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Sustainable Usage through Emotional Engagement: A User Experience Analysis of an Adaptive Driving School Application

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Abstract

This paper explores the factors affecting sustainable usage of digital services, such as mobile learning (m-learning) applications. We define a conceptual model of digital service sustainability and its measurement indicators and criteria. We assess the conceptual model by applying it to an adaptive m-learning application, which provides theory and assessment for driving school students based on their competence and learning progress. Additionally, the application provides mandatory self-evaluation reports to instructors after each practical driving session. The application assessment focused on how students' performed the predefined tasks at a usability lab. The assessment was based on educational components in conjunction with user experience factors of delightfulness, adjustability, satisfaction, and reliability. The key qualitative performance aspects proved to be user-centered (e.g., individual differences in cognitive and learning capabilities), UI-focused (e.g., interaction and adaptability to screen resolution) and content-related (e.g., contextual delivery, emotional appeal, adaptability). These elements resulted in overall delightful and effortless experience. The evaluation results indicate that the user experience factors impact sustainable usage because students are emotionally attached to the application. Therefore, we suggest that emotional attachment assessment results may serve as an indicator for sustainability of m-learning applications. These results help mobile application designers to design sustainable applications.

Sustainable usage, user experience factors, emotional engagement, driver's license application

INTRODUCTION

Smartphone usage among youths is increasing (Lee et al. 2014) at the expense of PC usage (Sung and Mayer 2012). Turner and Turner (2013) showed that physical proximity of artefacts, such as mobile phones, is strongly associated with our feelings of attachment. This is, however, different in mobile applications, such as games, social networking, and professional tools, that are proliferating in application stores. The main difference is that the mobile phone is a physical object, which is always accessible, while the mobile application is a non-physical object that user needs to identify in the phone and run to access it. Mobile learning (m-learning) applications are competing for learners' time and attention, and they must meet learners' educational requirements while also encourage frequent use (Seong 2006). Moreover, m-learning applications require careful design and development considerations as they deal with learning and learners alike. This is particularly true in formal learning settings where m-learning applications are meant to be used for long periods of time.

In formal education, learners are guided by a formal curriculum which leads to a diploma and degree that is recognised by authorities (Eaton 2010). Driving schools can be considered as one type of formal education environment. In Finland, driving school education is highly regulated teaching and learning activity. The contents of driving school education consist of theory lessons, assignments, and practical training sessions with an instructor. Driving school candidates are often young, recently graduated from upper secondary school and about to start higher education. They are very often competent smartphone users.

Our pilot study is an m-learning application that enables driving school candidates in Finland to complete compulsory theory lessons on their smartphones. Students at driving schools must study the materials, complete given tasks, and demonstrate through examination that they have learned the theory part. The application provides a self-evaluation form after each practical driving session. The instructors have the option to follow learners' progress through a reporting tool. The application also recommends follow-up lessons based on learners' competences and reading history. This functionality is a form of application adaptivity, as it personalises the application for individual learners. The design and the development of the application was published previously (Dirin and Casarini 2014).

Implementing the pilot study application involved three distinct challenges: 1. Content preparation, 2. User interface design, and 3. Analysing and designing the user experience for sustainable usage of the application. The content of the theory lessons must comply with specific regulations. Additionally, lesson contents must be easy to comprehend, unambiguous, simple to use, and consistent across platforms. Because learners use the application for a long period of time, the application must also be sustainable.

In this study, we consider content adaptivity, application usability and users' emotional engagement to the application to be major factors for promoting sustainable application usage. We focus on the non-functional requirements *application usability* and *user experience,* which Nielsen and Norman (2015) refer as a simplicity of a product which comes with elegance that user enjoy to own and to use. This definition suits well for m-learning applications to engage learners and educators emotionally for sustainable usage.

The term *emotional engagement* refers to the feeling that users construct through their emotions (Ekman 1999) and cognitive development in terms of values, trust, freedom and ownership. In addition, emotions and thoughts are interrelated with behaviour (Ruth et al. 2002). We are able to change and manipulate emotions through users' behaviour or ways of thinking, as can be seen in cognitive therapy (Wolpe 1996). Postareff et al. (2016) identify three emotion clusters associated to learning, study success and study progress: 1. Quickly progressing successful students experience positive emotions. 2. Quickly progressing successful students experience negative emotions. 3. Slowly progressing students experience negative emotions.

