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**CONCEPTUAL MODEL OF MOBILE AUGMENTED REALITY FOR  
CULTURAL HERITAGE SITE TOWARDS ENJOYABLE INFORMAL  
LEARNING (MARCHSTEIL)**

**ULKA CHANDINI PENDIT**



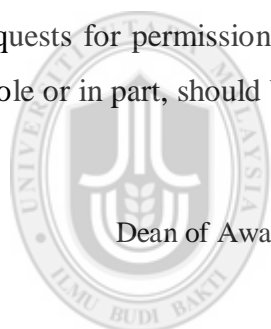
**UUM**  
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## Abstrak

Realiti luasan mudah alih (AR) adalah salah satu daripada teknologi termaju yang dapat menyediakan kandungan interaktif untuk pelancong di warisan budaya. Kajian lepas menunjukkan, pengalaman pembelajaran tidak formal yang menyeronokkan amat diperlukan bagi pelancong bagi meluaskan pengetahuan dari lawatan mereka. Walaupun banyak aplikasi AR mudah alih telah dibangunkan untuk memaparkan maklumat tapak warisan budaya kerana kurangnya model menyeluruh yang mengambilkira elemen pengalaman pembelajaran tidak formal yang menyeronokkan. Oleh itu, kajian ini mencadangkan satu model konsep AR mudah alih yang komprehensif yang mengambilkira komponen-komponen pengalaman pembelajaran tidak formal yang menyeronokkan di tapak warisan budaya. Kajian ini menggunakan kaedah penyelidikan sains reka bentuk. Model konsep yang dicadangkan telah diteliti dan disahkan melalui penilaian pakar dan perbincangan kumpulan fokus. Penilaian telah dianalisis berdasarkan frekuensi respon ke atas setiap komponen. Sebagai pembuktian konsep, satu prototaip dinamakan sebagai (AR@Melaka) telah dibangunkan dan kemudian ianya dinilai dari aspek pembelajaran tidak formal menyeronokkan terhadap 200 orang pelancong di sebuah tapak warisan budaya terkemuka. Dari perspektif pengguna, prototaip AR@Melaka telah terbukti dapat memberikan pembelajaran tidak formal yang menyeronokkan. Kesimpulannya, dapatan ini membuktikan bahawa model konsep yang dicadangkan itu adalah berguna untuk membantu pelancong dalam pembelajaran di tapak warisan budaya dalam cara yang menyeronokkan. Kajian ini menyumbang kepada model konsep untuk dijadikan garis panduan dalam membangunkan realiti luasan mudah-alih yang mengambilkira komponen pembelajaran tidak formal yang menyeronokkan.

**Kata kunci:** Realiti luasan mudah-alih, Pembelajaran tidak formal yang menyeronokkan, Tapak warisan budaya

## Abstract

A mobile augmented reality (AR) is one of the emerging technologies that may provide interactive content to tourists at cultural heritage sites. Past studies show enjoyable informal learning experience is highly needed for tourists to broaden knowledge for tourists. Although many mobile AR applications have been developed to expose cultural heritage site information, they are still lacking in providing such experience due to lack of comprehensive models which taking into consideration the elements of enjoyable informal learning experience in the development of such applications. Therefore, this study proposes a comprehensive conceptual model of mobile AR where it considers the components of enjoyable informal learning experience at cultural heritage site. This study followed design science research methodology. The proposed conceptual model is reviewed and validated through expert review and focus group discussion. The review was analysed based on frequency of the responses on each component. As a proof-of-concept, the prototype (named as AR@Melaka) was developed and then evaluated on its enjoyable informal learning aspects to 200 tourists of a renowned cultural heritage site. From user perspective, it is proven that AR@Melaka provides enjoyable informal learning. In conclusion, these findings proved that the conceptual model is useful for assisting tourists in learning at cultural heritage site in an enjoyable way. This study contributes a conceptual model to serve as guidelines for developing a mobile augmented reality that considers an enjoyable informal learning component.

**Keywords:** Mobile augmented reality, Enjoyable informal learning, Cultural heritage site

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Ulka Chandini Pedit

Kedah, March, 10<sup>th</sup>, 2015

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## List of Abbreviations

<b>API</b>	Application Programming Interface
<b>AR</b>	Augmented Reality
<b>ARCO</b>	Augmented Reality for Cultural Object
<b>ARCHEOGUIDE</b>	Augmented Reality based-Cultural Heritage On-Site GUIDE
<b>BWL</b>	Butterfly Watching Learning System
<b>EDA</b>	Exploratory Data Analysis
<b>EIL</b>	Enjoyable Informal Learning
<b>EULER</b>	Environment of Ubiquitous Learning with Educational Resources
<b>GLUT</b>	OpenGL Utility Toolkit
<b>GPS</b>	Global Positioning System
<b>iTACITUS</b>	Intelligent Tourism and Cultural Information through Ubiquitous Service
<b>LOL@</b>	Local Location Assistant
<b>MART</b>	Mobile Augmented Reality Tour
<b>MAR</b>	Mobile Augmented Reality
<b>MARS</b>	Mobile Augmented Reality System
<b>MARCH</b>	Mobile Augmented Reality for Cultural Heritage
<b>MARCHSTEIL</b>	Mobile Augmented Reality for Cultural Heritage Site towards Enjoyable Informal Learning
<b>MTG</b>	Mobile Tourism Guide
<b>OpenGL</b>	Open Graphics Library
<b>OpenGL ES</b>	Open Graphics Library for Embedded Graphics
<b>OS</b>	Operating System
<b>PoI</b>	Point of Interest
<b>RFID</b>	Radio-Frequency Identification
<b>SDK</b>	Software Development Kit
<b>SHMAR</b>	Sutoon Hoo Mobile Augmented Reality

# CHAPTER ONE

## INTRODUCTION

### Introduction

This chapter presents background of study followed by statement of problem, research questions, objectives of study, research scope and contributions of study.

