Journal of Innovative Technology, Vol. 3, No. 2, pp. 63-68, September 2021
http://doi.org/10.29424/JIT.202109_3(2).0008

Investigating the User Experience of Applying Augmented Reality to Guide Traditional Instrumental Music

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ABSTRACT

This study explores user satisfaction levels and interactive experiences when using a novel augmented reality (AR) application (app). Developments in technology now provide a means to easily share information regarding traditional instruments and music in an engaging way. A self-developed app (TMusic) was designed and tested on 37 survey respondents. Users were able to view 3D models of instruments, play a sample of instrumental music from each instrument and learn how each instrument is played. This study adopted a one-shot case study using two questionnaire types, and short post-use interviews. Subjects were randomly sampled and the research results showed that the app operation method was above average when measured by the System Usability Scale, meaning it was easy to use. The app also received good feedback when assessed using a Questionnaire for User Interface Satisfaction, where the learning aspect ranked highest. Using AR as a learning tool for teaching about traditional instruments and music is effective, and users generally found the app easy to use and were satisfied with this type of guide.

Keywords: Augmented Reality; Guide; Traditional Instrumental Music; User Experience.

1. INTRODUCTION

Traditional music is becoming less frequent in the modern world. In the end, what remains may only be some rare sample instruments; even the music itself may become lost, except for a few representative melodies. However, the preservation of disparate human cultures is an important issue for people in the near and distant future.

Taiwan's traditional music is highly diverse and colorful. It inherits traditional instruments and tunes, and is symbolic of the continuation of Taiwan's traditional culture. Lin (2000) suggests that understanding traditional music requires education, introspection, theory and practice. In recent years, with the exponential growth of information and communication technology (ICT), there are new ways to experience music. In particular, there has been a trend towards dependence on digitization (King and Himonides (eds), 2016; Tuuri and Koskela 2020). In terms of education, Zhu (2008) used multimedia computer-assisted teaching to teach Chinese musical instruments; they found that students had a higher learning achievement than when they used a traditional narration approach, and they also held positive views with regard to computer-assisted teaching strategies.

Modern society is now deep in the information age. Technology and information influence and change the behavior patterns of many aspects of human society including communication, consumption, learning, leisure and entertainment, and even the understanding of history. In this information explosion, humans inevitably accept the strong influence brought by technology, and at the same time enjoy the conveniences that digital technology provides. The latest iteration of technology is interactive and participatory, but more than that, it is also a primary communication medium. Digital tourism applications (apps) like VisitAR use augmented reality (AR) to present information in the form of landmarks and information windows (Finn and Kuusinen 2021). This study developed an app called TMusic, to provide people with a guide to traditional Taiwanese instrumental music through an AR portal. TMusic allows users to view a 3-D model of traditional Taiwanese musical instruments, play samples of instrumental music for each instrument, and demonstrate the way the instrument is played. Advances in technology have provided multiple ways to reproduce and preserve aspects of traditional cultures. In the past, many approaches have focused on visual and dynamic presentations. For example, Cantatore, Lasorella and Fatiguso (2020) used 360° images to create a virtual environment, Virtual Tour, to display and restore historical sites in the Apulia region, Italy. This research focuses on recreating the beauty of sound, and using AR to show the appearance, performance method and instrumental music of traditional musical instruments.

2. LITERATURE REVIEW

2.1 DIGITAL GUIDE

In recent years, digital guides have been become widely used for leading tourists and visitors to museums around the various antiquities. They are even used to introduce traditional culture and cultural relics. The modern AR interface can now allow visitors to watch and experience antiquities that have disappeared, or experience traditional performances that are difficult to replicate. Sung *et al*. (2010) pointed out that the design and application of mobile guides should be based on the structure of hu-

Manuscript received Auguet 9, 2021; revised September 14, 2021; accepted September 18, 2021.

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man-computer-context interaction. The design of a guide should include the learning context, and context of the entire guided environment, such as visitors, peers, exhibits, and the cultural and social implications behind the display. Naismith, Sharples, and Ting (2005) proposed in their research that visitors derive greater satisfaction from context-aware educational resource systems, and that they feel more immersed and involved in outdoor physical environments. Context-awareness refers to the occurrence of knowledge and learning after interaction with its context. Therefore, an optimal design framework for a mobile guide should allow visitors to interact with alternate ways of interpreting the exhibits in a cultural and historical context (Beck and Cable 1998). This flexibility is one of the factors that makes AR guides more interactive, more attractive and interesting. Most participants also thought that AR guide systems provided a better navigation method (Ping, Liu, and Weng 2020). Accordingly, this research adopts an AR system to show the appearance, performance methods and instrumental music of traditional musical instruments.

