CASE STUDY: FROM REQUIREMENTS LIST TO AN EDUCATIONAL GAME

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Abstract

This paper explores the development process of an educational mobile game from the customer's initial requirements list to a functional multi-platform mobile game prototype. The game was targeted for students, lecturers and visitors and was aimed to work as a new experimental teaching method that would adapt to various locations and premises. The development process was based mLUX usability and user experience development framework for m-learning. The process was utilized in order to design an application prototype that would appeal both to the customer and to the application's target users. The customer had provided a preliminary list of application requirements in order to speed up the design and implementation phase of the mobile learning application prototype. After the initial application concept that was implemented using paper and wireframing tools, a functional multi-platform mobile application prototype was developed by utilizing the PhoneGap framework. Additionally, the game development process was used as a case study to assess the mLUX framework performance in various application contexts. This case study was done as a Bachelor of Science thesis at the HAAGA-HELIA University of Applied Sciences. The design and development process resulted in a mobile educational game that fulfilled the customer's and potential users' essential needs. Usability evaluation results demonstrated that the users were delighted with the application's functionalities, UI and performance.

Keywords: User centred Design, educational game and mobile learning application development

1 INTRODUCTION

Smartphones are popular gadgets among people nowadays as the popularity and penetration of these devices into our daily lives is increasing at a fast pace [1]. The penetration and the increased usage is a result of advancements in wireless technologies and capabilities of smartphones. Increased popularity has ensued smartphones to become more than a communication medium in our daily lives. Smartphones have now breached all sectors of our lives due to the technological advancements in e.g. in-device sensors, [2] and relatively cheap network connectivity costs. Application development for smart devices has become imperative for all sectors which are considered to have a growing factor in business revenue [3] as these devices have overcome the time and place constrains to be able to access potential customers at any time or any place. The number of mobile applications used for social networking, entertainment purposes, personal and professional use, as well as gaming, are increasing rapidly. These applications are constantly competing for users' time and attention for retention [4] as well as to sustain their usage. There are many factors that are involved in ensuring the application's retention and sustainability. The traditional usability assessments [5] are not enough, especially in case of m-learning applications, to make the application appealing enough to compete for the users' time. To make the application appealing enough, it is essential that the application is developed "for users by users" and not blindly by following functional requirements. This means that the application's target users and other possible stakeholders should be involved in the application's concept design, and their impact on the application has to be clearly clarified [6]. Moreover, the m-learning application is ought to attract the

user on an emotional level (Dirin, Nieminen & Kettunen, 2013). User-Centered design (UCD) framework for m-learning application development (Dirin & Alamäki, 2015; Dirin, Nieminen, 2015) is proven to be successful for designing and developing highly usable mobile learning applications. This framework puts intended users of the target application at the centre of the design and development process. Mobile learning application is complex by nature as it deals with learning and learners. This leads to the fact that designers of an m-learning application are often faced with two distinct challenges: 1. The application content must support and follow the pedagogical usability principles [10], 2. The user interface design (Oppermann, 2002; Cho, Cheng, & Lai, 2009) must ensure that the device's screen estate is to be used properly and provides rich content in a usable, easy-to-use and accessible manner. Accordingly, the challenges encountered in this project were mainly design challenges as the content of the target application was provided by the customer. Moreover, the customer had conducted preliminary user studies and defined a list of requirements. Therefore, the pre-made requirements list and content were not modifiable enough to develop an m-learning application that would appeal to everybody. A common form of an m-learning application is a game of an educational genre. Educational games have nowadays become increasingly popular especially among the children and youth. The developers of educational games justify that playing is part of our social and mental development [13] which is why they believe playing educational videogames also makes learning easier. With the popularity of personal computers, many educational game models (Alan Amory & Seagram, 2004) have been developed and are still evolving all the time. There have also been an increasing number of design models for educational games after the increased popularity of smart devices [15], [16], [17]. This study utilizes the UCD framework for m-learning application development [18] to ensure that the application is appealing to the users and fulfils the essential needs and requirements through a proper concept design. This process assists in designing an application that the users prefer and recommend. The non-functional requirements of the proposed educational application are as important as the functional requirements. The application should be reliable, usable, as well as feel secure for the users to use. This paper, however, focuses mainly on the functional requirements and the development steps of the proposed application prototype.