A prerequisite for emotional engagement is to identify various aspects of stakeholders. In this study, stakeholders are students, instructors, and the driving school's administration. The stakeholders can be identified and characterised using questions such as: *Who are the actual users of the application? What motivates them? What do they aim to accomplish with the application?* Such questions enable us to address not only the visible activities with the m-learning application but also elaborate on the intrinsic characteristics that delve into the reasons of using and continuing the use of such an application.

The main contribution of this study is the Emotional Engagement Analysis (EEA) measurement criteria to measure emotional factors in m-learning applications. Furthermore, to illustrate the practical use of the EEA criteria, we apply them to evaluate a driving school application for mobile devices. Emotion according to Entwistle (1998), is the "amount of intellectual energy typically used in learning activities and this led to a belief that motivation could been seen as a stable characteristic of the individual". Emotional attachment motivates users which impact the overall the sustainability of an m-learning application usage.

RELATED RESEARCH

User Experience

Human aspects of an application's or a service's sustainability can be associated with two factors: 1. usability (Hertzum 2010) which ensures that something is working properly, and 2. user experience (UX), which ensures that something is useful, usable and desirable (Law et al. 2009). On one hand, usability refers to how things work with attributes such as learnability (how easy it is for first-time users to learn to handle the product), efficiency (how experienced users are able to carry out required tasks), memorability (how users remember the product usage), and error-tolerance (how the application deals with users' errors). User experience, on the other hand, refers to how it feels to work with the product. The feeling is subjective to the context and users, which often varies over the time but still is measurable. User experience includes aspects of usability despite the scope of user experience being slightly unclear (Law et al. 2009). However, user, interaction, artefacts, and context impact user experience (Nicolás et al. 2011).

User experience design has recently become a complementing part to traditional HCI design. Despite several attempts to establish a common definition for the term "user experience", there is no agreed consensus on it. For example, Roto et al. (2010) collected 27 definitions of user experience in the Dagstuhl seminar on Demarcating user experience. Glanznig (2012) defines user experience as "how human experiences the interaction with the technological artefact (e.g. computers, mobile phones, cameras)". In this paper, we use Glanznig's definition of user

experience as the basis, and amend it with user experience factors as described below.

Pu, Chen and Hu (2012) recommend that optimal user experience, although left undefined, of a system can be obtained through user-centered development and evaluation. We need an approach that stretches beyond usability to user experience despite the lack of proper definition of the latter. To alleviate this, we have previously proposed the mLUX framework (Dirin and Nieminen 2015) for m-learning application design and development. The mLUX framework is based on the UCD methodology so that through scenario-based design we can ensure positive user experience already at the concept design phase.

UCD results in a functionally rich application, but it may remain insufficient to gain users' emotional engagement (Keinonen 2008), which is necessary for sustainable usage. Emotional engagement is associated with user experience design. Hassenzahl et al. (2013) state that user experience factors help to link actions, feelings, and thinking in mobile applications. In m-learning applications, actions, feelings, and thinking play important role for application sustainability. This study demonstrates that *delightfulness, reliability, adjustability and satisfaction* represent important user experience factors for m-learning applications' sustainable usage. These factors affect and link actions, feelings, and thinking in m-learning applications, yet they are not novelties in academic research across fields, as we reveal in Table 1.

Table 1. User experience factors in relation to m-learning

User Experience Factors	Description	Relation to m-learning
Delightfulness	The term *delightfulness* refers to the perception of internal gain, such as emotional gain, or external gain, including physical gain, which Norman (2004) in his emotional design refers to as a joyful experience. Pucillo and Cascini (2014) state that "successful products typically delight the customers by satisfying their need in innovative or unexpected ways".	Fun and delightfulness can maximize learning among children (Fontijn and Hoonhout 2007), and learning on a small-screen device requires that the user perceives the process to be fun (Marcus 2007).
Reliability	O'Neill (2012) presents that trust has become an important factor in any information system. *Reliability*, as a form of trustworthiness, refers to a willingness for acceptance based upon positive expectations (Dunn and Schweitzer 2005).	Ibrahim and Walid (2014) address reliability as an important factor with respect to learning content accuracy and validity.
Adjustability	Du et al. (Du et al. 2006) suggest that product customisation is an effective way of meeting the needs of individual customers. *Adjustability* refers to the feeling of being involved, engaged, and in control. Gorlatch et al. (Gorlatch et al. 2006) define an adjustable program as one that allows users to introduce changes and optimisations to the program.	
Satisfaction	*Satisfaction* refers to the level of fulfilment of one's needs, wants, and desires with regard to the expected quality (Morse 1997). Haverila (Haverila 2011) demonstrated that mobile phone user satisfaction is associated with repurchasing intent.	Sun et al. (Sun et al. 2008) identified that the factors affecting satisfaction in e-learning are: learners' computer anxiety, instructors' attitudes toward e-learning, e-learning course flexibility, e-learning course quality, perceived usefulness, perceived ease of use, and diversity in assessments.