### 1.1 Background of Study

Augmented reality (AR) overlays the virtual object to the real world without replacing the real environment (Azuma, 1997). It is usually done by augmenting virtual image or textual annotations to the real world (Pulli et al., 2009). It enhances user perception and interaction with the real world, and present information which user cannot detect directly (Carmigniani & Furht, 2011; Izkara, Pérez, Basogain, & Borro, 2007; Reitmayr & Schmalstieg, 2001).

AR on mobile was developed in 1997 by Steven Feiner and was named the Touring Machine. It can be built in many forms, namely, mobile workstation, tablet PCs, Ultra Mobile PCs (UMPCS), Personal Digital Assistants (PDA), smart-phones and handheld devices (Chen, Tsai, Vedantham, Grzeszczuk, & Girod, 2009; Craig, 2013; Höllerer & Feiner, 2004; Papagiannakis, Singh, & Magnenat-thalmann, 2008). The implementation of mobile AR for cultural heritage had started since fourteen years ago (Angelopoulou, Economou, Bouki, Jin, Pritchard, & Kolyda, 2011; Armanno, Bottino, & Martina, 2012; “iTACITUS,”2007; Kim & Park, 2011; Seo, Kim, & Park, 2011; “Techcooltour,” 2013; Vlahakis et al., 2001). It provides image, text, animation, and video and has become alternative for common interpretive media

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internal user  
only

## REFERENCES

- Abowd, G. D., Atkeson, C. G., Hong, J., Long, S., Kooper, R., & Pinkerton, M. (1997). Cyberguide: a mobile context-aware tour guide. *Wireless Networks*, 3(5), 421–433. doi:10.1023/A:1019194325861
- Ahonen, T. (2011). *Mobile Future* [PowerPoint slides]. Retrieved from <http://www.slideshare.net/Mobil-Business/mobile-future-tomi-ahonen>
- Angelopoulou, A., Economou, D., Bouki, V., Jin, L., Pritchard, C., & Kolyda, F. (2012). Mobile augmented reality for cultural heritage. In N. Venkatasubramanian, V. Getov, & S. Steglich (Eds.), *Mobile Wireless Middleware, Operating Systems and Applications* (pp. 15–22). Springer Berlin Heidelberg.
- Ariffin, A. M. (2009). *Conceptual design of reality learning media (RLM) model based on entertaining and fun constructs*. Universiti Utara Malaysia, Malaysia. Retrieved from [http://etd.uum.edu.my/1521/2/1.Ariffin\\_Abdul\\_Mutalib.pdf](http://etd.uum.edu.my/1521/2/1.Ariffin_Abdul_Mutalib.pdf)
- Armanno, G., Bottino, A., & Martina, A. (2012). SkyLineDroid: an outdoor mobile augmented reality application for virtual heritage. In *International Conference on Cultural Heritage and Tourism* (pp. 91–96). Retrieved from <http://www.wseas.us/e-library/conferences/2012/CambridgeUK/CUMNUPEM/CUMNUPEM-14.pdf>
- ARToolkit. (n.d.). *ARToolkit Framework*. Retrieved from <http://www.hitl.washington.edu/artoolkit/documentation/devframework.htm>.
- Azuma, R. T. (1997). A survey of augmented reality. *Presence*, 6(4), 355–385. Retrieved from <http://pdf.thepdfportal.net/PDFFiles/26651.pdf>
- Bakar, J. A. A., Kassim, P. S. J., & Mahmud, M. (2010). The level of information and communication technology use by museums in malaysia. In *International Symposium on Information Technology* (pp. 1462–1467). IEEE. doi:10.1109/ITSIM.2010.5561490
- Beal, V. (n.d.). *API - Application Program Interface*. Retrieved June 28, 2015, from <http://www.webopedia.com/TERM/A/API.html>
- Beck, M. (1945). The cognitive character of aesthetic enjoyment. *The Journal of Aesthetics and Art Criticism*, 3(11/12), 55–61. doi:10.2307/426354
- Behrens, J. T. (1997). Principles and procedures of exploratory data analysis. *Psychological Methods*, 2(2), 131–160. doi:10.1037//1082-989X.2.2.131
- Bellotti, F., Berta, R., Gloria, A. De, & Margarone, M. (2002). User testing a hypmermedia tour guide. *IEEE Pervasive Computing*, 1(2), 33–41. doi:10.1109/MPRV.2002.1012335
- Bennet, E. E. (2010). A four-part model of informal learning: extending schugurensky's conceptual model. In *Proceedings of Adult Education Research Conference* (pp. 24–31). Saratoga Springs, New York: AERC. Retrieved from <http://www.adulterc.org/Proceedings/2012/papers/bennett.pdf>
- Berg, S. A., & Chyung, S. Y. (Yonnie). (2008). Factors that influence informal