2 APPLIED METHODOLOGY

User-Centred Design and development of interactive systems and devices has an increasing importance in product development organizations [19]. In addition, UCD is the most common method for developing a usable product. Gould et al. (Gould & Lewis, 1985; [21] argued that in a usable system, users are to be involved continually, and the design is to be modified based on users' feedback. User-centred design (UCD) cuts costs (Bossert, 1990; Gulliksen et al., 2003) and improves the usability of the product, since it continuously focuses on the essential needs of end-users as early as possible. The user requirements are the focus in all stages of the product development cycle. Human-centred design (ISO 9241-210, 2010) processes for an interactive system (Sharp and Rogers, 2006) defines three different design solutions for UCD: I. Cooperative design; designers and users are to be involved in all stages of development, II. Participatory design; users occasionally participate in the design process, III. Contextual design; design is based on the actual context.

2.1 mLUX Framework for M-learning Application Development

This case study is based on the mLUX framework for m-learning application development framework [24]. The following diagram reveals the mLUX framework for m-learning application development process.

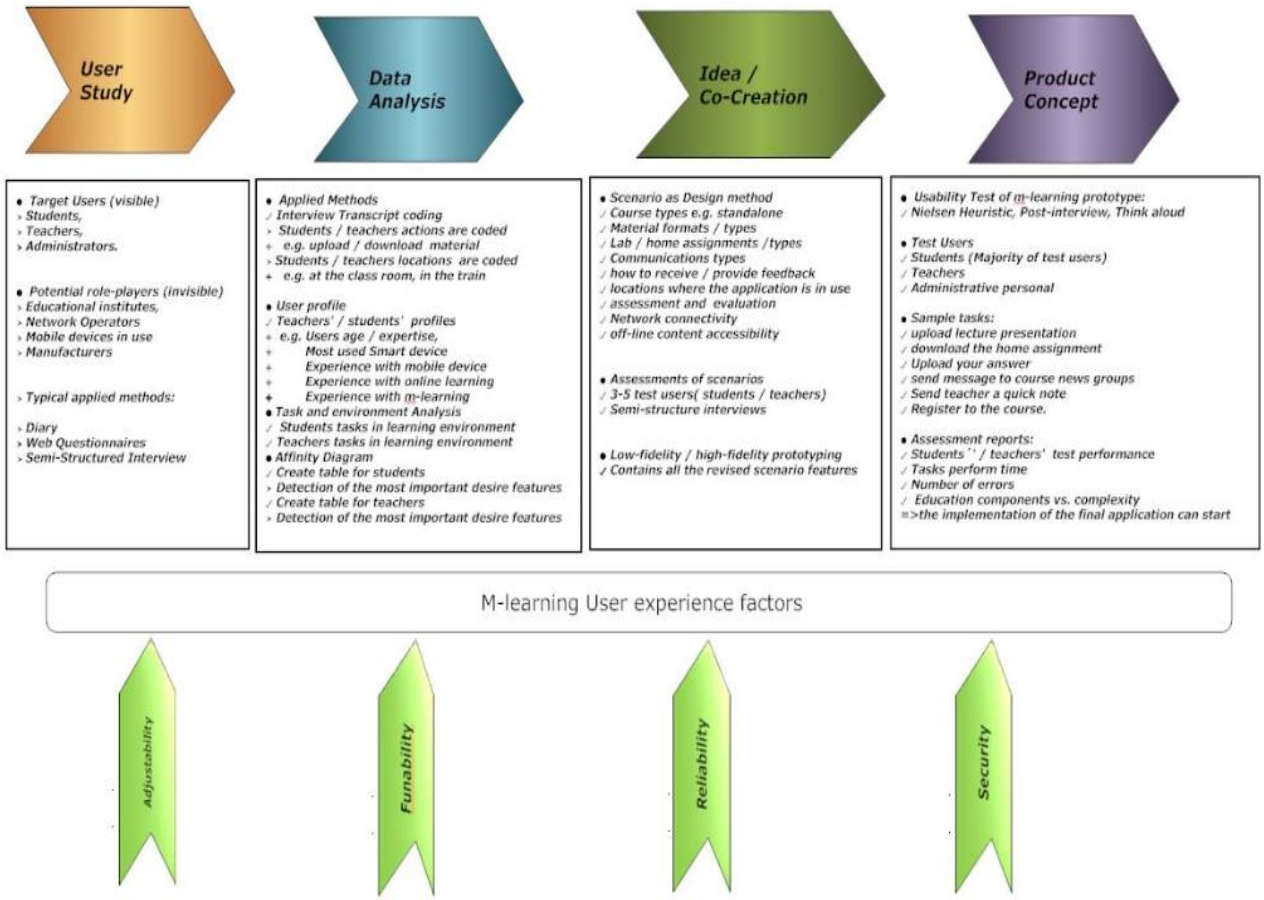

Figure 1: mLUX: usability and user experience development framework for m-learning application development.

The framework emphasizes user involvement in all stages of application concept development. The frameworks' development process consists of the following phases:

User Study – This is done by applying methods such as questionnaires and semi-structured interviews. In this phase, the designer aims to learn about the users' existing means to handle their work related tasks.

Data Analysis – Analysis of the data gathered from the user study phase. This analysis consists of transcript coding the user interviews [25], as well as the analysis and description of users' tasks and environments [26]. The overall requirements for the target application are identified in this phase.

Idea Creation – By using affinity diagrams [27], actions and requirements created in the previous phases are categorized. Use cases and scenarios are also applied as design methods to create a description of the application concept to the target users.

Product Concept – Scenarios are shared with 3 to 5 users for their feedback. A scenario reflects the potential overall concept of the application. After the feedback is reviewed, the designers conduct a short, semi-structured interview to learn about users' opinions about the application concepts and functionalities. Users' feedback is analysed to validate the feasibility of the concept and to ensure that the users and designers share the same understanding of the potential application. Feedback is also used to make sure that the functionality of the application fulfils the users' needs. When