2.2 LITERATURE REVIEW

AR is a medium that "combines real and virtual objects in a real environment, runs interactively in three dimensions (*i.e*., physical space), and in real time, and registers (aligns) real and virtual objects with each other" (Azuma *et al.* 2001, p. 34). With these characteristics, AR products provide new and rich ways to watch, listen and feel the world (van Krevelen and Poelman, 2010). AR gradually merges with the real life of human beings, adding innovative elements to today's entertainment business, commercial advertising, creative briefings, and digital learning.

In the education field, through AR, virtual objects, images, and text can be superimposed onto the real environment which gives learners a very realistic environment (Dede 2009). There are also more and more people integrating AR technology into learning-related research and discussion. Liu, Holden, and Zheng (2016) designed a set of AR action learning games that combined Hawaiian myths and legends called "Mo'o's Guide", where students could help the sick lizard goddess Mo'o complete tasks by exploring attractions on the University of Hawaii campus. This research hopes to enhance cultural understanding, language understanding and student motivation for language learning. Empirical research has already shown the potential and effectiveness that AR teaching methods provide in various subjects including science, mathematics and language (Radu 2014; Jain *et al*. 2017; Lee and Park 2019).

In recent years, with rapid developments in AR technology, people have begun to associate AR with musical instrument learning (Johnson *et al*. 2020; Martin-Gutierrez *et al*. 2020). For example, Lemos *et al*. (2017) used an Android app called AR Musical to teach children the musical notes. Their findings indicated that this program could make learners more involved in learning activities and stimulate their motivation and interest, which in turn helped participants acquire accurate knowledge about the course content.

2.3 USER EXPERIENCE

There are many methods of evaluating user experience, such as eye movement tracking, focus groups or surveys. In the survey evaluation method, standardized scales are required to produce a consistent and reliable analysis. For example, a User Experience Questionnaire (UEQ) is used to investigate a user's direct experience; the NASA Task Load Index (NASA-TLX) is used to review the psychological stress load of a user after completing a task, and the System Usability Scale (SUS) is used to evaluate the usability of a website or system. When users use interactive apps, good interactive design can create positive motivation. However, a larger number of interaction mechanisms does not necessarily equate to increased satisfaction. There are various user experience research questionnaires already available to researchers, such as the System Usability Scale (SUS) and the Questionnaire for User Interaction Satisfaction Scale (QUIS). The SUS scoring method is more complex, but the results are too general; therefore, it is inappropriate for in-depth analysis. QUIS improves over SUS in this regard, and provides detailed verification support, so that researchers can also get accurate verification of their questionnaire results (Santoso *et al*. 2016). Therefore, this study adopts both QUIS and SUS to evaluate the AR system user experience.

John Brooke proposed the System Usability Scale (SUS) in 1986 as a scale that could be applied broadly to website interfaces, applications and system interfaces. SUS has a limit of ten questions, and generates an average total score. In systems with a total average score exceeding 68 approval, the system is considered suitably usable for deployment (Sauro 2011). Figure 1 shows that the SUS score can be divided into six levels: A: 91-100, B: 81-90, C: 71-80, D: 60-70, F: 0-59 (Bangor, Kortum, and Miller, 2009).

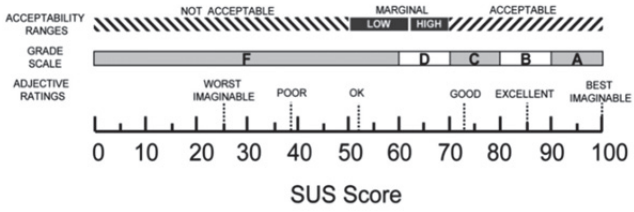

Fig. 1 System Usability Scale scoring methodology (Bangor, Kortum, & Miller, 2009)

The alternate QUIS system was proposed by the Human-Computer Interaction Lab (HCIL) at the University of Maryland in 1987. QUIS is widely used during the evaluation of interface design. The credibility and effectiveness of the early version 5.5 has already been confirmed by multiple studies (Chin, Diehl, & Norman, 1988). As of version 7.0, QUIS contains nine aspects: screen, terminology and system feedback, learning, system capability, technical manuals, on-line tutorials, multimedia, teleconferencing, and software installation. Harper, Slaughter, and Norman (1997) tested version 7.0 using 89 online respondents that completed a QUIS survey. In their study the Cronbach α value was .95, and the correlation coefficient between the main items was 0.49 and 0.61, confirming that the reliability and validity of the system.

