Application of augmented reality in museums – Factors influencing the learning motivation and effectiveness

Chun-An Chen¹ and Hsin-I Lai²

¹Department of Business Administration, College of Management, Chung Hua University, Taiwan, R.O.C
²PhD Program of Technology Management, Chung Hua University, Taiwan, R.O.C

Abstract

Technology advancement has led to the successful and broad application of augmented reality approach in museums. Several literature works have supported the influence of augmented reality in education. However, relatively few studies have been carried out on augmented reality in museum and relevant educational influence. Thus, this study aims to identify educational effectiveness by employing augmented reality in museum and conducting research and analysis on related theories and empirical evidence. In this context, the research is based on the theoretical and conceptual frameworks of relevant literature. Further, integrate them into a functional research prototype and framework to acknowledge the positive influence between the visitors’ acceptance, employ augmented reality in museum, and increase learning motivation. Also, the mutual positive relationship between learning motivation and learning effectiveness will be realized. The consequences of mutual effect among all the variables in this study have convinced the relationship of intermediary influence between augmented reality in museum and learning effectiveness.

Keywords

Museum, augmented reality, learning motivation, learning effectiveness, empirical

Introduction

The museum is an open space for preserving knowledge, culture, and an arena of educational equity. The historical value of cultural relics in the museum can inspire the lust to explorers, acquire unique learning opportunities, and explore various concepts through
visiting. Some museum buildings also possess great archaeological value, such as the Louvre in France, which has a collection of cultural relics and represents the historical trajectory and cultural reservation. However, not all museums around the world possess a rich historical ambiance like the Louvre in France. The value might be added while the museum purposefully exhibits specific curation of a particular culture.

Radder & Han (2015) mentioned that the traditional museums are the cultural custodian, information source, and research path to educate and entertain visitors. Under specific curation, the museum is a scenic resort and an imprescriptible learning center. According to Andre et al. (2017), research on museum and education are the interactivity between museums and visitors presents substantial educational support. The museum space provides free choice and dynamic surroundings for visitors, stimulating visitors’ inner motivation and interest in this new teaching methodology.

The advancement of modern science and technology has led museums to face a significant digital transformation challenge. Thus, the New Media Consortium operating recommendation for a museum is to be digitalized ranges from four to five years. The forthputting of such technology and imprescriptible learning like museums could facilitate a higher persuasiveness learning experience. It also entails an imprescriptible learning space, which will interact with visitors through interesting digitalization and create more inspiring, meaningful, and outstanding education. Digitalization covers a wide range of augmented and virtual reality, which are widely applied in modern technology. The augmented reality is one of the most neoteric techniques applied. It is easily garbled between the two techniques by Guerra, Pinto & Beato (2015) in definition as:

- Augmented reality: Digital information presented in the real-life surrounding.
- Virtual reality: Digital information that provides a new world of immersion.

The augmented reality superimposes the calculated data on objective view to effectively stimulate the sense of actual surroundings and achieve active interaction between the subscribers and the content. Thus, the significant reason behind augmented reality becoming increasingly popular is that this technology has proven to provide more personalized content and services to new interactive and highly dynamic experiences that satisfy most people’s unique needs.

Furthermore, the historical and cultural relics can be displayed by augmented reality and virtual compositions compared with viewing pictures from books in the real world. Thus, presenting a richer sense of scale and characteristic of no harm to the tangible cultural relics. This encouraged many cultural tourism organizations to employ augmented reality for enhancing their visitors’ experience, such as augmented reality in Dublin, Deoksugung Palace in South Korea, and/or the exhibition center at Manchester Art Gallery. These museums employed innovative tools like augmented reality to help their visitors deeply experienced the displayed content and historical trajectory. As a result, the augmented reality is gradually becoming another mainstream of museum visiting.

Numerous literature and scholars have explored the outstanding manifestation of augmented reality applied in education and the significances of improving learning experience transversion. Quite a lot of work had made a significant breakthrough and progress between museums and education. However, it is still unknown whether
augmented reality will facilitate the learning result indirectly. Further, the massive adoption of modern technology in museums is also a concern due to labor-cost competitiveness, affordable accessibility, and the expectation of augmented reality in real-settings. Therefore, it will be of great significance and a unique approach to studying the increasing exhibition format in museums with augmented reality to address the associated factors that lead to increasing learning motivation and effectiveness. Thus, in this study, these associated factors will be explored to understand the increasing learning motivation and effectiveness.