necessary, designers may return to the previous phase to modify the scenarios. After validating the concept through scenarios, developers are asked to design a low-fidelity or a high-fidelity prototype based on the proposed scenarios. Finally, developers are asked to perform usability evaluation of the prototype on users by following e.g. Nielsen's heuristic evaluation guidelines [28]. The UCD framework for mobile learning application is an iterative design method. In this method, the concept development mandates the users' involvement in every development phase of the mobile learning application. This minimizes the possible future failure of the application and maximizes the application's penetration among the target users.

3 APPLIED METHODS

3.1 User Study / Data Analysis

The target application's main users are the youth between 18-30 years old. However, others users such as teachers or visitors may use the application occasionally as well. The customer has already conducted preliminary user studies and provided a list of requirements. As a result, this project focuses on the third phase of the UCD framework methodology, which is idea creation. The goal behind the first two phases was to assess the idea and to analyse what kind of application the users were most interested in.

3.2 Idea Creations

The main goal of this phase was to create a proper mobile learning application concept that would be appealing and that would fulfil the essential needs of the target users. The phase was initiated by writing three different scenarios. The scenarios contained the requirements that were provided by the customer. The scenarios reflected different pedagogical approaches, one of which was written as an educational game. The scenarios were shared and consulted first with the customer and then with the potential users of the application. After receiving a confirmation from the customer, the scenarios were shared with five target users. The users were asked to read the scenarios and then take part in short semi-structured interviews. During the interviews, users were asked questions about the scenarios such as "What is your opinion on the current scenario?" and "Which scenario would you prefer to have in the final product?". The interview sessions were recorded for further analysis. After analysing the feedback, the scenario that gathered the most votes was identified. This scenario was then revised and modified accordingly based on the feedback. As a result, the scenario was implemented as a conceptual paper prototype with the help of a wireframing tool. The paper prototype representing the chosen scenario was then shared with potential users once again. In this review session there were five users (n=5), from which two users (n=2) were new. The other three users (n=3) took part in the previous session and were invited again to reflect on the changes. The goal of the review sessions was to gather user feedback on the potential educational game concept design. Figure 2 represents various views of the paper prototype.

