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Towards Design Patterns for Augmented Reality Serious Games

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Abstract. For professional workers today, keeping up with knowledge and the continuous technology progress is challenging. Increased innovation speed and dynamic work situations shorten preparation times for new tasks significantly. Traditional professional training approaches preparing employees for new tasks are becoming inappropriate. Thus new educational means are needed. These would help employees get acquainted with new situations faster and more efficiently.
According to learning theories such as action learning and situated learning, which embed the learning process in the application context and challenge the learner to be actively involved help to improve the learning process. These theories are the basis for mobile learning and serious games. From research in Serious Games we know that games have the potential to actively involve learners and to immerse them in a learning situation and increase their engagement.
With Augmented Reality (AR) and wearable devices a new generation of tools and applications becomes available, which inherently are mobile, contextualized and personalized. First successful application scenarios show the potential of these new technologies for education and training.
While the application of game-design patterns to learning processes help to systematically design learning games supporting specific learning outcomes, an empirically tested, systematic approach towards the design of AR-based learning solutions is still missing.
Based on the state of the art in AR research and in applying design patterns for serious games, we consequently propose a research methodology to apply game design patterns to augmented reality-based learning games for the training of professionals in dynamic situations.

Keywords: augmented reality, mobile serious games, game-design patterns

1 Introduction

We live in a complex society where technology and knowledge are changing at a very fast rate (Aleandri & Refrigeri, 2013). In today's 'high performance organizations', workers must be prepared for continuous growth and development on-the-job (ERIC Digest).

"In such fast-moving working contexts, skills and competences rapidly become out-dated and need to be continuously implemented and empowered as a strategic factor for global competitiveness. Traditional models of learning both inside and outside of the workplace have become unable to explain the complexity of such a process" (Manuti *et al*. 2015)

In this context, learning plays an important role "in individual career development and organizational success". To better underline how important learning is in the workplace, Sambrook (2005) described the concept of *workplace learning*. His work is very connected with Eruat (2000) and gives an important contribution to the clarification of its meaning by distinguishing between different types of context where the learning process takes place:

- Learning *at* work: associated with planned training and education courses;
- Learning *in* work: correlated with the more informal processes implied in these activities, such as discussing, observing, asking questions, solving problems;
- Learning *outside* work: connected with the idea that some forms of learning could also occur outside the boundaries of the work setting.

Besides, these distinctions foster an easier parallelism with the formal, informal and non-formal learning definition retrieved from the educational/instructional field. This is why "in all or nearly all situations where learning takes place, elements of both formal and informal learning are present" (Manuti *et al.* 2015).

This concept is in line with the following learning theories: action learning theory, based on the idea that learning requires action in a *context* (formal or informal) and reciprocally action requires learning (Lewis & Williams, 1994). Furthermore the situated learning theory is based on the premise that knowledge is not independent, but fundamentally situated; a product of the activity, *context* (either formal or informal), and culture within which it is developed (Brown, 1998). Last but not least, according to the mobile learning theory, learning cannot be separated from everyday activities: it is integrated with non-learning tasks such as shopping or entertainment; it is organized into projects that are interleaved with everyday activities. Therefore "learning needs emerge when a person strives to overcome a problem or breakdown in everyday activity" (Sharples *et al.* 2005).

These theories are also the fundament for game-based learning (Wu et al, 2012), where systematic approaches towards the design of applications have already been explored with respect to delivering / providing the needed skills (Johnson et al., 2011), the motivational potential (Carstens & Beck, 2010; Douch, & Savill-Smith, 2010) as well as their ability to address various target groups in the most effective way (Unterfauner *et al*. 2010; Liao *et al*. 2011).

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In the remainder of this paper we discuss Game Design Patterns (GDP) for serious games, the characteristics of Augmented Reality (AR) and propose a new research idea focused on transferring the pattern-based approach onto designing AR Serious Games.

2 Serious Games and Game-design Patterns

The Mobile Learning NETwork's (MoLeNET) review on learning game technologies suggests that mobile learning games provide potential for learning and teaching in terms of "assessment", "learner performance and skills development" or "social and emotional well-being" (Douch *et al.* 2010).