**Literature review**

**Augmented reality**

This is an elongated technique of virtual reality. It mainly employs image input to capture real-world scenes for locating and overlay the virtual images or animations on a real-time calculation in the system and then present them through an augmented reality indicator. According to Azuma et al. (2001), there are three characteristics of augmented reality: (a) integrate real and virtual objects into reality, (b) collaboration between real and virtual objects, and (c) real-time interaction between real and virtual objects. Therefore, the images and sounds generated through augmented reality can significantly enhance the visual and auditory experience in real life. Furthermore, the real-time scenes through calculation could improve a more meaningful experience during the transversion that employers experienced.

**Definition of learning motivation**

The term ‘Learning’ involves many different territories such as psychology, linguistics, artificial intelligence, neuroscience, and many more. As defined by Lee Dai-Hua (2014), learning has been regarded as a science of training. Thus, the term ‘Motivation’ is a psychological construction connected with teaching and identifies as a series of transversions. Motivation can be divided into intrinsic and extrinsic motivation. Thus, motivation theory can be applied to evaluate learning alone and not on any other education theory.

Additionally, Richard & Edward (2000) elaborated on the fundamental differences between intrinsic and extrinsic motivation. Thereby defining intrinsic motivation as the act of doing something exciting and pleasant, and extrinsic motivation as the act of doing something that leads to separation. Gopalan, Zulkifli & Bakar (2016) pointed out a positive correlation for learning motivation through active, pleasure, and energetic participation. The key factors affecting intrinsic motivation are challenges, curiosities, control, and fantasy.

**Technology Acceptance Model (TAM)**

Technology Acceptance Model (TAM) was proposed by Davis in 1989 and originated from the theory of reasoned action (TRA) in rational behavior or decision-making
TAM has recently developed a key behavior model in predicting the potential acceptance or rejection of technology by humans and has been widely applied in various studies. According to Davis (1989), the TAM model is employed as a tendency to specific technology which depends on the attitude towards technology, and the attitude on ‘perceived’ accessibility, applicability, and enjoyment with the starting point of each personal beliefs and standards responsible for specific behaviors. Furthermore, this model has conducted numerous meta-analyses in different educational models and identified solid and firm effectiveness to the research intentions.

- **Perceived Usefulness (PU):** the degree to which individuals believe the new technology can improve their job manifestation.
- **Perceived Convenience (PC):** the degree to which an individual perceived a specific technology would not be complicated.
- **Perceived Enjoyment (PE):** activity of using a specific system is perceived to be enjoyable in its own right, aside from any manifestation consequences resulting from the system.

According to Almenara et al. (2019), the TAM application possesses an excellent predictive factor for diagnosing augmented reality variables. Therefore, to establish the dimensions of visitors’ acceptance of the augmented reality employed in museums, this research employed the TAM model as a measurement variable, with “perceived usefulness,” “perceived convenience,” and “perceived enjoyment” as the three main dimensions.

**Employ of augmented reality on repositories and learning motivation**

Research work by Dalgarno & Lee (2010) has shown that augmented reality employment led employers to interact with virtual objects in real-time to enhance their sensory stimulation. The learners can personally experience and transverse the interaction and guidance to facilitate learning satisfaction, enhancing the knowledge efficiently, and increasing the momentum to complete the learning task. With numerous technological handy channels, augmented reality technology will provide attractive surroundings essentials for learning. The specific circumstance will be one of the most significant factors to stimulate learning motivation. According to Lin, Chen & Liu (2017), learning transversion could be more joyful through augmented reality, and learners can also unanimously identify the teaching modus of augmented reality. Learning in a positive atmosphere can make learners more participatory. Gopalan et al. (2016) also mentioned that the teaching modus of augmented reality could effectively increase learning motivation. Therefore, the museum can employ augmented reality to support learning transversion with digitized educational content and improve the learning experience and motivation in implementation simultaneously. However, the systems must develop applicable content and focus on handheld devices that are easier to access.

Nonetheless, after a thorough literature review, most discussions on the relationship between augmented reality and learning motivation variables, which practically employed the ARCS model (ARCS: attention, relevance, confidence, and satisfaction)
by Keller (1983) is one of the major analysis tools. Furthermore, the research results using augmented reality and learning motivation can often form a benign circle with the ARCS model. The relevant description of the ARCS model is shown in Figure 1.