- learning in the workplace. *Journal of Workplace Learning*, 20(4), 229–244.  
doi:10.1108/13665620810871097
- Billinghurst, M., Kato, H., & Poupyrev, I. (2008). Tangible augmented reality. *ACM SIGGRAPH ASIA*, 1–10. doi:10.1145/1508044.1508051
- Billinghurst, M. (2014). *Professional course: Mobile-based augmented reality development*. Johor, Malaysia: Universiti Teknologi Malaysia
- Blackwell, K. (2005). TechTarget. *Software Developer's Kit (SDK)*. Retrieved June 28, 2015, from <http://whatis.techtarget.com/definition/software-developers-kit-SDK>
- Boticki, I., Hoic-bozic, N., & Budiscak, I. (2009). A system architecture for a context-aware blended mobile learning environment. *CIT. Journal of Computing and Information Technology*, 17(2), 165–175.  
doi:10.2498/cit.1001187
- Brandtzaeg, P. B., Følstad, A., & Heim, J. (2005). Enjoyment: lessons from karasek. In J. Karat & J. Vanderdonck (Eds.), *Funology from usability to enjoyment* (pp. 55–66). Dordrecht, Netherlands: Kluwer Academic Publishers. .
- Braun, N. (2003). Storytelling in Collaborative Augmented Reality Environments. In *Proceedings of the 11th International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision* (p. 39). Retrieved from [http://wscg.zcu.cz/WSCG2003/Papers\\_2003/G03.pdf](http://wscg.zcu.cz/WSCG2003/Papers_2003/G03.pdf)
- Brelot, M., Cotarmanac'h, A., Damala, A., & Kockelcorn, H. (2005). Nomadic computing in indoor cultural settings: intelligent connectivity, context awareness and the mobile museum experience. In *Proceedings of International Cultural Heritage Informatics Meeting* (pp. 1–21). Paris.
- Carbo, M. (1996). Educational leadership students with special needs reading styles high gains for the bottom third. *Educational Leadership*, 53(5), 8–13. Retrieved from <http://www.ascd.org/publications/educational-leadership/feb96/vol53/num05/Reading-Styles@-High-Gains-for-the-Bottom-Third.aspx>
- Carillo, E., Rodriguez-Echavaria, K., & Arnold, D. (2007). Displaying intangible heritage using ICT. Roman everyday life on the frontier: Vindolanda. In D. Arnold, A. Chalmers, & F. Niccolucci (Eds.), *Future Technologies to Empower Heritage Professionals The 8th International Symposium on Virtual Reality , Archaeology and Intelligent Cultural Heritage Incorporating the 5th EUROGRAPHICS Workshop* (pp. 51–55). Budapest, Hungary: ARCHAEOLOGIA. Retrieved from <http://public-repository.epoch-net.org/publications/VAST2007/vast2007.pdf>
- Carmigniani, J., & Furht, B. (2011). *Handbook of augmented reality*. (B. Furht, Ed.). New York, NY: Springer New York. doi:10.1007/978-1-4614-0064-6
- Chen, D. M., Tsai, S. S., Vedantham, R., Grzeszczuk, R., & Girod, B. (2009). Streaming mobile augmented reality on mobile phones. In *International Symposium on Mixed and Augmented Reality* (pp. 181–182). IEEE.  
doi:10.1109/ISMAR.2009.5336472

- Chen, Y., Kao, T., Yu, G., & Sheu, J. (2004). A mobile butterfly-watching learning system for supporting independent learning. In *The 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE'04)* (pp. 11–18). IEEE. doi:10.1109/WMTE.2004.1281327
- Churchill, D. (2007). Towards a useful classification of learning objects. *Educational Technology Research and Development*, 55(5), 479–497. doi:10.1007/s11423-006-9000-y
- Collins Dictionary. (2007). *Collins cobuild advanced dictionary of american english* (First Edit.). Glasgow, Great Britain: Harper Collins Publishers
- Computer Hope. (n.d.). *Operating System*. Retrieved June 28, 2015, from <http://www.computerhope.com/os.htm>
- Craig, A. B. (2013). *Understanding augmented reality: concepts and applications* (First Edit.). Morgan Kauffman.
- Cross, N. (2001). Designerly ways of knowing: design discipline versus design science. *Design Issues*, 17(3), 49–55. doi:10.1162/074793601750357196
- Damala, A., & Lecoq, C. (2005). Mobivisit: Nomadic computing in indoor cultural settings. A field study in the museum of Fine Arts, Lyon. In X. Perrot (Ed.), *ICHIM International Cultural Heritage Informatics Meeting* (pp. 1–19). Paris, France: Archives and Museum Informatics. Retrieved from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.99.5941&rep=rep1&type=pdf>
- Damala, A. (2007). Design principles for mobile museum guides using visitor studies and museum learning theories. In *IADIS (International Association for Development of the Information Society), Mobile Learning Conference* (pp. 277–281). Lisbon, Portugal. Retrieved from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.161.6113&rep=rep1&type=pdf>
- Damala, A., Marchal, I., & Houlier, P. (2007). Merging augmented reality based features in mobile multimedia museum guides. In *Anticipating the Future of the Cultural Past, CIPA Conference 2007* (pp. 259–264). Athens, Greece. Retrieved from <https://halshs.archives-ouvertes.fr/halshs-00530903/document>
- Damala, A., Cubaud, P., Bationo, A., Houlier, P., & Marchal, I. (2008). Bridging the gap between the digital and the physical: design and evaluation of a mobile augmented reality guide for the museum visit. In *Proceedings of the 3rd International Conference on Digital Interactive Media in Entertainment and Arts* (pp. 120–127). Athens, Greece: ACM. Retrieved from <http://portal.acm.org/citation.cfm?id=1413660>
- Damala, A. (2009). *Interaction design and evaluation of mobile guides for the museum visit: a case study in multimedia and mobile augmented reality*. (Doctoral dissertation, Ecole Doctorale EDITE, Paris, France, 2009). Retrieved from <https://tel.archives-ouvertes.fr/tel-00526141/document>
- Davis, W. A. (1982). A causal theory of enjoyment. *Mind*, 91(362), 240–256. Retrieved from <http://www.jstor.org/stable/2253480>