This study used a questionnaire designed by Perlman (2015) based on version QUIS 7.0, and after factor selection due to research criteria, it included: overall response, screen, terminology and system feedback, learning, and application capability. These factors were used to measure the interactive satisfaction level of users experiencing the AR app.

3. EXPERIMENTS

After collecting information and resources related to Taiwan's traditional musical instruments and instrumental music, this study selected seven traditional instruments for inclusion in the app. The selected instruments were: Bon Gu, Tong Gu, Beiguan Gong, Xiao Zhan, Da Choa, Xiao Choa, and Da Luo.

The selection cards were produced in a hand-painted style, with a warm yellow background to create a nostalgic atmosphere (Fig. 2). Users were able to use a smart device to scan each card and generate a corresponding 3-D model of the musical instrument. Each card is designed with the pattern and characteristic description of each instrument. Users are then able to read a description on the card that gives a brief overview of the instrument they are looking at. Enabling the AR function of the TMusic app leads to an environment where users can then interact with the virtual instrument. Through this clear and easy-to-understand card design, it is hoped that the user's overall impression of traditional Taiwanese musical instruments will be enhanced.

The content of the TMusic app is primarily divided into two major categories, the "Augmented Reality Experience" and the "Introduction to Musical Instrument Information", as shown in Figure 3. Users with a smart device can scan a card, which then generates a 3-D model of the instrument, after that they can tap on the instrument to play the corresponding sound, as shown in Fig. 4. The real-time interactivity improves the user's perception, and the auxiliary operations are explained with text, to make the experience easier (Fig. 5). The TMusic app was developed using Unity version 2019.3.12f1 (Figure 6), and built for Android devices. The AR functionality was set up using Vuforia. The instrument models were built using 3DS Max and Blender.