- **Attention**: According to Pappas (2015), attention can be obtained through different ways, like active participation, employ of humor, conflict, variety, and the real world. It is one of the most important factors to stimulate learning motivation.
- **Relevance**: Stimulate the motivation of learning through related language, analogies, and stories, linking to the previous experience, perceived present worth, perceived future usefulness, modeling, choice, and more.
- **Confidence**: Facilitate self-growth, communicate objectives and prerequisites, providing feedback, and giving learners control on ways to increase self-confidence. The level of self-confidence is usually related to motivation.
- **Satisfaction**: Praises, rewards, and immediate forthputting are the best ways to reflect satisfaction in the learning transversion. The higher the encouragement, the greater the self-achievement and self-recognition. Therefore, the sense of accomplishment can be regarded as contentment.

Based on the literature, this research employed the ARCS model as the four main dimensions of learning motivation and set up the research direction as $H1$: A positive influence for “Acceptance in the forthputting of augmented reality in museums” to the “learning motivation.”

**Learning motivation and effectiveness**

According to Gopalan et al. (2017), intrinsic motivation was autonomous and persistent to affect learning participation, if without any external anticipation. However, many intrinsic motivations are driven by extrinsic motivations. For example, rich and

![Figure 1. Keller’s ARCS model of motivational design.](image)
interesting textbook contents will stimulate interest and turn to proactive learning and influence learning effectiveness under strong motivation. On the other hand, extrinsic motivation is the learning motivation induced by others’ rewards and/or punishment and identity to certain behavioral values. The learning results might be decreased due to a lack of interest in the content. Besides, “Learning effectiveness” includes “self-directed learning cognition” and “ability improvement”. Thus, employing this research on a four-level evaluation model proposed by Kirkpatrick (2006) as a reference.

- **Level 1 Evaluation - Response**: degree of learner’s satisfaction.
- **Level 2 Evaluation - Learning**: degree of learner’s acquisition.
- **Level 3 Evaluation - Behavior**: extent to which the learners will employ the knowledge they have learned.
- **Level 4 Evaluation - Achievement**: economic output from the knowledge learned.

Based on the evaluated research work, this study employed “response evaluation,” “learning evaluation,” “behavior evaluation,” and “outcome evaluation” as the four main dimensions, and set up a research direction as H2: A positive influence for “learning motivation” to “learning effectiveness.”

**Research modus**

**Research framework**

This research employed models of review-based literature as mentioned above and acknowledged the augmented reality to have a substantial influence on education. Nevertheless, the influence of augmented reality on learning effectiveness for different areas is still a keen subject for further study. Therefore, this research employed key museums as a paradigm and prototyped the research framework to probe whether exhibition with augmented reality directly influences learning effectiveness (Figure 2).

**Questionnaire design**

This research employs questionnaires as the research tool. The questionnaires were developed based on the collection and integration of domestic and foreign literature, which were categorized into four parts: part 1, the acceptance for the employ of augmented reality in museums; part 2, the learning motivation; part 3, the learning effectiveness; and part 4, basic information of participants. The research questionnaires applied a 5-point Likert scale anchored with “strongly disagree” and “strongly agree” and values of 1 through 5.

**Data collection**

After predefined modifications and decontamination of some unrelated topics, the questionnaire was finalized and distributed among selected museums with experience in using augmented reality as research participants. All participants involved in this study were
selected and qualified to participate: (a) informed consent to participate, (b) had been to the museum and had experienced or used augmented reality technologies. The participants were asked to answer the questionnaire based on their level of understanding of the technology. Throughout the survey, the influence of augmented reality technology on the participants’ learning motivation and effectiveness were probed as correlations among variables.

A total of 299 participants/entries were collected in a random sampling from 1 Dec 2020 to 30 Dec 2020. After deleting 24 invalids entries (filled in incomplete), 275 valid entries were obtained, with an effective recovery rate of 91.97%.

**Research tool**

This research applied Partial Least Square (PLS) for reliability and validity analysis and research model verification. PLS is a structural equation modeling analysis technology with the analytical ability to detect or construct predictive models, especially for the causal model analysis among latent variables, which is much better than the general linear structural relationship model. Since the sample size is less compared to standard sampling, it is deemed significant in providing a good predictive model and explanatory capabilities to handle. In addition, it could not be restricted by the variables allocation type and quantity of samples under PLS. Thus, the sample size in this study was fully able to handle this predictive model. SmartPLS (SmartPLS v3 GmbH, Bönningstedt) was employed as the analysis tool and based on the assumption of the partial least square to minimize the linear structural relationship and the external measurement relationship of residual variance matrix with series of independent regressions.
Research results

Descriptive statistics of the participants

A total of 275 valid samples were collected with augmented reality experience in museums (Table 1). The results present a 58.18% female versus 41.82% male, where 94.55% of the total samples were with a university/college or above degree. The age group is mainly distributed within 41–51 years old (27.64%), followed by 19–29 years old (26.91%), 52 years old and above (22.91%), and 30–40 years old (21.09%). The participants experienced in exhibition activities with augmented reality less than 5, weigh up to 77.82%.