- Dede, C. (2009). Immersive interfaces for engagement and learning. *Science*, 323(66), 66–69. doi:10.1126/science.1167311
- Demiris, A. M., Vlahakis, V., & Ioannidis, N. (2006). System and infrastructure considerations for the successful introduction of augmented reality guides in cultural heritage sites. *Proceedings of the ACM Symposium on Virtual Reality Software and Technology - VRST '06*, 141. doi:10.1145/1180495.1180524
- Dishman, R. K., Motl, R. W., Saunders, R., Felton, G., Ward, D. S., Dowda, M., & Pate, R. R. (2005). Enjoyment mediates effects of a school-based physical-activity intervention. *Medicine & Science in Sports & Exercise*, 37(3), 478–487. doi:10.1249/01.MSS.0000155391.62733.A7
- Driscoll, M. P. (2004). Constructivism. In *Psychology of Learning for Instruction* (Third Edit., p. 393). Pearson.
- Duh, H. B.-L., & Billingham, M. (2008). Trends in augmented reality tracking, interaction and display: A review of ten years of ISMAR. In *7th IEEE/ACM International Symposium on Mixed and Augmented Reality (ISMAR 2008)* (pp. 193–202). Cambridge: IEEE. doi:10.1109/ISMAR.2008.4637362
- Dunleavy, M. (2014). Design principles for augmented reality learning. *TechTrends*, 58(1), 28–34. doi:10.1007/s11528-013-0717-2
- Dunleavy, M., & Dede, C. (2014). Augmented reality teaching and learning. In J. M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (Eds.), *The Handbook of Research on Educational Communications and Technology* (Fourth Edi., pp. 5–8). New York: Springer. Retrieved from [http://link.springer.com/chapter/10.1007/978-1-4614-3185-5\\_59](http://link.springer.com/chapter/10.1007/978-1-4614-3185-5_59)
- Elinich, K. J. (2011). *Augmented hands-on: an evaluation of the impact of augmented reality technology on informal science learning behaviour*. Pepperdine University, Malibu, California, United States of America. Retrieved from <http://pepperdine.contentdm.oclc.org/cdm/ref/collection/p15093coll2/id/123>
- Epstein, M., & Vergani, S. (2006). History unwired: mobile narrative in historic cities. In *Proceedings of the Working Conference on Advanced Visual Interfaces - AVI '06* (pp. 302–305). Venezia, Italy: ACM. doi:10.1145/1133265.1133327
- Etzeberria, A. I., Asensio, M., Vicent, N., & Cuenca, J. M. (2012). Mobile devices: a tool for tourism and learning at archaeological sites. *International Journal of Web Based Communities (IJWBC)*, 8(1), 57–72. Retrieved from [http://www.researchgate.net/profile/Jose\\_Lopez55/publication/220131865\\_Mobile\\_devices\\_a\\_tool\\_for\\_tourism\\_and\\_learning\\_at\\_archaeological\\_sites/links/00b495325c75f67c9e000000.pdf](http://www.researchgate.net/profile/Jose_Lopez55/publication/220131865_Mobile_devices_a_tool_for_tourism_and_learning_at_archaeological_sites/links/00b495325c75f67c9e000000.pdf)
- Falk, J., & Storksdieck, M. (2005). Using the contextual model of learning to understand visitor learning from a science center exhibition. *Science Education*, 89(5), 744–778. doi:10.1002/sci.20078
- Field, A. P. (2005). *Discovering statistics using SPSS* (2<sup>nd</sup> Edit.). London: Sage.

- Fritz, F., Susperregui, A., & Linaza, M. T. (2005). Enhancing cultural tourism experiences with augmented reality technologies. In M. Mudge, N. Ryan, & R. Scopigno (Eds.), *6th International Symposium on Virtual Reality, Archaeology and Cultural Heritage (VAST 2005)*. Pisa, Italy: The Eurographics Association 2005. Retrieved from <http://public-repository.epoch-net.org/publications/VAST2005/shortpapers/short2005.pdf>
- Gargalakos, M., & Rogalas, D. (2011). The EXPLOAR project: Visualizing the invisible. In A. Lazoudis, H. Salmi, & S. Sotiriou (Eds.), *Proceedings of the Science Center To Go Workshops* (pp. 51–61). Ellinogermaniki Agogi.
- Geerts, G. L. (2011). A design science research methodology and its application to accounting information systems research. *International Journal of Accounting Information Systems*, 12(2), 142–151. doi:10.1016/j.accinf.2011.02.004
- Grafe, M., Wortniann, R., & Westphal, H. (2002). AR-based interactive exploration of a museum exhibit. In *the First IEEE International Augmented Reality Toolkit Workshop*. doi:10.1109/ART.2002.1106945
- Gumbel, M., & Yasko, G. (2011). *OpenGL (open graphic library)*. Retrieved June, 28<sup>th</sup>, 2015, from <http://whatis.techtarget.com/definition/OpenGL-Open-Graphics-Library>
- Hair, Jr., Joseph, F., Black, William, C., Babin, Barry, J., & Anderson, Ralph, E. (2010). *Multivariate data analysis*. (P.-P. Hall, Ed.) (Seventh Ed.). USA: Prentice Hall.
- Ham, S. H. (1992). What is interpretation? In *Environmental interpretation: A practical guide for people with big ideas and small budgets* (pp. 3–51). Golden, Colorado, USA: North American Press.
- Hassenzahl, M. (2003). The thing and i: understanding the relationship between user and product. In M. A. Blythe, A. F. Monk, K. Overbeeke, & P. C. Wright (Eds.), *Funology from usability to enjoyment* (pp. 31–42). Dordrecht, Netherlands: Kluwer Academic Publishers.
- Hein, G. E. (1995). The constructivist museum. *Journal for Education in Museums*, (16), 21–23. Retrieved from <http://www.gem.org.uk/pubs/news/hein1995.php>
- Hevner, A., & Chatterjee, S. (2010). Design science research in information systems. In *Design research in informatuon systems: Theory and practice* (Vol. 22, pp. 9–22). Boston, MA: Springer US. doi:10.1007/978-1-4419-5653-8
- Holden, W. (2011). *Press Release: Mobile augmented reality attracts leading brands as Juniper Research forecasts \$1.5 billion revenue stream by 2015*. Retrieved from <http://www.juniperresearch.com/viewpressrelease.php?pr=225>
- Höllerer, T. H., & Feiner, S. K. (2004). Mobile augmented reality. In H. Karimi & A. Hammad (Eds.), *Telegeoinformatics: Location-based computing services* (pp. 1–39). London, UK: Taylor & Francis Books Ltd. Retrieved from [http://web.cs.wpi.edu/~gogo/courses/imgd5100\\_2012f/papers/Hollerer\\_AR\\_2004.pdf](http://web.cs.wpi.edu/~gogo/courses/imgd5100_2012f/papers/Hollerer_AR_2004.pdf)
- International Council on Monuments and Sites. (2008). *Interpretation and*