Still, the use of (mobile) serious games, as compared to the continuous boost in the games' market (GlobalCollect, 2013; PWC, 2010; National Gaming Survey, 2009) is limited (Arnab *et al.* 2012). Reasons for this are partly due to:

- The high technical demands required to design games or simulations (Goosen *et al.* 2001); game development is complex and thus hard to realise within the educational budgets (Westera *et al.* 2008).
- The difficulty to organise/customise Serious Games in a way that they fit into the educational process (Klopfer *et al.* 2009). Games are often designed for a specific purpose (and not customisable) or they require specialised customisation skills (which can hardly be done by a teacher/educator, who is usually not a game designer or developer).

In the Serious Games research field, an approach to help simplifying the design process for Serious Games is through applying a pattern-based approach as known from the branch of the entertainment games (Björk & Holopainen, 2004) and combining it with educational objectives (Kelle *et al*. 2011). While this approach has also successfully been applied to mobile learning games (Schmitz, 2014), little is known on how to systematically apply game-design patterns to augmented reality.

We agree with Schmitz (2014), claiming that "Generally, mapping learning outcomes, patterns and context information may lead to a better understanding of AR and pervasive games for learning and feasible results, which are suitable as a base for design guidelines that define (a) patterns, which support the achievement of a desired learning outcome and (b) ways of applying them".

In the recent literature, we found some work by Wetzel (2013), "*Design Patterns supporting the Development of Mobile Mixed Reality Games*", who used the pattern-based approach to design a game in AR/ mixed reality, but without providing any evaluation or evidence that indicates the connection between the game patterns used and their learning efficacy.

Considering the potential of AR for learning, which will be highlighted in the next paragraph, we consequently propose a research methodology that applies GDP to augmented reality-based learning games for the training of professionals in dynamic situations.

With our idea we propose to move two steps further from Wetzel's (2013) work by performing: (1) an evaluation of the patterns which are suitable for an AR Serious

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Games and (2) to study those patterns and understand the types of learning they are able to improve or stimulate in the users.

At this point clarification about the terms used is needed. What do we mean with game-pattern, what is it? Is it a game mechanic, an algorithm, or a concept more connected with pedagogy?

Computer game designers frequently use the term "game mechanic" both in the context of board games and that of technical programming (Lundgren & Björk, 2003; Ott *et al*. 2014).

Lundgren and Björk (2003) outline game mechanics as "any part of the rule system of a game that covers one, and only one, possible kind of interaction that takes place during the game, be it general or specific (…) mechanics are regarded as a way to summarize game rules". Cook's (2006) claims: "game mechanics are rule based system/simulations that facilitate and encourage a user to explore and learn the properties of their possibility space through the use of feedback mechanisms". "A typical mechanic is "roll and move" that simply states that the dice are rolled and that something else is moved depending on the outcome of the dice roll. The mechanic does not state how and why something should be moved; this is determined in the rules for the particular game" (Lundgren & Björk, 2003).

According to Björk & Holopainen (2003), however, we can look at patterns as a mean to support creative designing. Patterns are semiformal interdependent descriptions of commonly recurring parts of the design of a game that concern gameplay (McGee, 2007). Through them it is possible to describe how the components and the individual aspects of the game interact to create a gameplay experience.

The origin of the concept of "design patterns" hails from the field of architecture and in particular was coined by Christopher Alexander (McGee, 2007). The Design Pattern is a method of codifying design knowledge in separate but interrelated parts and has been used to describe game elements related to interaction. "The pattern approach has increasingly been applied to other areas such as the domain of educational science by way of pedagogical patterns (Kohls & Wedekind, 2011), for example, or to the design of digital games" (Schmitz, 2014).

The GDP approach, indeed, has been successfully used in Serious Games (Kelle, *et al*. 2011) and Mobile Games (Schmitz, 2014) and in the literature examples of "Design Patterns supporting the Development of Mobile Mixed Reality Games" (Wetzel, 2013) are already available.

Furthermore already in research the effects of AR solutions have been analysed, as will be shown in the next paragraph.

The purpose of this article is to highlight that AR Serious Games can be effective tools for training but need to be understood also how an AR game should be designed to be effective for learning.