Fig. 2 TMusic card design

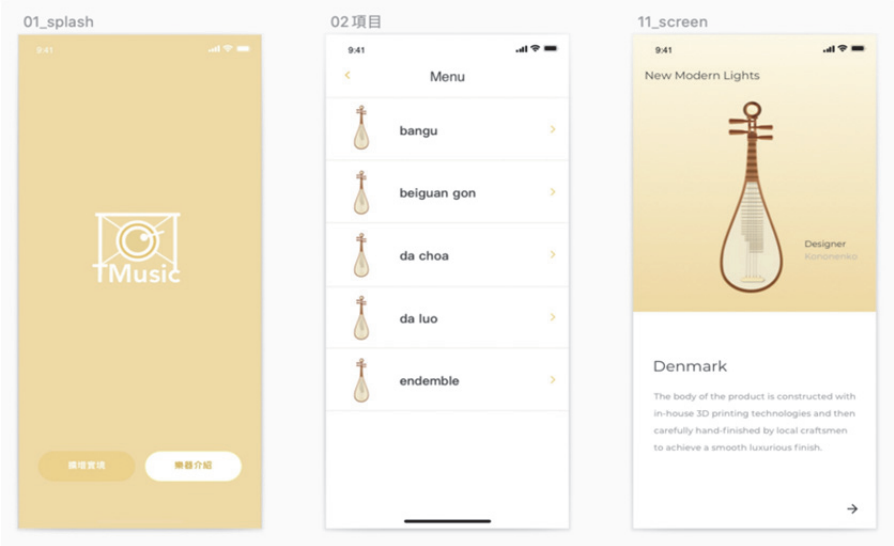

Fig. 3 Interface design of the TMusic

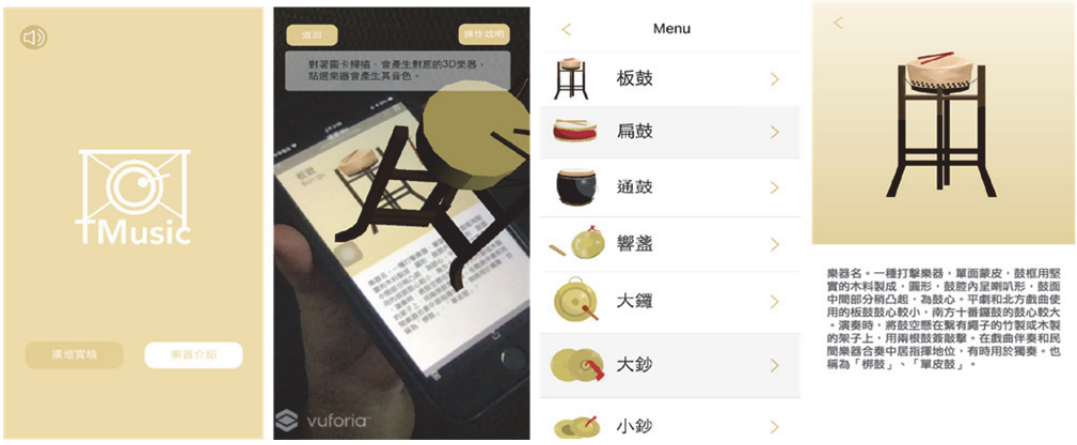

Fig. 4 App screen from within the TMusic app

Fig. 5 TMusic operation

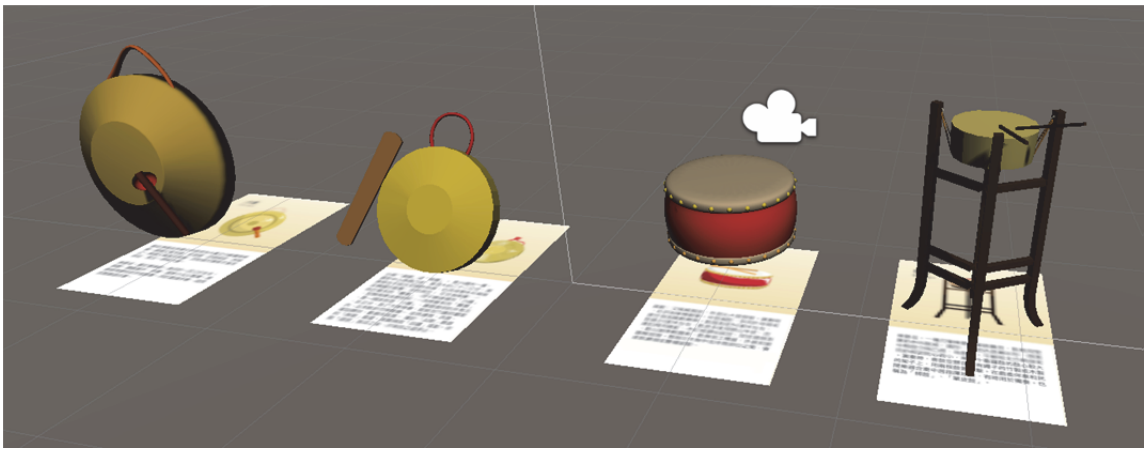

Fig. 6 3D Development in Unity

4. SIMULATION MODELLING AND EXPERIMENT RESULT VERIFICATION

In order to understand whether the TMusic app was providing users with a good interaction experience, a study was conducted. 42 volunteers were asked to use the app and then complete a questionnaire. After the survey was completed, 5 questionnaires with incorrect check marks were marked invalid, leaving 37 valid responses. Of the 37 respondents, 14 were male (37.8%) and 33 were female (62.2%). 30 respondents (81.1%), were in the age range 20-29 years old and the remaining 7 (18.9%), were 19 years old. No participants were over 30 years old.

5. RESULTS AND DISCUSSION

The questionnaire was divided into three parts. The first part was basic participant information and included 3 questions. The second part was the SUS, which included 10 questions, to test whether the system met the standards for of ease of use. The third part was the QUIS which had 25 questions that would measure the user's subjective experience while using the app. After completing the questionnaire, a brief interview was conducted to determine the user's experience.

On the SUS questionnaire, questions 1, 3, 5, 7, and 9 were forward questions, and 2, 4, 6, 8, and 10 were reverse questions. Table 1 provides the data on the narrative statistics from the SUS. The highest average score for forward questions was on question 7 "I can imagine that most people will learn how to use this app soon", which scored an average of 4.6 points. This implies that the app is simple and easy to understand and operate, and that most users can quickly adapt to it. The lowest average score from the forward questions was question 1, "I think I would be willing to use this app often", with a score of 3.1. Participants were less willing to use this app to learn about traditional Taiwanese musical instruments. In contrast, the lowest average score from the reverse questions was Question 8 "I think this application is very troublesome to use", which scored 1.6 points. This implies that the app functions smoothly and will not cause users to have any negative experience. The highest average score from the reverse question group was question 4 "I think I need somebody's help to use this app", which scored 2.2 points. This implies that some users may need help learning how to use the app.