*presentation of cultural heritage sites*. Retrieved from [http://international.icomos.org/charters/interpretation\\_e.pdf](http://international.icomos.org/charters/interpretation_e.pdf)

- International Standard Organization. (1999). *Human-Centred Design Processes for Interactive Systems*, ISO 13407
- Ismail, I., Harun, S. N., & M. Zin, M. R. (2006). A perception survey of domestic tourists towards historical buildings in Ipoh Town, Malaysia. *Proceedings of the Fifth Asia Pacific for Graduate Student Research Tourism*, 20<sup>th</sup>-22<sup>nd</sup> of September, 2006, Bangkok, Thailand (pp. 661-662). Retrieved from [https://www.academia.edu/5950378/A\\_PERCEPTION\\_SURVEY\\_OF\\_DOMESTIC\\_TOURISTS\\_TOWARDS\\_HISTORICAL\\_BUILDINGS\\_IN\\_IPOH\\_TOWN\\_MALAYSIA](https://www.academia.edu/5950378/A_PERCEPTION_SURVEY_OF_DOMESTIC_TOURISTS_TOWARDS_HISTORICAL_BUILDINGS_IN_IPOH_TOWN_MALAYSIA)
- iTacitus. (2007). Retrieved from [itacitus.org](http://itacitus.org)
- Izkara, J. L., Pérez, J., Basogain, X., & Borro, D. (2007). Mobile augmented Reality, an advanced tool for the construction sector. In *Proceedings of CIB 24th W78 Conference* (pp. 453-460). Maribor, Slovakia.
- Jaramillo, G. E., Quiroz, J. E., Cartagena, C. A., Vivares, C. A., & Branch Bedoya, J. W. (2010). Mobile augmented reality applications in daily environments. *Revista EIA*, (14), 125-134. Retrieved from <http://dialnet.unirioja.es/servlet/articulo?codigo=3669780&info=resumen&idoma=POR>
- Jokisalo, E., & Riu, A. (2004). Informal learning in the era of Web 2.0. *Education*, Vol. 14, 1-6. Retrieved from <http://www.elearningeuropa.info/files/media/media19656.pdf>
- Kamarainen, A. M., Metcalf, S., Grotzer, T., Browne, A., Mazzuca, D., Tutwiler, M. S., & Dede, C. (2013). EcoMOBILE: integrating augmented reality and probeware with environmental education field trips. *Computers and Education*, 68(10), 545-556. doi:10.1016/j.compedu.2013.02.018
- Kettanurak, V. (Nui), Ramamurthy, K., & Haseman, W. D. (2001). User attitude as a mediator of learning performance improvement in an interactive multimedia environment: an empirical investigation of the degree of interactivity and learning styles. *International Journal of Human-Computer Studies*, 54(4), 541-583. doi:10.1006/ijhc.2001.0457
- Kim, J., & Park, C. (2011). Development of mobile AR tour application for the national palace museum of Korea. In *2011 International Conference on Virtual and Mixed Reality : New Trends- Volume Part 1* (pp. 55-60). Orlando, FL, USA: Springer Berlin Heidelberg. doi:10.1007/978-3-642-22021-0\_7
- Klopper, E., & Squire, K. (2008). Environmental detectives-the development of an augmented reality platform for environmental simulations. *Educational Technology Research and Development*, 56, 203-228. doi:10.1007/s11423-007-9037-6
- Kretschmer, U., Coors, V., Darmstadt, D., Spierling, U., Grasbon, D., De, D. G., Schneider, K., Rojas, I., Malaka, R., & De, R. M. (2001). Meeting the spirit of history. In *Proceedings of the 2001 Conference on Virtual Reality, Archaeology*

and Cultural Heritage (VAST'01) (pp. 141–152). New York, New York, USA: ACM. doi:10.1145/584993.585016

Layar. (n.d.). Retrieved from <https://www.layar.com/>

Lazar, J., Feng, J. H., & Hochheiser, H. (2010). *Research methods in human and computer animation*. West Sussex, United Kingdom: John Wiley & Sons Ltd.

Light, D. (1995a). Heritage as informal education. In D.T. Herbert (Ed.), *Heritage, tourism and society* (pp. 117–145). Mansell: London.

Light, D. (1995b). Visitors' use of interpretive media at heritage sites. In D. J. Timothy (Ed.), *Managing heritage and cultural tourism resources* (pp. 184–266). Hampshire, England: Ashgate Publisheng Limited.

Lin, A. C. H., Fernandez, W. D., & Gregor, S. (2012). Understanding web enjoyment experiences and informal learning: a study in a museum context. *Decision Support Systems*, 53(4), 846–858. doi:10.1016/j.dss.2012.05.020

Lin, A. C. H., Gregor, S., & Ewing, M. (2008). Developing a scale to measure the enjoyment of web experiences. *Journal of Interactive Marketing*, 22(4), 40–57. doi:10.1002/dir.20120

Liu, T., Tan, T., & Chu, Y. (2009). Outdoor natural science learning with an RFID-supported immersive ubiquitous learning environment. *Educational Technology and Society*, 12(4), 161–175. Retrieved from [http://www.ifets.info/journals/12\\_4/15.pdf](http://www.ifets.info/journals/12_4/15.pdf)

Lowry, C. M. (1989). Supporting and facilitating self-directed learning. *ERIC Digest*, 93, 1–4. Retrieved from <http://files.eric.ed.gov/fulltext/ED312457.pdf>

Lukman, E. (2013). BootstrapsAccelerator asia selects 3 malaysian startups for July intake, opens doors for publications. Retrieved from <https://www.techinasia.com/bootstrapaccelerator-asia-selects-malaysian-startups/>

Majid, N. A. A. (2013). Application of mobile augmented reality in computer science course. In and S. V. Halimah Badioze Z, P. Robinson, P. Olivier, T. K. Shih (Ed.), *Advanced in Visual Informatics* (pp. 516–525). Springer International Publishing. doi:10.1007/978-3-319-02958-0\_47

Malpas, J. (2007). Cultural Heritage in the Age of New Media. In Y. Kalay, T. Kvan, & J. Affleck (Eds.), *New Heritage: New Media and Cultural Heritage* (pp. 13–26). Oxon: Routledge.