3 Augmented Reality

In accordance with Bower *et al.* (2014) we believe that AR is "poised to profoundly transform education as we know it". Considering the widespread availability of the Internet, and the level of diffusion of mobile, smart and wearable devices, it is evident

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that technology is already part of our daily life. It is expected, that approaches towards AR will become a major trend in education and training once wearable glasses/devices and other display technologies become widely accessible to end-users (Freina & Ott, 2015).

AR can be considered as "a system that enhances a person's primary senses (vision, aural and tactile) with virtual or naturally invisible information made visible by digital means" (Specht, *et al.* 2011).

Thanks to a wide range of mobile devices, "AR is set to become a ubiquitous commodity for leisure and mobile learning. With this ubiquitous availability, mobile AR allows us to devise and design innovative learning scenarios in real world settings. This carries much promise for enhanced learning experiences in situated learning" (Specht *et al.* 2011).

The basic equipment/hardware needed for an AR system includes:

- Video camera to capture live images;
- Ample storage space for virtual objects;
- Powerful processor to either compose virtual and real objects or display a 3D-simulated environment in real time;
- An interface that allows the user to interact with both real and virtual objects (Bower *et al*. 2014) and
- Sensor infrastructure capable of identifying position, direction, movement (such as geo-localization system and head - or other part of the body - tracking movement sensor).

Due to its potential and the availability of the equipment needed for an AR system, it has been used in different contexts, such as medicine, military, entertainment, training, tourism, social networking, industrial applications, cultural heritage etc. Mobile AR has been used in different projects, a wide taxonomy of which is available in FitzGerald *et al.* (2013) work. Furthermore, the authors stress the educational potential of AR; they mention a series of studies that empirically indicate the efficiency of AR in

- Promoting engagement and motivation (Klopfer & Squire, 2008; Luckin & Stanton Fraser, 2011);
- Improving memorability, engagement (Luckin & Stanton Fraser, 2011) and motivation (Di Serio *et al.* 2012);
- Improving spatial skills (Martin-Gutierrez *et al.* 2011; Schmalstieg & Wagner, 2007);
- Supporting collaborative problem solving, (Cook 2010).

The use of AR in education has been profusely explored during the last decades, showing significant evidence of its benefits for learning (Muñoz-cristóbal, *et al.* 2014). It is now necessary to explain how and why this medium differs from others in the training context and what the advantages and disadvantages are for the learner, taking into consideration Radu's (2014) literature review: the author compared 26 academic papers and underlined the positive impact that AR experiences have had on learners, as compared to non-AR initiatives:

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- *Increased content understanding*: The studies examined by the author "generally indicate that students learn better when using AR than when using either printed media or using desktop software";
- *Long term memory retention:* Research indicates that "content learned through AR experiences is memorized better than through non-AR experience";
- *Improved physical task performance:* "Through an AR experience, maintenance tasks are performed with higher accuracy, and students are able to better transfer their learning to operate physical machinery";
- *Improved collaboration:* in the Morrison *et al.* (2009) study it is shown that the group who used AR to create a shared space, contrary to "the more individual experience of a student using a GPS mapping application";
- *Increased student motivation:* "user motivation remains significantly higher for AR systems (vs. the non-AR alternative) even when the AR experience is deemed more difficult to use than the non-AR alternative".

The added value that AR has compared with other delivery techniques/tools comprise:

- Multi-modal visualization of difficult theoretical concepts;
- Practical exploration of the theory through tangible examples;
- Natural interaction with multimedia representations of teaching material;
- Effective collaboration and discussion amongst the participants (Liarokapis & Anderson, 2010).

Starting from what has been highlighted until now, it is necessary to mention some disadvantages experienced by learners compared to non-AR systems, found in the literature and strictly connected with formal education, but relevant for our research idea:

1. Attention tunneling; in the studies reported by Radu (2014) it is shown that learners needed more attention than usual not only to live the experience but also to understand how to use the AR tool with the consequence of "ignoring important parts of the experience or feeling unable to properly perform team tasks";

*2. Usability difficulties; "*In several studies, users rate AR systems as more difficult to use than the physical or desktop-based alternatives";

3. Learner differences: people with high-achieving or cognitive disabilities have some problems; for example "low-ability readers did not learn from parts of the AR experience which presented textual content. This is not surprising, but it does reinforce the issue that educational tools must be well tailored to the capabilities of their audience".