Furthermore, the narrative statistics presents 35 questions with variables research. The research results obtained from each dimension were presented in a simplified manner. The conduct questions with a higher average value of each variable were presented (Table 2). In terms of acceptance, “perceived usefulness” (Mean: 4.229) showed the highest manifestation, which presents the experience in a meaningful augmented reality, consistent with Siegle (2018).

As depicted in Table 3., the learning motivation, “relevance” (Mean: 4.349), showed the highest manifestation. This study suggests that the museums with an open learning surrounding have no compulsion or standardization for education. Therefore, tourists are autonomously visiting museums by their own choice. In terms of learning effectiveness (Table 3), “response evaluation” (Mean: 4.349) showed the highest manifestation, followed by “learning evaluation” (Mean: 4.222), “behavior evaluation” (Mean: 4.222).

Table 1. Participants statistics.

| Demographic Variables | Category       | Frequency | %    |
|-----------------------|----------------|-----------|------|
| Gender                | Male           | 115       | 41.82|
|                       | Female         | 160       | 58.18|
| Educational Level     | Primary School | 0         | 0.00 |
|                       | Jr. High School| 0         | 0.00 |
|                       | Sr. High School| 15        | 5.45 |
|                       | University/    | 140       | 50.91|
|                       | College        |           |      |
|                       | Master or above| 120       | 43.64|
|                       | under 18       | 4         | 1.45 |
|                       | 19 ~ 29        | 74        | 26.91|
|                       | 30 ~ 40        | 58        | 21.09|
|                       | 41 ~ 51        | 76        | 27.64|
|                       | 52 or above    | 63        | 22.91|
| Participation Frequency for the Exhibitions with AR and VR | Under 5 | 214 | 77.82 |
|                       | 6 ~ 10         | 45        | 16.36|
|                       | 11 ~ 15        | 9         | 3.27 |
|                       | 16 ~ 20        | 2         | 0.73 |
|                       | 20 or above    | 5         | 1.82 |

AR: Augmented Reality.
VR: Virtual reality.
4.218), and “achievement evaluation” (Mean: 4.149). From the literature overview, the adaptation of self-evaluation was achieved. However, the evaluation manifestation of the participants in the “learning evaluation,” “behavior evaluation,” and “achievement evaluation” could not be comprehended. Therefore, through their confidence dimension of learning motivation (Mean: 4.196), the participants were still not entirely confident about their manifestation after learning. Thus, they can hardly give themselves any higher evaluation during the self-assessment of those three aforementioned dimensions.

Reliability analysis

The reliability analysis result is presented in Table 4. In this section, the test based on whether it meets the required reliability and validity standards was detected first. The result shows that each item factor loadings is between 0.638 and 0.868, greater than the ideal value of 0.7, which allows all items to be retained for analysis. The composite reliability (CR) and Cronbach’s Alpha of the three variables are all above 0.9 and even higher than the recommended value of 0.7 by Hair et al. (2010). Thus, denoting that the indicators in this study have a higher degree of internal consistency. The average extraction variation (AVE) of the three variables is between 0.61 and 0.65 and all higher than 0.5, which meets the standard amount recommended by Fornell & Larcker.

Table 2. Acceptance in the forthputting of AR on repository.

| Variables                                      | Facet              | Highest homogeneity | Standard deviation |
|------------------------------------------------|--------------------|---------------------|--------------------|
| Acceptance in the forthputting of AR in museum | Perceived Usefulness | 4.229               | 0.628              |
|                                                | Perceived Convenience| 3.927               | 0.832              |
|                                                | Perceived Enjoyment  | 4.211               | 0.676              |

Table 3. Learning Motivation.

| Variables    | Facet               | Highest homogeneity | Standard deviation |
|---------------|---------------------|---------------------|--------------------|
| Learning Motivation | Attention       | 4.098               | 0.725              |
|                | Relevance          | 4.349               | 0.64               |
|                | Confidence         | 4.196               | 0.722              |
|                | Satisfaction       | 4.164               | 0.817              |
| Learning Effectiveness | Response Evaluation | 4.349               | 0.645              |
|                | Learning Evaluation | 4.222               | 0.717              |
|                | Behavior Evaluation | 4.218               | 0.726              |
|                | Achievement Evaluation | 4.149               | 0.721              |
The result shows that this model has a good convergence validity, based on the research findings on the various dimensions used in the model.

