), "Potential negative effects of mobile learning on students' learning achievement and cognitive load – a format assessment perspective", *Journal of Educational Technology & Society*, Vol. 17 No. 1, pp. 332-344.

Chu, H.C., Hwang, G.J. and Tseng, J.C. (2010), "An innovative approach for developing and employing electronic libraries to support context-aware ubiquitous learning", *The Electronic Library*, Vol. 28 No. 6, pp. 873-890.

Chu, H.C., Hwang, G.J., Huang, S.X. and Wu, T.T. (2008), "A knowledge engineering approach to developing e-libraries for mobile learning", *The Electronic Library*, Vol. 26 No. 3, pp. 303-317.

Diamond, J., Luke, J.J. and Uttal, D.H. (2009), *Practical Evaluation Guide: Tools for Museums and Other Educational Settings*, 2nd ed., Rowman & Littlefield, Altamira and Plymouth.

Dierking, L.D. (2002), "The role of context in children's learning from objects and experiences", in Paris, S.G. (Ed.), *Perspective on Object-Centered Learning in Museums*, Lawrence Erlbaum Associates, Mahawah, NY, pp. 3-18.

Dockett, S., Main, S. and Kelly, L. (2011), "Consulting young children: experiences from a museum", *Visitor Studies*, Vol. 14 No. 1, pp. 13-33.

Drotner, K. and Schrøder, K.C. (2013), *Museum Communication and Social Media: The Connected Museum*, Routledge, New York, NY.

Falk, J. and Storksdieck, M. (2005), "Using the contextual model of learning to understand visitor learning from a science center exhibition", *Science Education*, Vol. 89 No. 5, pp. 744-778.

Falk, J.H. and Dierking, L.D. (2000), *Learning from Museums: Visitor Experiences and the Making of Meaning*, AltaMira Press, Walnut Creek.

Falk, J.H. and Dierking, L.D. (2013), *The Museum Experience Revisited*, Left Coast Press, Walnut Creek.

Falk, J.H., Heimlich, J.E. and Foutz, S. (2009), *Free-Choice Learning and the Environment*, AltaMira Press, Plymouth.

Freeman, A., Adams Becker, S., Cummins, M., McKelroy, E., Giesinger, C. and Yuhnke, B. (2016), *NMC Horizon Report: 2016 Museum Edition*, The New Media Consortium, Austin, TX.

Gutwill, J.P. and Allen, S. (2010), "Facilitating family group inquiry at science museum exhibits", *Science Education*, Vol. 94 No. 4, pp. 710-742.

Hou, H.T., Wu, S.Y., Lin, P.C., Sung, Y.T., Lin, J.W. and Chang, K.E. (2014), "A blended mobile learning environment for museum learning", *Journal of Educational Technology and Society*, Vol. 17 No. 2, pp. 207-218.

Hsu, T.-Y., Kuo, F.-R., Liang, H.-Y., Lee and M.-F. (2016), "A curriculum-based virtual and physical mobile learning model for elementary schools in museums", *The Electronic Library*, Vol. 34 No. 6, pp. 997-1012.

Huang, Y.M., Liu, C.H., Lee, C.Y. and Huang, Y.M. (2012), "Designing a personalized guide recommendation system to mitigate information overload in museum learning", *Educational Technology and Society*, Vol. 15 No. 4, pp. 150-166.

Hung, C.M., Huang, I. and Hwang, G.J. (2014), "Effects of digital game-based learning on students' self-efficacy, motivation, anxiety, and achievements in learning mathematics", *Journal of Computers in Education*, Vol. 1 Nos 2-3, pp. 151-166.

Hung, P.-H., Hwang, G.-J., Lee, Y.-H., Wu, T.-H., Vogel, B., Milrad, M. and Johansson, E. (2014), "A problem-based ubiquitous learning approach to improving the questioning abilities of elementary school students", *Educational Technology and Society*, Vol. 17 No. 4, pp. 316-334.

Hussain, A. (2015), "Adoption of web 2.0 in library associations in the presence of social media", *Program*, Vol. 49 No. 2, pp. 151-169.

Hwang, G.J. and Chang, S.C. (2015), "Effects of a peer competition-based mobile learning approach on students' affective domain exhibition in social studies courses", *British Journal of Educational Technology*, Vol. 47 No. 6, pp. 1217-1231.

Johnson, L., Adams Becker, S., Estrada, V. and Freeman, A. (2015), *NMC Horizon Report: 2015 Museum Edition*, The New Media Consortium, Austin, TX.

Kanellopoulos, D.N. (2011), "Quality of service in networks supporting cultural multimedia applications", *Program*, Vol. 45 No. 1, pp. 50-66.

Keskin, N.O. and Metcalf, D. (2011), "The current perspectives, theories and practices of mobile learning", *Turkish Online Journal of Educational Technology-TOJET*, Vol. 10 No. 2, pp. 202-208.