Usability problems are also highlighted in Klemke *et al.* (2014), which also recognizes the potential of AR wearable devices in overtaking the attention tunneling problem by making the interaction and the user experience as much as natural, immersive and intuitive possible, avoiding also the need from the user to switch his/her attention between the task deployed in the augmented context and the device in his/her hand.

Bacca *et al.* (2014) performed a detailed systematic review of the state of the art in AR, analysing the field of education, the target group, the type of AR, the reported purposes, advantages, limitations, affordances and effectiveness of AR in educational settings. While a number of successful AR-cases can be found according to this re-

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view, only limited research has been devoted to analysing the combination of AR and Serious Games with respect to realizing professional training for adults (Furió *et al.* 2013). Especially, while systematic approaches towards the design of AR games are emerging (Wetzel, 2013), their underpinning with empirical research is still missing.

4 Conclusion: Applying Game-Design Patterns to Augmented Reality

While TEL-based educational approaches in general and game-based learning specifically proved to be helpful for learning, we found that research is needed studying the potential of AR based mobile learning games for professional educational scenarios. Especially, empirical evidence about how to design learning games using AR is missing.

Consequently, we propose to adopt the GDP approach as methodology, in order to investigate game design patterns suitable for AR games and determine whether they are effective for learning.

Therefore, empirical work is needed to understand which patterns are suitable for which type of learning (considering design, usability and learning outcome). A starting point for this work is the literature and previous research (Kelle, 2012; Schmitz, 2014); that demonstrated the empirical evidence of the efficacy of the GDP approach in Serious Games and Mobile Games. We now propose to move forward by transferring this functional methodology to a different field: AR, and by analysing, studying and in case designing suitable new patterns for AR games.

Below some design patterns already identified by the authors of this paper, which take advantage of AR potential, are listed:

- Localization: adding information related to the user's position and orientation;
- Video recording and view sharing: sharing the user's view with another user or an expert;
- Synchronous communication: using communication features while performing a task;
- Contextualization: enriching the current view by providing contextual information (e.g. distance to specific points);
- Object recognition: enhancing or enriching an object in the field of vision of the user;

We expect, that the utilization of these patterns in AR-based games can be beneficial to task performance and learning effects. However, little is known so far, when and how these patterns should be used in order to foster positive effects. Consequently, a mapping to educational objectives will further help to describe design processes towards the systematic application of GDP for AR games.

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References

Aleandri, G and Refrigeri, L (2013), *Lifelong learning, training and education in globalized economic systems: Analysis and Perspectives.* 'Third World Conference on Learning, Teaching and Educational Leadership – WCLTA 2012'. Held at Brussels. Published by Elsevier Ltd. Procedia - Social and Behavioral Sciences, 93, 1242 – 1248.

Arnab S, Berta R, Earp J, de Freitas S, Popescu M, Romero M, Stanescu I & Usart M 2012, 'Framing the Adoption of Serious Games in Formal Education', *Electronic Journal of e-Learning*, vol. 10, no. 2, pp. 159-171. Available from www.ejel.com

Bacca, J., Fabregat, R., Baldiris, S., Graf, S., & Kinshuk. (2014). Augmented reality trends in education: A systematic review of research and applications. Educational Technology & Society, 17, 133–149.

Björk S, Holopainen J (2004), *Patterns In Game Design*, Charles River Media.

Brown J S et al. (1988) 'Situated cognition and the culture of learning'. Technical report. Palo Alto, CA: Palo Alto Research Center.

Bower M, Howe C, McCredie N, Robinson A, & Grover D (2014). Augmented Reality in education – cases, places and potentials. *Educational Media International*, 51(1), 1–15.

Carstens A & Beck,J (2010). Get Ready for the Gamer Generation. *TechTrends*, 49(3), 22-25.

Cook D (2006). *What are game mechanics?* At http://www.lostgarden.com/2006/10/what-are-game-mechanics.html, 29 July 2015.

Cook J (2010). Mobile Phones as Mediating Tools within Augmented Contexts for Development. *International Journal of Mobile and Blended Learning*, 2(3), 1-12

Di Serio Á, Ibáñez M B, & Kloos C D (2012). Impact of an augmented reality system on students' motivation for a visual art course. *Computers & Education*, 1-11.