March, S. T., & Smith, G. F. (1995). Design and natural science research on information technology. *Decision Support Systems*, 15(4), 251–266. doi:10.1016/0167-9236(94)00041-2

MarketingCharts. (2011). *Mobile AR value near \$1.5B by '15*. Retrieved from <http://www.marketingcharts.com/online/mobile-ar-value-near-15b-by-15-15943/>

Marimon, D., Sarasua, C., Carrasco, P., Álvarez, R., Montesa, J., Adamek, T., ... Gascó, P. (2010). MobiAR: tourist experiences through mobile augmented

- reality. In *Proceedings of 2010 NEM Summit*. Barcelona, Spain.
- Marsick, V. J., & Watkins, K. E. (2001). Informal and incidental learning. *New Directions for Adult and Continuing Education*, 2001(89), 25–34. doi:10.1002/ace.5
- Mayer, R. E. (2003). The promise of multimedia learning: using the same instructional design methods across different media. *Learning and Instruction*, 13(2), 125–139. doi:10.1016/S0959-4752(02)00016-6
- Mayer, R. E. (2005). *The cambridge handbook of multimedia learning*. Cambridge: Cambridge University Press.
- Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist*, 38(1), 43–52. doi:10.1207/S15326985EP3801\_6
- McCutcheon, M. (2003). *Roget's super thesaurus*. (K. Nickell & M. Ruberg, Eds.) (Third Edit.). Cincinnati, Ohio: Writer's Digest Books.
- Mestre, J. (2002). *Transfer of learning: issues and research agenda*. Arlington, VA: National Science Foundation. Arlington. Retrieved from <http://www.nsf.gov/pubs/2003/nsf03212/nsf03212.pdf>
- Melaka Museum Corporations. (2013)
- Milgram, P., Takemura, H., Utsumi, A., & Fumio, K. (1994). A class of displays on the reality-virtuality continuum. In *SPIE Proceedings Volume 2351: Telemicroscopy and Telepresence Technologies* (Vol. 2351, pp. 282–292). Boston, MA. Retrieved from [http://web.cs.wpi.edu/~gogo/hive/papers/Milgram\\_Takemura\\_SPIE\\_1994.pdf](http://web.cs.wpi.edu/~gogo/hive/papers/Milgram_Takemura_SPIE_1994.pdf)
- Mocker, D. W., & Spear, G. E. (1982). Lifelong learning: formal, nonformal, informal, and self-directed. *Information Series*, 241.
- Mohammed-Amin, R. K., Levy, R. M., & Boyd, J. E. (2012). Mobile augmented reality for interpretation of archaeological sites. In *Proceedings of the second international ACM workshop on Personalized access to cultural heritage - PATCH '12* (pp. 11–14). Nara, Japan: ACM. doi:10.1145/2390867.2390871
- Moscardo, G. (1996). Mindful visitors: heritage and tourism. *Annals of Tourism Research*, 23(2), 376–397. doi:10.1016/0160-7383(95)00068-2
- Moscardo, G. (2001). Cultural and Heritage Tourism : The Great Debates. In B. Faulkner, G. Moscardo, & E. Laws (Eds.), *Tourism in the 21st Century: Lessons from Experience* (pp. 3–16). London: Continuum.
- Nofal, E. M. (2015). Taking advantages of augmented reality technology in museum visiting experience. In *6th International Congress "Science and Technology for the Safeguard of Cultural Heritage in the Mediterranean Basin."* Athens, Greece. Retrieved from [https://www.researchgate.net/profile/Eslam\\_Nofal/publication/258510269\\_Taking\\_Advantages\\_of\\_Augmented\\_Reality\\_Technology\\_in\\_Museum\\_Visiting\\_Experience/links/02e7e533004591a458000000.pdf](https://www.researchgate.net/profile/Eslam_Nofal/publication/258510269_Taking_Advantages_of_Augmented_Reality_Technology_in_Museum_Visiting_Experience/links/02e7e533004591a458000000.pdf)

- Noh, Z., Sunar, M. S., & Pan, Z. (2009). A review on augmented reality for virtual heritage. In M. Chang, R. Kuo, Kinshuk, G.-D. Chen, & M. Hirose (Eds.), *4th International Conference on E-Learning and Games: Learning by Playing. Game-based Education System Design and Development* (pp. 50–61). Springer-Verlag Berlin, Heidelberg. doi:10.1007/978-3-642-03364-3\_7
- Norman, D. A. (2014). Some observations on mental model. In D. Gentner & A. L. Stevens (Eds.), *Mental models* (p. 7). New York, New York, USA: Psychology Press.
- Olsson, T. (2012). *User expectations and experiences of mobile augmented reality services. Thesis*. Retrieved from <http://dspace.cc.tut.fi/dpub/handle/123456789/21226>
- Ortman, E., & Swedlund, K. (2012). *Guidelines for user interactions in mobile augmented reality*. Umeå University, Sweden.
- Oui, W. W., Ng, E. G. ., & Khan, R. U. (2011). An augmented reality's framework for mobile. In *Proceedings of the 5th International Conference on It & Multimedia at UNITEN (ICIMU 2011) Malaysia, 14-16 November, 2011* (pp. 1–4). Kuala Lumpur: IEEE. doi:10.1109/ICIMU.2011.6122762
- Owen, M., Owen, S., Barajas, M., & Trifonova, A. (2011). Pedagogic issues and questions from the science centre to go, augmented reality, project implementation. In *EDEN-2011 Open Classroom Conference, Augmented Reality in Education*, (pp. 13–30). Athens, Greece.
- Packer, J. (2004). *Motivational factors and the experience of learning in educational leisure settings*. Queensland University of Technology, Australia. Retrieved from <http://core.ac.uk/download/pdf/10884610.pdf>
- Packer, J. (2006). Learning for fun: the unique contribution of educational leisure experiences. *Curator*, 49(3), 329–344. doi:10.1111/j.2151-6952.2006.tb00227.x
- Papagiannakis, G., Ponder, M., Molet, T., & Kshirsagar, S. (2002). LIFEPLUS : Revival of Life in Ancient Pompeii. In *8th International Conference on Virtual Systems and Multimedia (VSMM '02)* (pp. 1–11).
- Papagiannakis, G., Singh, G., & Magnenat-thalmann, N. (2008). A survey of mobile and wireless technologies for augmented reality systems. *Computer Animation and Virtual Worlds*, 19(1), 3–22. doi:10.1002/cav
- Park, D., Nam, T.-J., & Shi, C.-K. (2006). Designing an immersive tour experience system for cultural tour sites. In *CHI '06 Extended Abstracts on Human Factors in Computing Systems* (pp. 1193–1198). New York, New York, USA: ACM Press. doi:10.1145/1125451.1125675
- Park, D.-J., Hwang, S.-H., Kim, A.-R., & Chang, B.-M. (2007). A Context-Aware Smart Tourist Guide Application for an Old Palace. *2007 International Conference on Convergence Information Technology (ICCIT 2007)*, 89–94. doi:10.1109/ICCIT.2007.211
- Pempek, T. a., Yermolayeva, Y. a., & Calvert, S. L. (2009). College students' social networking experiences on Facebook. *Journal of Applied Developmental*