**Structural model analysis**

The structural model analysis mainly tests whether the standardized Path Coefficient among dimensions is statistically significant and then judges the model explanatory ability by the variation explanatory quantity ($R^2$) from endogenous dimensions. A larger standardized path coefficient refers to a higher causal relationship. $R^2$ explains the variation, and a higher $R^2$ value represents the highest ideal explanatory ability of the model. The ability of model explanatory, according to the recommendation, the $R^2$ value must be at least 0.1, which is more than 10% of our model $R^2$ output. Difference analysis refers to analyze results through the statistical modus like independent sample T-test and single-factor variance analysis in SPSS statistics and observe the significance between the background variables and dependent variables. As depicted in Figure 3, the $R^2$ value is 0.777 for “learning motivation” and 0.684 for “learning effectiveness,” which indicates that the dependent variables in this study had reached a good level of explanatory ability.

**Table 4. Reliability analysis.**

| Variable | rho_A | Reliability | Variation (AVE) | Cronbach’s Alpha |
|----------|-------|-------------|----------------|-----------------|
| Acceptance for the employ of AR in museums | 0.924 | 0.933 | 0.610 | 0.919 |
| Learning Motivation | 0.956 | 0.960 | 0.649 | 0.955 |
| Learning Effectiveness | 0.958 | 0.961 | 0.653 | 0.956 |

AR: Augmented Reality.

(1981). The result shows that, this model has a good convergence validity, based on the research findings on the various dimensions used in the model.

**Table 5. Structural model analysis.**

| Path | Expected Relationship | Path Coefficient | T-Value | P-Value | Hypothetical Result |
|------|-----------------------|------------------|---------|---------|---------------------|
| Acceptance to employ AR in museum $\rightarrow$ Learning Motivation | + | 0.881 | 49.957 | 0.000 | Supported |
| Learning Motivation $\rightarrow$ Learning Effectiveness | + | 0.827 | 31.483 | 0.000 | Supported |
| Acceptance to employ AR in museum $\rightarrow$ Learning Motivation $\rightarrow$ Learning Effectiveness | + | 0.729 | 22.497 | 0.000 | Supported |

AR: Augmented Reality.
The applied bootstrapping to generate the T-value of each path by repeatedly sampling 5000 times for evaluating the significant degree of T-value. According to Table 5, the model hypotheses of this study were all supported by the analysis of the test results. The acceptance of augmented reality employed by museums has a positive and significant influence on learning motivation. Follow by learning motivation, which also has a positive and significant influence on learning effectiveness. The total indirect effect is 0.729, with a T-value of 22.497 and a p-value of 0.000 (<0.001). The result indicates that learning motivation has a mediating effect between augmented reality employ in museum and learning effectiveness.

**Difference analysis**

The influence of gender, age, education level, and frequency of experiencing augmented reality or virtual reality on the variables were explored. Employing the difference analysis to explore whether there are significant differences among the variables and/or dimensions of those who have experienced augmented reality or virtual reality in museum with different background variables. This result is run on an independent sample T-test and single-factor variance analysis inside SPSS statistics.

The demographic and dependent variables are presented in Table 6, in which “+” means significant differences among variables for those who experienced augmented reality or virtual reality in museum, while “-” means no significant difference.

The study results show a significant difference between the level of education and learning effectiveness (significance: 0.046). According to the number of samples
collected, 94.55% are in university/college and master degrees. However, gender, age, and frequency of experiences have no significance on any dependent variables.

Discussion and conclusion

The museum is an open space for the preservation of knowledge and culture. Although defined as a space of imprescriptible learning, it still contributes to the popularization of knowledge. Furthermore, the museum gradually integrates augmented reality in the exhibitions to improve visitors’ educational experience, which has changed traditional education.

A pleasant learning surrounding can make learning more effective, and augmented reality is a catalyst for a pleasant learning surrounding. Through the examination of the ARCS model, the results of this research had identified that the employ of augmented reality in museum has a positive and significant influence on learning motivation ($\beta = 0.881^{***}$, $p < 0.001$), which means that museums can increase the learning motivation of visitors through augmented reality. The key factor is the higher acceptance of visitors to employ augmented reality in museums, which fully satisfies their desire to explore museums. Numerous pieces of literature had shown the influence of museums on learning motivation. Also, the results of this research further identified the museums, with digitization representing the authoritative indicator in educational improvement. This also proved that, visitors that goes to museums freely, had stimulated the intrinsic motivation to satisfy their curiosity. The “relevance” in the ARCS model (Table 3, Mean: 4.349) significantly influences (based-on a 5-point Likert scale anchored with strongest agreement) on the participants’ learning motivation. It is a determinant which satisfied learning motivation as it positively influence the acceptance in the forthputting of augmented reality in museums. Therefore, in this study, “relevance” in imprescriptible learning surroundings seems to be more important than “attention.” However, literature had never identified this point of view. Previous work shows the Palace Repository to cooperate with telecom operators in September 2019 to build up the first indoor 5G communication experimental site in Taiwan and employ the “AR Smart Guide” for visitors to experience the fantasy world of ancient paintings. Thus, this brought a sensational