Douch R, Attewell J & Dawson D. (2010). *Games technologies for learning. More than just toys*. At http://goo.gl/mazqJ, 29 July 2015.

Douch R & Savill-Smith C (2010). *The Mobile Learning Network: The Impact of Mobile Game-Based Learning*. 'IADIS Int'l Conf. Mobile Learning 2010'. Held at Porto, 189-197.

ERIC Digest. *New Ways of Learning in the Workplace*. ERIC Digest, No. 161, 1-8. From https://archive.org/details/ERIC_ED385778, 29 July 2015.

Eruat M (2000). Non Formal learning and tacit knowledge in professional work. *British Journal of Educational Psychology*, 70 (1), 113-136.

FitzGerald E, Adams A, Ferguson R, Gaved M, Mor Y, Thomas R & Keynes M (2013). *Augmented reality and mobile learning: the state of the art*. '11th World Conference on Mobile and Contextual Learning (mLearn 2012)'. Held from October 16-18 at Helsinki, Finland, 62−69.

Freina L & Ott M (2015). *A Literature Review on Immersive Virtual Reality in Education: State Of The Art and Perspectives*. 'eLearning and Software for Education- eLSE'. Held from April 23-24 at Bucharest, Romania.

DRAFT

Furió D, González-Gancedo S, Juan M-C, Seguí I & Rando N (2013). Evaluation of learning outcomes using an educational iPhone game vs. traditional game. *Computers & Education*, 64, 1–23.

GlobalCollect (2013). The Global Mmo Games Market: Payments, Intelligence and Trends. *GlobalCollect Video Gaming Payments: knowledge series*, Edition 2, July 2013. From http://info.globalcollect.com/gaming-report-lading-page/

Goosen K R, Jensen R & Wells R (2001). Purpose and learning benefits of simulations: A design and development perspective. *Simulation & Gaming*, 32(1), 21-39.

Johnson L, Levine A, Smith R & Stone S (2011). 'The 2011 Horizon Report'. Aus-tin, Texas: The New Media Consortium.

Kelle S, Klemke R, Gruber M & Specht M (2011). *Standardization of Game Based Learning Design.* 'International Conference on Computational Science and Applications'. Held from June 20-23, 2011 at Santander, Spain. Published by Springer, Heidelberg, Berlin.

Kelle, Sebastian (2012, 9 November) Game Design Patterns for Learning. Doctoral dissertation, Open Universiteit in the Netherlands, Heerlen, The Netherlands. SIKS Dissertation Series No. 2012-41. Publisher: Shaker Verlag, Aachen.

Klemke R, Ternier S, Kalz M, Schmitz B & Specht M (2014). Immersive Multi-user Decision Training Games with AR- Learn. In Rensing C, de Freitas S, Ley T, Muñoz-Merino P (Eds.), *Open Learning and Teaching in Educational Communities*. '9th European Conference on Technology Enhanced Learning (EC-TEL)', Lecture Notes in Computer Science 8719, 207-220. Springer International Publishing.

Kohls C & Wedekind J (2011). *Investigations of E-Learning Patterns: Context Factors, Problems and Solutions*. IGI Global, Hershley, PA.

Klopfer E, Osterweil S & Salen K (2009). *Moving Learning Games Forward, Obstacles Opportunities & Openness*. Cambridge MA: MIT/The Education Arcade. From http://education.mit.edu/papers/MovingLearningGamesForward_EdArcade.pdf

Lewis L H & Williams C J (1994). Experiential Learning: Past and Present. *New Directions For Adult And Continuing Education*, 62, 5-16.

Liao C C Y, Chen Z-H, Cheng H N H, Chen F-C & Chan T-W (2011). My-Mini-Pet: a handheld pet-nurturing game to engage students in arithmetic practices. *Journal of Computer Assisted Learning*, 27(1), 76-89.

Liarokapis F & Anderson E F (2010). Using Augmented Reality as a Medium to Assist Teaching in Higher Education. *Eurographics 2010*, 9 – 16.

Luckin R & Fraser D S (2011). Limitless or pointless? An Evaluation of Augmented Reality Technology in the School and Home. *Int. J. Technology Enhanced Learning*, 3 (5).