*Psychology*, 30(3), 227–238. doi:10.1016/j.appdev.2008.12.010

- Pendit, U. C., Zaibon, S. B., & Abu Bakar, J. A. (2014). Mobile augmented reality for enjoyable informal learning in cultural heritage site. *International Journal of Computer Applications*, 92(14), 19–26. Retrieved from <http://research.ijcaonline.org/volume92/number14/pxc3895286.pdf>
- Perry, J., Klopfer, E., Norton, M., & Ave, M. (2008). AR gone wild: two approaches to using augmented reality learning games in zoos. In *Proceedings of the 8th International Conference for the Learning Sciences, ICLS '08* (pp. 322–329). Utrecht, Netherlands. Retrieved from <http://web.mit.edu/marleigh/www/portfolio/Files/argonewild.pdf>
- Pospischil, G., Umlauft, M., & Michlmayr, E. (n.d.). Designing LoL@, a mobile tourist guide for UMTS. In *Proceedings of the 4th International Symposium on Mobile Human-Computer Interaction* (pp. 140–154). Springer-Verlag London, UK. Retrieved from <http://dl.acm.org/citation.cfm?id=758125>
- Pulli, K., Chen, W.-C., Gelfand, N., Grzeszczuk, R., Tico, M., Vedantham, R., Grzeszczuk, R., Tico, M., Vedantham, R., Wang, X., & Xiong, Y. (2009). Mobile visual computing. In *2009 International Symposium on Ubiquitous Virtual Reality* (pp. 3–6). IEEE. doi:10.1109/ISUVR.2009.12
- Reitmayr, G., & Schmalstieg, D. (2001). Mobile collaborative augmented reality. *Proceedings IEEE and ACM International Symposium on Augmented Reality*, 114–123. doi:10.1109/ISAR.2001.970521
- Roos, D. (2007). How to leverage API for conferencing. Retrieved from <http://money.howstuffworks.com/business-communications/how-to-leverage-an-api-for-conferencing.htm>
- Roussou, M. (2004). Learning by doing and learning through play: an exploration of interactivity in virtual environments for children. *ACM Computers in Entertainment*, 2(1), 1–23. doi:10.1145/973801.973818
- Sacco, K., & Bucciarelli, M. (2008). The role of cognitive and socio-cognitive in learning to reason. *Mind & Society*, 7(1), 1–19. Retrieved from [http://www.psych.unito.it/csc/pers/bucciarelli/pdf/2008\\_MindSoc.pdf](http://www.psych.unito.it/csc/pers/bucciarelli/pdf/2008_MindSoc.pdf)
- Sarif, S. M. (2011). *Conceptual design model of computerized personal-decision aid (CompPDA)*. Universiti Utara Malaysia. Retrieved from <http://etd.uum.edu.my/2803/>
- Schneiderman, B. (1992). *Designing the user interface: strategies for effective human-computer interaction*. Reading, MA: Addison-Wesley Longman.
- Schugurensky, D. (2000). *The forms of informal learning: towards a conceptualization of the field*. Toronto, Canada. Retrieved from <https://tspace.library.utoronto.ca/bitstream/1807/2733/2/19formsofinformal.pdf>
- Schwartz, D., & Bransford, J. D. (2005). Efficiency and innovation in transfer. *Transfer of Learning from a Modern Multidisciplinary Perspective*, (3), 1–51. doi:10.1111/j.1365-2133.2005.06492.x
- Sefton-Green, J. (2004). *Literature review in informal learning with technology*