Table 6. Difference analysis on demographic against dependent variables.

| Demographic Variables | Acceptance to AR Employ in museums | Learning Motivation | Learning Effectiveness |
|-----------------------|-----------------------------------|---------------------|-----------------------|
| Gender                | −                                 | −                   | −                     |
| Education level       | −                                 | −                   | +                     |
| Age                   | −                                 | −                   | −                     |
| Frequency of Experience| −                                 | −                   | −                     |

AR: Augmented Reality.
response and stimulated the visitors to experience the museum autonomously. This spontaneous behavior is precisely the same as the explanation of Richard & Edward (2000) to motivation.

In terms of learning effectiveness, this study identified the influence of augmented reality in museums on learning effectiveness. Follow by collecting and researching questionnaires, discussing, and analyzing the problems in detail, and understanding the relationship between augmented reality in museum and the effectiveness of learning primarily. This study also employed the four-level evaluation model of Kirkpatrick (2006) for learning effectiveness. It is important to note that the practice of all levels, which are from the questionnaires of self-evaluation by the participants, had presented a positive relationship in the manifestation (total indirect effect = 0.729, \( p < 0.001 \)). From the reviewing literature, most research results between augmented reality and education had also been highly identified. In the transversion of research, we also found that the visitors have a higher sense of identification with “attraction,” “logical clarity,” and “promoting the desire for knowledge”.12,50

Furthermore, it is interesting and intriguing that there is a significant relationship between education and learning effectiveness. The analysis of differences show that the higher the educational background, the greater the influence on learning effectiveness. Moreover, the influence between augmented reality in museums and learning effectiveness also shows that the participants have a higher sense of identity in “logical clarity.” Therefore, it seems that participants with higher education levels will pay more attention to the logical concepts of learning content.

In conclusion, this research was restricted in the objective evaluation of learning evaluation, behavior evaluation, and achievement evaluation due to the lack of participants’ specific assessment results and future development in the learning transversion. Nevertheless, the transversion of research still provides a prototype framework for discussion. Thus, there is still no suitable modus for evaluating learning effectiveness. Therefore, the research must change the future focus, discuss the existing research modus in groups, and employ a unique sampling for museum. The separation of measurement for experienced and non-experienced augmented reality could be an objective guideline in the relationship between augmented reality and learning effectiveness. Additionally, there is still a lack of literature to support the relationship between academic qualifications and learning effectiveness found in this study and whether the “relevance” of the ARCS model affects the imprescriptible learning surrounding. Based on these two interesting research directions, we might need further practical verification to guide new vision and research in the future.

**Declaration of conflicting interests**

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

**Funding**

The author(s) received no financial support for the research, authorship and/or publication of this article.
References