Figure 2. Paper prototype of the proposed application

The paper prototype tests were carried out with five (n=5) users aged 21-59 years. The test sessions were mainly carried out at the HAAGA-HELIA University of Applied Sciences under supervision. In each test session, the users were asked to carry out predefined tasks. The tasks were designed to mimic the application's proposed flow and the users were asked to perform the tasks on a paper prototype. The semi-structured interview aimed also to gather information about users' opinions about the proposed application design and general functionality. Both the test sessions and the interviews were recorded for further analysis. The conducted paper prototype test turned out to be very valuable. The feedback resulted in modifications to the scenario concept and to the design. An analysis of the collected feedback indicated the users' dissatisfaction towards the starting phase of the application, the non-responsiveness of the soft keys (buttons) in the UI and also the lack of some essential functionality. A second prototype was then designed and assessed with five (n=5) more users. The general UI at this point was complete and only slight modifications were done in order to improve the usability. The back and next action buttons were redesigned to be more visible. Based on the feedback, the Back button was moved to the top left corner and the Next button was set moved to the bottom right corner of the UI. In addition, a progress bar was added in order to provide visual feedback to the users about remaining tasks. The location of the progress bar was set to vary based on the content and the screen size of the user's device. The final results of the tests and analysed data were shared with the customer. After confirmation, a revised product concept was created and implemented.

4 PROTO IMPLEMENTATION

Based on the paper prototype assessment results and customer's thoughts, the potential educational game concept was ready for implementation. The functional, proof-of-concept prototype was then implemented using technologies such as PhoneGap, HTML5, CSS3 and various JavaScript libraries. The server-side of the application was implemented using Ruby for building the API and Redis for persistent data storage.

4.1 Architecture design

After the educational game concept was generated, the next step was to develop a functional proof of concept – a prototype application. The implementation was initiated by conducting an architectural design of the target application. The architecture was based on a three-layer architectural design incorporating a client, an API and a backend. The client consisted of the PhoneGap multiplatform mobile application that enabled the user to select a game character, language and a nickname, and to perform quiz-type tasks in various in-game locations. Game progress was saved automatically to enable users to continue the game where they left. After completing the game, users were able to submit their high score to a global high score list. The high scores were stored in a database on the backend and accessed over the Internet through an API. The general architecture of the PhoneGap application is presented in Figure 3.

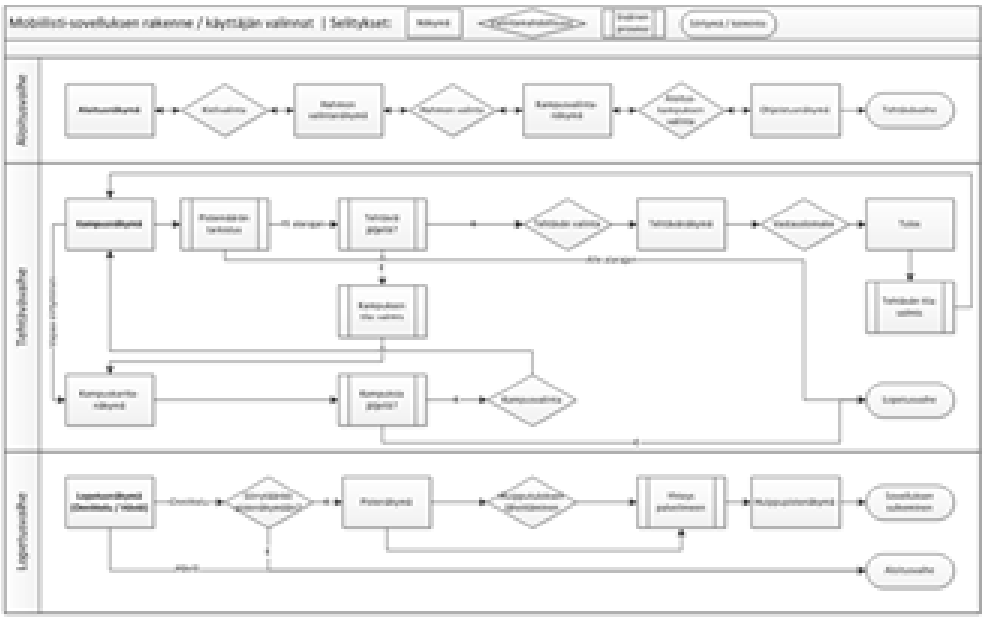

Figure 3. Architectural design of the application

Once the architectural design was complete, the PhoneGap framework was utilised to implement the high-fidelity application prototype. In Figure 4 screenshots of an early phase PhoneGap application are shown.