The SUS total average score for this study was 76.7 points, which puts the app and content in the C-level range. This is higher than the SUS average score of 68 points. 28 respondents provided scores higher than the SUS average of 68, and the passing rate for the app was 75.7%. From this it was determined that the app is well designed and easy to use, however it does not reach the B-level, thus there is room for improvement.

Data analysis of each QUIS aspect is presented in Table 2. The overall average of 4.2 points is much higher than the average of 3 points, showing that user feedback regarding app satisfaction is positive. The highest average score in each aspect was the "Learning" aspect, with 4.4 points, and the lowest score was the "Overall response", with 3.9 points. Data analysis showed that users generally felt that they could learn new things from this app, but also that the app operation was relatively boring.

In the brief interviews that were conducted after the questionnaire, the respondents frequently offered suggestions and thoughts how AR could be applied to apps that introduce traditional musical instruments and music. For example, some users would have preferred to see a wider variety of instruments in the app, or strengthening the performance part of the instrument, as this may make the music more interesting. Another point raised was something to show the size ratio between the instruments, or have links so people can learn more elsewhere if they wanted to. Respondents also made some suggestions for optimizing the app in the future, in addition to more directions for future research.

Table 1 SUS Descriptive Statistics

Item	M	SD
(1) I think I would be willing to use this app often	3.1	0.66
(2) I think this app is too complicated	1.8	0.58
(3) I think this app is easy to use	4.3	0.51
(4) I think I need somebody's help to use this app	2.2	0.84
(5) I think the functions of this app are well integrated	3.7	0.56
(6) I think there are too many inconsistencies in this app	1.9	0.64
(7) I can imagine that most people will learn how to use this app soon	4.6	0.55
(8) I think this application is very troublesome to use	1.6	0.55
(9) I am confident that I can use this app	4.4	0.60
(10) I need to learn a lot of additional information to use this app	1.9	0.95

Table 2 Total average data of each aspect of QUIS

Aspect	M
Overall response	3.9
Screen	4.3
Terminology and system feedback	4.3
Learning	4.4
Application capability	4.1
Total	4.2

6. CONCLUSION

The results of this study showed that the TMusic app was seen as easy to use. It had an average level of ease of use, and obtained good feedback in the satisfaction category. For the respondents tested, the AR was generally easy to operate, and users felt satisfied while navigating through the traditional instrumental music cards. However, the initial app content was relatively simple, and did not provide users with more freedom. Therefore in that respect there is still room for improvement in the application program interface and system. In the future, this study may be extended to develop the gameplay of the system to develop richer content, optimize the application program interface and system performance, and increase user willingness to continue using the app. The goal of this app was to allow users to learn some of the characteristics of traditional musical instruments and music, in order to promote related cultural development.

REFERENCES

Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., and MacIntyre, B. (2001). "Recent advances in augmented reality." *IEEE Comput. Graph. Appl*. **21**, 34-47. doi: 10.1109/38.963459

Bangor, A., Kortum, P., and Miller, J. (2009). "Determining what individual SUS scores mean: Adding an adjective rating scale." *Journal of Usability Studies*, **4**(3), 114-123. doi:66.39.39.113

Beck, L. and Cable, T. (1998) *Interpretation for the 21st Century: Fifteen Guiding Principles for Interpreting Nature and Culture*.

Boston: Sagamore Publishing.

Cantatore, E., Lasorella, M. and Fatiguso, F. (2020). Virtual Reality to Support Technical Knowledge in Cultural Heritage. The Case Study of Cryptoporticus In the Archaeological Site of Egnatia (ITALY). The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLIV-M-1-2020, doi:10.5194/isprs-archives-XLIV-M-1-2020-465-2020

Chin, J. P., Diehl, V. A., and Norman, K. L. (1988). Development of an instrument measuring user satisfaction of the human-computer interface. Paper presented at the SigChi'88, New York.

Dede, C. (2009). *Immersive interfaces for engagement and learning. Science*, **323**(5910), 66-69.

Finn, E., amd Kuusinen, J. (2021). "Innovation Through Universal Design in Agile UX Software Development Teams. A Collaborative Case Study of an Under Graduate AR Tourist Guide Project." *Stud Health Technol Inform*. **282**: 252-258.

Harper, B., Slaughter, L., and Norman. K. (1997). Questionnaire administration via the WWW: A validation & reliability study for a user satisfaction questionnaire. Paper presented at WebNet 97 Conference. Available at http://lap.umd.edu/quis.