1. Andre L, Durksen T and Volman ML. Museums as avenues of learning for children: a decade of research. *Learn Environ Res* 2017; 20: 47–76.
2. Radder L and Han X. An examination of the museum experience based on pine and Gilmore’s Experience economy realms. *Journal of Applied Business Research (JABR)* 2015; 31: 455–470.
3. Jin J. Spatial Augmented Reality (SAR) for Museum Learning Merging Augmented Reality Based Features in Educational Space. *Digital Learning in Museums*. Oxford University Museums: Oxford, UK 2017, p. 1–21.
4. Johnson L, Becker SA, Estrada V, et al. *NMC Horizon Report: 2015 Library Edition*. Report no. 0996283242, 2015. Austin, Texas: The New Media Consortium.
5. Sommerauer P and Müller O. Augmented reality for teaching and learning—a literature review on theoretical and empirical foundations. *Twenty-Sixth European Conference on Information Systems* Portsmouth, UK 2018, p. 1–17.
6. Singhal S, Bagga S, Goyal P, et al. Augmented Chemistry: Interactive Education System. *International Journal of Computer Applications* 2012; 49: 1–5. doi:10.5120/7700-1041.
7. Lee H, Chung N and Jung T. Examining the Cultural Differences in Acceptance of Mobile Augmented Reality: Comparison of South Korea and Ireland. In: Tussyadiah I and Inversini A (eds) *Information and Communication Technologies in Tourism*. Springer International Publishing, Wien, New York: Springer, 2015, pp. 477–491.
8. Guerra JP, Pinto MM and Beato C. Virtual reality—shows a new vision for tourism and heritage. *Eur Sci J, ESJ* 2015; 11: 1–6.
9. Siegle D. Seeing is believing: using virtual and augmented reality to enhance student learning. *Gifted Child Today* 2019; 42: 46–52.
10. Kounavis CD, Kasimati AE and Zamani ED. Enhancing the tourism experience through mobile augmented reality: challenges and prospects. *International Journal of Engineering Business Management* 2012; 4: 10.
11. Jung T, tom Dieck MC, Lee H, et al. Effects of Virtual Reality and Augmented Reality on Visitor Experiences in Museum. *Information and Communication Technologies in Tourism* 2016. Springer, Cham: Springer International Publishing, 2016, pp. 621-635.
12. Kaźmierczak R, Szczepańska A, Kowalczyk C, et al. Using AR technology in tourism based on the example of maritime educational trips—A conceptual model. *Sustainability* 2021; 13: 7172.
13. Dalgarno B and Lee MJ. What are the learning affordances of 3-D virtual environments? *Br J Educ Technol* 2010; 41: 10–32.
14. Boccanfuso L, Barney E, Foster C, et al. Emotional robot to examine different play patterns and affective responses of children with and without ASD. In: 2016 11th ACM/IEEE International Conference on Human-Robot Interaction (HRI) 2016, pp.19–26. IEEE.
15. Knight H and Simmons R. An intelligent design interface for dancers to teach robots. In: 2017 26th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN) 2017, pp.1344–1350. IEEE.
17. Zhongming Z, Linong L, Wangqiang Z, et al. Realizing Education for All in the Digital Age. 2019. Asian Development Bank: Asian Development Bank Institute and Japan International Cooperation Agency (JICA) Research Institute (JICA-RI).
18. Bellini H, Chen W, Sugiyama M, et al. Virtual & Augmented Reality: Understanding the race for the next computing platform. 2016. Goldman Sachs: Vancouver, BC Canada V6T 1Z4.
19. Flavián C, Ibáñez-Sánchez S and Orús C. The impact of virtual, augmented and mixed reality technologies on the customer experience. J Bus Res 2019; 100: 547–560.
20. Gleasure R and Feller J. A rift in the ground: theorizing the evolution of anchor values in crowdfunding communities through the oculus rift case study. Journal of the Association for Information Systems 2016; 17: 708–736. doi:10.17705/1jais.00439
21. Azuma RT. A survey of augmented reality. Presence-Virtual and Augmented Reality 1997; 6: 355–385. doi:10.1162/pres.1997.6.4.355
22. Skarbez R, Smith M and Whitton MC. Revisiting milgram and Kishino’s Reality-Virtuality continuum. Frontiers in Virtual Reality 2021; 2: 27.
23. Azuma R, Baillot Y, Behringer R, et al. Recent advances in augmented reality. IEEE Comput Graph Appl 2001; 21: 34–47. doi:10.1109/38.963459
24. Lee D-H. A study on the promotion of English learning performance with e-learning model, National Pingtung University, Pingtung County, Taiwan, National Pingtung University, 2014.
25. Melian-Melian JA and Martin-Gutierrez J. Influence of learning objects of graphics architecture on motivation. Sage Open 2020; 10: 2158244020935886. doi:10.1177/2158244020935886
26. Yardimci F, Bektas M, Ozkutuk N, et al. A study of the relationship between the study process, motivation resources, and motivation problems of nursing students in different educational systems. Nurse Educ Today 2017; 48: 13–18. doi:10.1016/j.nedt.2016.09.017
27. Ryan RM and Deci EL. Intrinsic and extrinsic motivations: classic definitions and New directions. Contemp Educ Psychol 2000; 25: 54–67. doi:10.1006/ceps.1999.1020
28. Gopalan V, Bakar JAA, Zulkifli AN, et al. A review of the motivation theories in learning. In: AIP Conference Proceedings 2017, p.020043. AIP Publishing LLC.
29. Davis FD. Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. Mis Quart 1989; 13: 319–340. doi:10.2307/249008
30. Granić A and Marangunić N. Technology acceptance model in educational context: a systematic literature review. Br J Educ Technol 2019; 50: 2572–2593.
31. Salloum SA, Alhamad AQM, Al-Emran M, et al. Exploring Students’ acceptance of E-learning through the development of a comprehensive technology acceptance model. Ieee Access 2019; 7: 128445–128462. doi:10.1109/access.2019.2939467
32. Cabero-Almenara J, Barroso-Osuna J, Llorente-Cejudo C, et al. Educational uses of augmented reality (AR): experiences in educational science. Sustainability 2019; 11: 4990. doi:10.3390/su11184990
33. Venkatesh V. Determinants of perceived ease of use: integrating control, intrinsic motivation, and emotion into the technology acceptance model. Inf Syst Res 2000; 11: 342–365. doi:10.1287/isre.11.4.342.11872
34. Solak E and Cakir R. Exploring the effect of materials designed with augmented reality on language Learners’ vocabulary learning. Journal of Educators Online 2015; 12: 50–72.
35. Chiang THC, Yang SJH and Hwang GJ. An augmented reality-based mobile learning system to improve Students’ learning achievements and motivations in natural science inquiry activities. Educ Technol Soc 2014; 17: 352–365.
36. Lin M-H, Chen H-g and Liu k-S. A Study of the Effects of Digital Learning on Learning Motivation and Learning Outcome. EURASIA Journal of Mathematics, Science and Technology Education 2017; 13: 3553–3564. doi:10.12973/eurasia.2017.00744a
37. Gonzalez Vargas JC, Fabregat R, Carrillo-Ramos A, et al. Survey: using augmented reality to improve learning motivation in cultural heritage studies. *Applied Sciences* 2020; 10: 897.