Land, S.M. and Zimmerman, H.T. (2015), "Socio-technical dimensions of an outdoor mobile learning environment: a three-phase design-based research investigation", *Educational Technology Research and Development*, Vol. 63 No. 2, pp. 229-255.

Lanir, J., Kuflik, T., Dim, E., Wecker, A.J. and Stock, O. (2013), "The influence of a location-aware mobile guide on museum visitors' behavior", *Interacting with Computers*, Vol. 25 No. 6, pp. 443-460.

Lee, C.S. and Ma, L. (2012), "News sharing in social media: the effect of gratifications and prior experience", *Computers in Human Behavior*, Vol. 28 No. 2, pp. 331-339.

Lu, C., Chang, M., Kinshuk, Huang, E. and Chen, C.W. (2014), "Context-aware mobile role playing game for learning – a case of Canada and Taiwan", *Educational Technology and Society*, Vol. 17 No. 2, pp. 101-114.

Mayfield, M.I. (2005), "Children's museums: purposes, practices and play?", *Early Child Development and Care*, Vol. 175 No. 2, pp. 179-192.

Perry, D.L. (2012), *What Makes Learning Fun? Principles for the Design of Intrinsically Motivating Museum Exhibits*, Rowman, Altamira.

Reynolds, R., Walker, K. and Speight, C. (2010), "Web-based museum trails on PDAs for university-level design students: design and evaluation", *Computers and Education*, Vol. 55 No. 3, pp. 994-1003.

Ronimus, M., Kujala, J., Tolvanen, A. and Lyytinen, H. (2014), "Children's engagement during digital game-based learning of reading: the effects of time, rewards, and challenge", *Computers and Education*, Vol. 71, pp. 237-246.

Russell-Rose, T. and Tate, T. (2013), "Chapter 1 – the user", in Russell-Rose, T. and Tate, T. (Eds), *Designing the Search Experience*, Morgan Kaufmann, pp. 3-21.

Russo, A., Watkins, J., Kelly, L. and Chan, S. (2008), "Participatory communication with social media", *Curator: The Museum Journal*, Vol. 51 No. 1, pp. 21-31.

Ryan, R.M., Rigby, C.S. and Przybylski, A. (2006), "The motivational pull of video games: a self-determination theory approach", *Motivation and Emotion*, Vol. 30 No. 4, pp. 344-360.

Scott, C. (2013), *Museums and Public Value: Creating Sustainable Futures*, Ashgate Publishing, Ltd, Farnham.

Sedano, C.I., Sutinen, E., Vinni, M. and Laine, T.H. (2012), "Designing hypercontextualized games: a case study with lieksamyst", *Educational Technology and Society*, Vol. 15 No. 2, pp. 257-270.

Shih, J.L., Hwang, G.J., Chu, Y.C. and Chuang, C.W. (2011), "An investigation-based learning model for using digital libraries to support mobile learning activities", *The Electronic Library*, Vol. 29 No. 4, pp. 488-505.

Simon, N. (2010), *The Participatory Museum*, Museum 2.0, Santa Cruz, CA.

Sintoris, C., Stoica, A., Papadimitriou, I., Yiannoutsou, N., Komis, V. and Avouris, N. (2010), "Museumscrabble: design of a mobile game for children's interaction with a digitally augmented cultural space", *International Journal of Mobile Human Computer Interaction (IJMHCI)*, Vol. 2 No. 2, pp. 53-71.

Speight, M.C., Reynolds, M.R. and Cook, M.B. (Eds) (2012), *Museums and Design Education: Looking To Learn, Learning to See*, Ashgate Publishing, Ltd, Farbham.

Sung, Y., Hou, H., Liu, C. and Chang, K. (2010), "Mobile guide system using problem-solving strategy for museum learning: a sequential learning behavioural pattern analysis", *Journal of Computer Assisted Learning*, Vol. 26 No. 2, pp. 106-115.

Talboys, G.K. (2012), *Museum Educator's Handbook*, Ashgate Publishing, Ltd.

Vassilakaki, E. and Garoufallou, E. (2014), "The impact of Facebook on libraries and librarians: a review of the literature", *Program*, Vol. 48 No. 3, pp. 226-245.

Wallace, M. (2016), *Museum Branding: How to Create and Maintain Image*, loyalty, and support, Rowman & Littlefield Publishers Inc., Oxford.

Yiannoutsou, N. and Avouris, N. (2012), "Mobile games in museums: from learning through game play to learning through game design", *ICOM-Education*, Vol. 23, pp. 79-86.

Further reading

Sterry, P. and Beaumont, E. (2006), "Methods for studying family visitors in art museums: a cross-disciplinary review of current research", *Museum Management and Curatorship*, Vol. 21 No. 3, pp. 222-239.

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