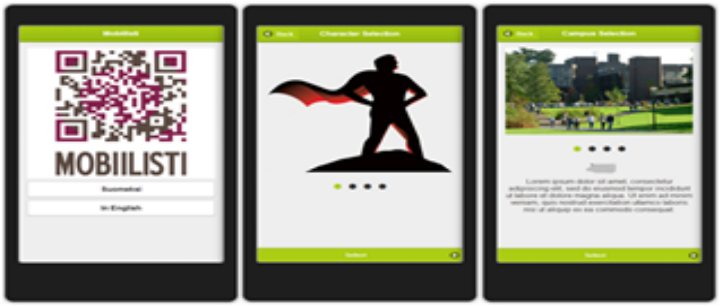

Figure 4. Sample of PhoneGap concept design

5 HI-FI PROTOTYPE USABILITY ASSESSMENT

Soon after the application was ready and functional, usability tests were conducted by applying Nielsen heuristic evaluation guidelines [28]. Unlike in the paper prototype usability assessment where the users carried out predefined sets of tasks, in this assessment the users had the freedom to play the game as they wished. The users were only asked to pause the game once they reached a specific stage in order to gather feedback. Additionally, the users were asked to think aloud while

playing the game. The test sessions were recorded for further analysis. Table 1 represents the user profiles of the hi-fi prototype test users.

TABLE 1. USER PROFILES

User	Age	Occupation	Current phone	Gender
# 1	23	Student	Nokia 520	Male
# 2	24	Student	Older Nokia Symbian	Male
# 3	57	Physician	Nokia N9	Male
# 4	59	Nurse	Nokia N9	Female
# 5	24	Student	Various models	Male

The main goal of this assessment round was to measure the consistency and aesthetic of the proposed educational game. A secondary goal was to evaluate the usability of the product. The users were invited for a short interview after the test session. In the interview, the users were mainly asked about their experiences with the educational game that they assessed. The tests were conducted with five users (n=5) aged 23 to 60 years (including four males and one female). Among the test users, three (n=3) users were new with no previous experience on the concept, whereas two (n=2) users had already participated in previous testing sessions. The usability assessment sessions with the hi-fi prototype took considerably more time compared to the paper prototype testing sessions. Table 2 reveals the frequencies of improvement recommendations that were mentioned during the usability evaluation.

TABLE 2. IMPROVEMENTS RECOMMENDATIONS

Improvement	Frequency
Visuals (Animations / Graphics)	4
Diversity of tasks	3
Sounds & effects	3
Significance of game characters	2
Haptic response	1
Application performance	1

The results of the assessment indicate that the application's content and the general UI appealed to the users. However, there were many improvement recommendations related to various aspects, such as visual design with the highest frequency of 4, game task diversity (3) and improving the significance of the game characters (2). These improvements were recommended to the customer to be included in the final product implementation. In general, the users believed that the game was challenging enough, but two users (n=2) recommended that the game could be improved to challenge users even more. The most important findings that manifested during the free-play and interview sessions were the excellent intuitiveness and functionality of the UI, and the gameplay in general. The users displayed no criticism towards the game's concept or content. The game felt enjoyable and the users were able to perform essential tasks without any difficulties, as intended.