38. Di Serio Á, Ibáñez MB and Kloos CD. Impact of an augmented reality system on students’ motivation for a visual art course. *Comput Educ* 2013; 68: 586–596.

39. Gopalan V, Zulkifli AN and Bakar JAA. A study of students’ motivation using the augmented reality science textbook. In: AIP Conference Proceedings 2016, p.020040. AIP Publishing LLC.

40. Chang YS, Hu KJ, Chiang CW, et al. Applying mobile augmented reality (AR) to teach interior design students in layout plans: evaluation of learning effectiveness based on the ARCS model of learning motivation theory. *Sensors (Basel)* 2019; 20: 05. doi:10.3390/s20010105

41. Kapp K. *Motivation slides from Workshop at DevLearn*. Education. Oct. 29 2012. Slideshare.

42. Malik S. Effectiveness of ARCS model of motivational design to overcome non completion rate of students in distance education. *Turkish Online Journal of Distance Education* 2014, 15: 194–200.

43. Khan T, Johnston K and Ophoff J. The Impact of an Augmented Reality Application on Learning Motivation of Students. *Advances in Human-Computer Interaction* 2019: 1–14. doi:10.1155/2019/7208494

44. Liu Y-C, Lu S-J, Kao C-Y, et al. Comparison of AR and physical experiential learning environment in supporting product innovation. *International Journal of Engineering Business Management* 2019; 11: 1847979019839578.

45. Tu JC and Chu KH. Analyzing the relevance of peer relationship, learning motivation, and learning effectiveness-design students as an example. *Sustainability* 2020; 12: 4061. doi:10.3390/su12104061

46. Kirkpatrick D and Kirkpatrick J. *Evaluating Training Programs: The Four Levels*. Berkley, USA: Berrett-Koehler Publishers, 2006, p. 392.

47. Fornell C and Larcker DF. Evaluating structural equation models with unobservable variables and measurement error. *Journal of marketing research* 1981; 18: 39–50. doi:10.2307/3151312

48. Hair JF, Black WC, Babin BJ, et al. Multivariate data analysis: International version. *Upper Saddle River, NJ: Pearson Education* Haley, RI (1968) Benefit segmentation: a decision-oriented research tool *The Journal of Marketing* 2010; 32: 30–35.

49. Falk RF and Miller NB. *A Primer for Soft Modeling*. Illustrated ed.: University of Akron Press, 1992, p. 103.

50. Zheng J. A functional review of research on clarity, immediacy, and credibility of teachers and their impacts on motivation and engagement of students. *Front Psychol* 2021; 12: 712419. doi:10.3389/fpsyg.2021.712419

**Author biographies**

**Chen, Chun-An** is a Professor at Chung Hua University, Taiwan. He received his BS degree in Mechanical Engineering and MA, PhD in Management from National Chiao Tung University in Taiwan, and working in the Industrial Technology Research Institute. His research interest focuses on Tourism Strategy Management, DEMATEL, MMDE, AHP, and ANP approaches.

**Lai, Hsin-I** is currently a PhD student at Chung Hua University, Taiwan. Her research areas are mainly in work performance and self-help tourism. Her research interest is on Technology Management.