Jain, N., Youngblood, P., Hasel, M., and Srivastava, S. (2017). "An augmented reality tool for learning spatial anatomy on mobile devices." *Clin. Anat*. **30**, 736-741. doi: 10.1002/ca.22943

Johnson, D., Damian, D., and Tzanetakis, G. (2020). "Evaluating the effectiveness of mixed reality music instrument learning with the theremin." *Virtual Real*. *24*, 303-317. doi: 10.1007/s10055-019-00388-8

King, A. and Himonides, E. (eds) (2016). *Music, Technology, and Education: Critical Perspectives*. New York: Routledge.

Lee, S.-M., and Park, M. (2019). "Reconceptualization of the context in language learning with a location-based AR app. Comput." *Assist. Lang. Learn*. **33**, 1-24. doi: 10.1080/09588221.2019.1602545

Lemos, B.H.V., Corrêa, A.G.D., Nascimento, M.D., and Lopes, R. D.D. (2017). "Augmented reality musical app to support children's musical education." *Comput. Sci. Inf. Technol*. **5**, 121-127. doi: 10.13189/CSIT.2017. 050401

Lin, G. F. (2000). Inheritance and Prospects of Modern Chinese Music in Taiwan~Integrating with Traditional Music. In Proceedings of Inheritance and Prospects of Modern Chinese Music in Taiwan~Integrating with Traditional Music. 8-12. Kaohsiung.

Liu, Y., Holden, D., and Zheng, D. (2016). "Analyzing students' language learning experience in an augmented reality mobile game: an exploration of an emergent learning environment." *Procedia-Social and Behavioral Sciences*, 228, 369-374.

Martin-Gutierrez, J., Del Rio Guerra, M. S., Lopez-Chao, V., Soto Gastelum, R. H., and Valenzuela Bojórquez, J. F. (2020). "Augmented reality to facilitate learning of the acoustic guitar." *Appl. Sci*. **10**:2425. doi: 10.3390/app10072425

Naismith, L., Sharples, M., and Ting, J. (2005). Evaluation of CAERUS: a context aware mobile guide. In van der Merwe H, Brown T, Mobile Technology: The Future of Learning in Your Hands, mLearn 2005 Book of Abstracts, 4th World Conference on mLearning, Cape Town, 25-28 October 2005. Cape Town: mLearn 2005, p. 50.

Perlman, G. (2015). "User Interface Usability Evaluation with Web-Based Questionnaires." ttp://garyperlman.com/quest/quest.cgi?form=QUIS. Accessed 14 December 2018.

Ping, J., Liu, Y., and Weng, D. 2020. "Study on Mobile AR Guide System to Enhance User Experience in Cultural Heritage Sites. In Proceedings of 2020 International Conference on Virtual Reality and Visualization (ICVRV)." doi: 10.1109/ICVRV51359.2020.00027

Radu, I. (2014). "Augmented reality in education: a meta-review and cross-media analysis." *Pers. Ubiquitous Comput*. **18**, 1533-1543. doi: 10.1007/s00779-013-0747-y

Santoso, H.B., Schrepp, M., Yugo Kartono Isal, R., Utomo, Y., and Priyogi, dan B. (2016). "Measuring User Experience of the Student-Centered eLearning Environment." *J. Educ. Online-JEO*, Vol. 13, No. 1, hal. 142-166.

Sauro, J. (2011). "SUStisfied? Little-Known System Usability Scale Facts." *User Experience Magazine*, **10**(3). Retrieved from https://uxpamagazine.org/sustified/

Sung J, Bjornrud T, Lee Y, and Wohn, D.Y. (2010). Social network games: exploring audience traits. In Proceedings of the 28th of the international conference on Human factors in computing systems. 3649-3654.

Tuuri, K. and Koskela, O. (2020). "Understanding human–technology relations within technologization and appification of musicality." *Front. Psychol.* **11**:416. doi: 10.3389/fpsyg.2020.00416

van Krevelen, D.W.F. and Poelman, R. (2010). "A survey of augmented reality technologies, applications and limitations." *Int. J. Virtual Real*. 9, 1–20. doi: 10.20870/IJVR.2010.9.2.2767

Zou, Y. C. (2008). *A Study of Multi-media Computer-Assisted Instruction on Music Appreciation: An Example of Chinese Musical Instruments*. Pingtung. doi: 10.6346/NPUST.2008.00090