6 RESULTS

The main goal of this case study was to design an m-learning application based on the requirement list provided by the customer. Moreover, this study was considered as a potential case to assess the mLUX framework for m-learning application development processes. This case study, however, had some challenges, as there was no possibility to conduct the preliminary user studies under supervision, and the customer was strict on adding new requirements. The design of the potential application concept based on the provided set of requirements was considered as the first objective. The scenario design model, which is the recommended design method in mLUX development process, was utilized and studies were conducted on users to come up with a proper application concept. With this approach, the studies enabled to find out the preferred application type and also to assess the possible functionalities of the potential application. The analysis of the scenarios provided valuable information, such as users' preferred educational application style, and how the content should be displayed to the users. Additionally, scenario design enabled conceptualizing of the requirements in order to develop the potential educational application concept. The design iterations from scenario to the hi-fi prototype design, helped to identify errors, improve the UI concept and graphics, modify the game characters and most of all, and create a challenging game based on the initial set of requirements. Most of the feedback, including improvements, was collected during the scenario and the lo-fi prototype assessment. During the hi-fi prototype assessment, the number of issues decreased significantly. The final usability assessment of the hi-fi prototype also indicated that the test users were very satisfied with application's user experience. They considered the educational game application a fun way to learn and felt entertained regardless of the game's educational genre. The feedback gathered from the hi-fi usability assessment mainly concerned improvements that were not directly detectable at the paper prototype phase, such as visual improvements and sounds & effects. This case study demonstrates that the mLUX framework for m-learning application development process is an appropriate methodology to create mobile learning applications, such as educational games. The overall aim of the framework was to create a usable mobile learning application that would attach users on an emotional level by focusing on the adjustability, delightfulness, reliability and satisfaction of the application. The analysis of the data gathered during the interview session after the hi-fi usability assessment indicates that the users were especially satisfied with the application's style. The application's clear design also motivated them to continue playing the game without any frustration. The designers and developers involved in development processes have expressed their satisfaction towards the mLUX framework for m-learning application development with statements such as "*the steps are easy to follow*", "*it is clear what to do next" and "it is a systematic approach that results in a usable m-learning application*." The usability assessments in this case study indicate that the mLUX framework has the potential to provide a robust approach with proper methods in each phase to develop usable and efficient mobile learning applications. Moreover, the customer of the educational game gave very positive feedback on the overall design of the application and its performance.

7 DISCUSSIONS AND FUTURE WORK

The educational game was designed and developed as part of a BSc. final thesis. The thesis work was considered as an excellent achievement at the Business Information Technology (BIT) department. The thesis was done approximately in a six-month period alongside a full-time job. Having dedicated time for this project would have had the same results in a much shorter time. Pedagogical evaluation is very important when an application deals with learning and learners. In this study, the pedagogical evaluation was not part of the application's design and development scope. As a result, the pedagogical perspective of the proposed educational game has not been assessed. It is important to study the level of education, which the proposed mobile learning application is designed to provide. Additionally, it is vital to assess if the proposed mobile application will allow students to learn more efficiently. Evaluating whether students comprehend the mobile-learning materials easier than traditional learning material is another topic that needs future investigation.

REFERENCES

[1] M. N. K. Boulos, S. Wheeler, C. Tavares, and R. Jones, "How smartphones are changing the face of mobile and participatory healthcare: an overview, with example from eCAALYX.," *Biomed. Eng. Online*, vol. 10, p. 24, 2011.

[2] A. Campbell and T. Choudhury, "From smart to cognitive phones," *IEEE Pervasive Comput.*, vol. 11, pp. 7–11, 2012.

[3] N. D. Lane, E. Miluzzo, H. Lu, D. Peebles, T. Choudhury, and A. T. Campbell, "A survey of mobile phone sensing," *IEEE Commun. Mag.*, vol. 48, pp. 140–150, 2010.

[4] A. Dirin and M. Nieminen, "STATE-OF-THE-ART OF M-LEARNING USABILITY AND USER EXPERIENCE," *Fourth Int. Conf. e-Learning*, 2014.

[5] A. Mostakhdemin-Hosseini, "Usability Considerations of Mobile Learning Applications," *International Journal of Interactive Mobile Technologies (iJIM)*, vol. 3. 2009.

[6] A. Dirin and M. Nieminen, "Managing m-learning application development : Roles and Responsibilities," in *International Conference on Advanced ICT (ICAICTE-2014).*, 2014.

[7] A. Dirin, M. Nieminen, and M. Kettunen, "Student capabilities to utilize m-learning service in new smart devices," in *Proceedings of the 2013 International Conference on Advanced ICT*, 2013.