Lundgren S & Bjork S (2003). *Game mechanics: Describing computer-augmented games in terms of interaction*. 'First International Conference on Technologies for Interactive Digital Storytelling and Entertainment- TIDSE'. Held from March 24 – 26 at Darmstadt, Germany.

Manuti A, Pastore S, Scardigno A F, Giancaspro M L & Morciano D (2015). Formal and informal learning in the workplace: a research review. *International Journal of Training and Development*, 19(1), 1–17.

Martin S, Diaz G, Sancristobal E, Gil R, Castro M & Peire J (2011). New technology trends in education: Seven years of forecasts and convergence. *Computers & Education*, 57(3), 1893-1906. Elsevier Ltd

McGee K (2007). *Patterns and computer game design innovation*. '4th Australasian conference on Interactive entertainment'. Held for 3-5 December at Storey Hall University.

Morrison A, Oulasvirta A, Peltonen P, Lemmela S, Jacucci G, Reitmayr G, Nasanen J, Juustila A (2009). *Like bees around the hive: a comparative study of a mobile augmented*

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reality map. 'Conference on Human Factors in Computing Systems-SIGCHI'. ACM, 1889–1898.

Muñoz-cristóbal J A, Martínez-monés A, Asensio-pérez J I, Villagrá-sobrino S L & Hoyos-torío J E (2014). City Ads : Embedding Virtual Worlds and Augmented Reality in Everyday Educational Practice. *Journal of Universal Computer Science*, 20(12), 1670-1689.

National Gaming Survey (2009). *Detailed data of gaming in the Netherlands*. Newzo, TNS-NIPO. From: www.nationaalgamingonderzoek.nl

Ott M, Antonaci A, Dagnino FM, Bellotti F, Berta R, De Gloria A, Lavagnino E, Mayer I F, Romero M, Usart M (2014). A Gamified Collaborative Course in Entrepreneurship: Focus on Objectives and Tools. *Computers in Human Behavior,* 51, 1276–1283.

PWC (2010). *Global Entertainment and Media Outlook: 2010-2014*. From; http://www.pwc.com/

Radu I (2014). Augmented reality in education: a meta-review and cross-media analysis. *Personal and Ubiquitous Computing*, 18(6), 1533−1543.

Sambrook S (2005). Factors influencing the context and process of work-related learning: syn- thesizing findings from two research projects. *Human Resource Development International*, 8, 101–19.

Schmalstieg D & Wagner D (2007). Experiences with Handheld Augmented Reality. '6th IEEE and ACM International Symposium on Mixed and Augmented Reality'. Held for 13-16 Nov at Nara, Japan. Published on *Mixed and Augmented Reality, 2007. ISMAR 2007. 6th IEEE and ACM International Symposium on.* IEEE, 3-18.

Schmitz, Birgit (2014, 12 December). Mobile Games for Learning: A Pattern-Based Approach. Doctoral dissertation, Open Universiteit in the Netherlands, Heerlen, The Netherlands. SIKS Dissertation Series No. 2014-45

Sharples M, Taylor J & Vavoula G (2005). *Towards a Theory of Mobile Learning*. '4th World conference on mLearning'. Held from 25- 28 October 2005 at Cape Town, South Africa. 1, 1–9.

Specht M, Ternier S & Greller W (2011). Dimensions of Mobile Augmented Reality for Learning: A First Inventory. *Journal of the Research Center for Educational Technology*, 7(1), 117-127.

Unterfauner E, Marschalek I, Fabian C M (2010). Mobile Learning With Marginal-ized Young People. 'IADIS Int'l Conf. Mobile Learning 2010'. Held at Porto, 28-36.

Westera W, Nadolski R, Hummel H & Wopereis I (2008). Serious Games for Higher Education: a Framework for Reducing Design Complexity. *Journal of Computer-Assisted Learning*, 24(5), 420-432.

Wetzel R (2013). A Case for Design Patterns supporting the Development of Mobile Mixed Reality Games. *Foundations of Digital Games*. From http://www.fdg2013.org/program/workshops/papers/DPG2013/b6-wetzel.pdf

Wu W H, Hsiao HC, Wu P L, Lin C H & Huang S H (2012). Investigating the learning theory foundations of game based learning: a meta analysis. *Journal of Computer Assisted Learning*, 28(3), 265-279.

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