- outside school* (Report No. 7). Bristol, United Kingdom: Futurelab. Retrieved from [http://www2.futurelab.org.uk/resources/documents/lit\\_reviews/Informal\\_Learning\\_Review.pdf](http://www2.futurelab.org.uk/resources/documents/lit_reviews/Informal_Learning_Review.pdf)
- Sekaran, U. (2003). *Research methods for business: a skills-building approach* (4th editio.). USA:John Wiley & Sons, Inc.
- Seo, B., Kim, K., & Park, J.-I. (2011). Augmented reality-based on-site tour guide: a study in Gyeongbokgung. In R. Koch & F. Huang (Eds.), *the 2010 International Conference on Computer Vision - Volume part 2* (pp. 276–285). Springer-Verlag Berlin, Heidelberg. doi:10.1007/978-3-642-22819-3\_28
- Shea, P. O., Mitchell, R., Johnston, C., & Dede, C. (2009). Lessons learned about designing augmented realities. *Int'l Journal of Gaming and Computer-Mediated Simulations*, 1(March), 1–15. Retrieved from [http://isites.harvard.edu/fs/docs/icb.topic443490.files/Final\\_IJCCMS.pdf](http://isites.harvard.edu/fs/docs/icb.topic443490.files/Final_IJCCMS.pdf)
- Shiratuddin, N., & Hassan, S. (2013). *Design Research in Software Development: Constructing and Linking Research Questions, Objectives, Methods and Outcomes* (Second Edi.). Sintok: UUM Press.
- Smith, M. K. (1996). Informal learning. *the encyclopaedia of informal education*. Retrieved July 3, 2013, from <http://infed.org/mobi/informal-learning-theory-practice-and-experience/>
- Social Compare. (2015). *Augmented Reality SDK Comparison*. Retrieved from <http://socialcompare.com/en/comparison/augmented-reality-sdks>
- Sung, Y. -T., Hou, H. -T., Liu, C. -K., & Chang, K. -E. (2010). Mobile guide system using problem-solving strategy for museum learning: A sequential learning behavioral pattern analysis. *Journal of Computer Assisted Learning*, 26, 106-115
- Tay, D. (2015). *Augmented reality ads platform Playme AR wins Malaysian edition of Tech in Asia Tour*. Retrieved from <https://www.techinasia.com/playme-ar-wins-tech-in-asia-tour-malaysia/>
- Techcooltour. (2013). *Techcooltour*. Retrieved from <http://www.techcooltour.com/en/>
- Tejlingen, V. E., & Hundley, V. (2014). The importance of pilot study. *Nursing Standard*, 16(40), 33–36. Retrieved from [rcnpublishing.com](http://rcnpublishing.com)
- Tilden, F. (1977). *Interpreting our heritage. Interpreting our heritage* (Third Edit.). Chapel Hill: University of North Carolina Press.
- Timothy, D. J., & Boyd, S. W. (2003). *Heritage tourism* (First Edit.). Essex, England: Pearson Education Limited Ltd.
- Toh, Y.-W., Jeung, J.-H., & Pan, Y.-H. (2010). A combined user research process for designing mobile AR guide in cultural heritage. *2010 IEEE International Symposium on Mixed and Augmented Reality - Arts, Media, and Humanities*, (M), 71–72. doi:10.1109/ISMAR-AMH.2010.5643287

- Vaishnavi, V. K., & Kuechler, W. J. (2008). *Design science research methods and patterns: innovating information and communication technology*. Boca Raton, FL: Taylor & Francis Groups.
- Vallino, J. R. (1998). *Interactive augmented reality*. University of Rochester. Retrieved from <http://yogi.se.rit.edu/~jrv/publications/VallinoThesis.pdf>
- Vlahakis, V., Ioannidis, N., Karigiannis, J., Tsotros, M., & Gounaris, M. (2002). Virtual reality and information technology for archaeological site promotion. In *Proc. 5th International Conference on Business Information Systems (BIS02)*.
- Vlahakis, V., Karigiannis, J., Tsotros, M., Gounaris, M., Almeida, L., Stricker, D., Gleue, T., Christou, I. T., Carlucci, R., & Ioannidis, N. (2001). ARCHEOGUIDE: first results of an augmented reality, mobile computing system in cultural heritage sites. In *Conference on Virtual Reality, Archaeology and Virtual Heritage (VAST)* (pp. 131–140). ACM. doi:10.1145/584993.585015
- Vuforia. (2015). Retrieved from <https://developer.vuforia.com/>
- Wagner, D. (2007). *Handheld augmented reality*. Graz University of Technology, Graz, Austria. Retrieved from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.245.413&rep=rep1&type=pdf>
- Waite, M., Hollingworth, L., & Marshall, D. (Eds.). (2008). *Compact oxford thesaurus* (Third Edit.). Oxford: Oxford University Press.
- Walker, K. B. (2007). *The role of interpretation in sustainable tourism: a qualitative approach to understanding passenger experiences on expedition cruises*. James Cook University, Queensland, Australia. Retrieved from <http://researchonline.jcu.edu.au/2098/2/02whole.pdf>
- Warner, R. (1980). Enjoyment. *The Philosophical Review*, 89(4), 507–526. doi:10.2307/2184734
- White, M., Mourkoussis, N., Darcy, J., Petridis, P., Liarokapis, F., Lister, P., Walczak, K., Wojciechowski, R., Cellary, W., Chmielewski, J., Wiza, W., Patel, M., Stevenson, J., Manley, J., Giorgini, F., Sayd, P., & Gaspard, F. (2004). ARCO — an architecture for digitization, management and presentation of virtual exhibitions. In *Proceedings of the Computer Graphics International, June* (pp. 622–625). Crete: IEEE. Retrieved from [http://ieeexplore.ieee.org/xpls/abs\\_all.jsp?arnumber=1309277&tag=1](http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=1309277&tag=1)
- Wikitude. (n.d.). Retrieved from <http://www.wikitude.com/>
- Zikmund, W. G. (2003). *Business research methods* (Seventh Ed.). Mason, Ohio: South-Western: Thomson Learning.
- Zikmund, William G., Babin, Barry J., Carr, Jon C., & Griffin, M. (2010). *Business research methods* (Seventh Ed.). Cincinnati, Ohio, USA: South-Western College Pub.
- Zoellner, M., Stricker, D., Bleser, G., & Pastarmov, Y. (2007). iTACITUS – novel interaction and tracking paradigms for mobile AR. In D. Arnold (Ed.), *The European Research Network of Excellence in Open Cultural Heritage*

(*EPOCH*) (pp. 110–117). Budapest: Archaeolingua. Retrieved from [https://www.researchgate.net/publication/242559707\\_iTACITUS\\_-\\_Novel\\_Interaction\\_and\\_Tracking\\_Paradigms\\_for\\_Mobile\\_AR](https://www.researchgate.net/publication/242559707_iTACITUS_-_Novel_Interaction_and_Tracking_Paradigms_for_Mobile_AR)