[8] A. Dirin and A. Alamäki, "ANALYSING THE IMPLEMENTATION OF TWO DISTINCT PEDAGOGICAL APPROACHES IN HIGHER EDUCATION INSTITUTION," no. inted2015, Madrid, Spain, 2015.

[9] Dirin Amir and N. Marko, "Assessment of User-Centered Design Framework for m-learning Application Development," in *17th International Conference on Human-Computer Interaction*, 2015.

[10] F. Ozdamli, "Pedagogical framework of m-learning," in *Procedia - Social and Behavioral Sciences*, 2012, vol. 31, pp. 927–931.

[11] R. Oppermann, "User-interface design," in *Handbook on Information Technologies for Education and Training*, 2002, pp. 233–248.

[12] V. Cho, T. C. E. Cheng, and W. M. J. Lai, "The role of perceived user-interface design in continued usage intention of self-paced e-learning tools," *Comput. Educ.*, vol. 53, pp. 216–227, 2009.

[13] A. Amory, K. Naicker, J. Vincent, and C. Adams, "The use of computer games as an educational tool: identification of appropriate game types and game elements," *Br. J. Educ. Technol.*, vol. 30, pp. 311–321, 1999.

[14] A. Amory and R. Seagram, "Educational game models: conceptualization and evaluation," *South African Journal of Higher Education*, vol. 17. 2004.

[15] M. Miloš, "Mobile educational game : adventure anywhere," *Proc. 11th Int. Conf. HumanComputer Interact. with Mob. Devices Serv. Bonn Ger. Artic.*, pp. 1–2, 2009.

[16] E. Turtiainen, S. Blignaut, C. Els, T. H. Laine, and E. Sutinen, "Story-based ufractions mobile game in South Africa: Contextualization process and multidimensional playing experiences," in *CEUR Workshop Proceedings*, 2009, vol. 498.

[17] T. H. Laine, E. Sutinen, E. Nygren, and M. Joy, "Rapid improvement of technology integration in context-aware learning spaces," in *IEEE AFRICON Conference*, 2011.

[18] A. Dirin and M. Nieminen, “Framework for Addressing Usability and User Experience in M-Learning,” *J. Interact. Mob. Technol.*, 2015.

[19] M. Nieminen, “Information Support for User-Oriented Development Organisation. Considerations based on the Construction and Evaluation of Knowledge Storage,” *Tesis Dr.*, p. 228, 2004.

[20] J. D. Gould and C. Lewis, “Designing for usability: key principles and what designers think,” *Commun. ACM*, vol. 28, no. 3, pp. 300–311, 1985.

[21] J. D. Gould, S. J. Boies, and J. Ukelson, “Chapter 10 - How To Design Usable Systems,” in *Handbook of Human-Computer Interaction (Second Edition)*, 1997, pp. 231–254.

[22] J. L. Bossert, *Quality Functional Deployment: A Practitioner’s Approach*. CRC Press, 1990.

[23] J. Gulliksen, B. Göransson, I. Boivie, S. Blomkvist, J. Persson, and Å. Cajander, “Key principles for user-centred systems design,” *Behaviour & Information Technology*, vol. 22. pp. 397–409, 2003.

[24] A. Dirin and M. Nieminen, “mLUX :Usability and User experience development framework for m-learning,” *iJIM, Int. J. Interact. Mob. Technol.*, 2015.

[25] J. Saldana, “An Introduction to Codes and Coding,” in *The coding manual for qualitative researchers*, Los Angeles: Sage Publications, 2009, pp. 1–31.

[26] J. T. Hackos and J. C. Redish, *User and Task Analysis for Interface Design*, vol. 42. John Wiley & Sons, 1998.

[27] K. Holtzblatt, J. B. Wendell, and S. Wood, “Chapter 8 - Building an Affinity Diagram,” in *Interactive Technologies*, 2005, pp. 159–179.

[28] J. Nielson, “Heuristic Evaluation: How-To: Article by Jakob Nielsen,” *Nielson Norman GroupNorman*, 1995. [Online]. Available: http://www.nngroup.com/articles/how-to-conduct-a-heuristic-evaluation/.