Emotional Engagement and Sustainability

In an m-learning environment, the context in which the user uses the application, the application's functional richness to satisfy user's pedagogical needs, and the way the user expects to have the content presented, are associated with emotional engagement. Learning users' emotional expectations can help designers create applications that provide usable and positive experiences.

Measurement of emotional engagement has been a challenge for researchers. For example, Rodden et al. (Rodden et al. 2010) proposed the HEART (Happiness, Engagement, Adoption, Retention, and Task success) framework for user experience quality metrics, including also metrics for measuring emotional engagement. HEART consists of five categories: 1) Happiness: measures users' attitudes, which are often collected via a survey; 2) Engagement: measures the level of user involvement, which is typically measured based on behaviour such as the frequency of use; 3) Adaption: measures how new users are adapted to use the product; 4) Retention: measures the rate at which existing users are returning; and 5) Task success: measures how efficiently, effectively, and error-freely the tasks are performed.

Before a technology can be sustainable, it must be accepted among users. In this study, we follow Dillon and Morris' (Dillon and Morris 1996) definition of user acceptance as a demonstrable willingness within a user group to employ information technology for the tasks it is designed to support. Moreover, Dillon and Morris (Dillon and Morris 1996) conclude that users' acceptance of new technology depends on the user's psychology, the design process, and the user's perceived quality of the technology.

Allen and Hoekstra (Allen, T.F.H.; Hoekstra 1992) define *sustainability* as something that is not absolute, independent of human conceptual frameworks. Rather, it is always set in the context of decisions about what type of system is to be sustained and over what spatio-temporal scale. Sustainable development needs to satisfy social, economic and ecological requirements (Brown et al. 1987). Penzenstadler et al. (Penzenstadler et al. 2012) noted that human sustainability is an additional demand on sustainable software development. Penzenstadler (Penzenstadler 2013) identifies four sustainability aspects in software engineering: the development process, maintenance process, system production and system usage.

In this study, we consider sustainable m-learning application usage to depend on several important elements such as: 1) target users of the application, 2) user experience design of the application, and 3) users' emotional engagement. All these elements deal with users and the application design and development approaches.

THE EMOTIONAL ENGAGEMENT ANALYSIS (EEA) METHOD

Measuring User Experience and Emotions

User experience measurement has been a key research topic in user experience domain. A variety of proposed user experience measurement approaches indicate that a commonly accepted measurement approach has not yet been identified. In the following, we disclose some of the recent approaches relevant to this study. Ardito et al. (Ardito et al. 2007) recommend a user experience evaluation to involve measurements of motivation, engagements, and social interactions. They propose various measurement techniques such as direct observation for behavioural analysis, capturing the users' first impressions via focus groups, questionnaires, and essays and drawing analysis. Turner (Turner 2011) proposed metrics to measure Return On Investment (ROI) on user experience of a product. Their findings help practitioners to identify financial and non-financial metrics, help decision-makers balance between their values and the company's goals, and demonstrate positive ROI in UX activities.

Tullis and Albert (2013a) review and organize metrics for user experience measurements into six main categories: performance, issue-based, self-reported, web navigation, derived, and behavior / physiological. They also recommend ten key points as guidelines to measure user experience, such as collecting continuously data from users and stakeholders, allocate budget for measurements, plan metrics beforehand, and benchmark the product's user experience. Moreover, Tullis and Albert (2013b) promote to present the results of each key point as a story. This is aligned with the mLUX framework in which scenarios and stories are used to embed emotional and behavioural factors in the concept development phase of an m-learning application.

Finally, it is also possible to measure UX by analyzing physiological data of the user. For example, Qu et al. (Qu et al. 2016) proposed the use of eye-tracking technology for UX design of smartphone applications.

Scherer (Scherer 2005) explains that there is no single standard method to measure emotions, suggesting that there are *subjective*, *behavioural* (arousal) and *physiological* (bodily) components that have to be analysed separately. We recognize that these components suit for measuring emotional engagement related

to m-learning application's user experience. In the following, Scherer's (Scherer 2005) measurement components are explained with examples.

Subjective measurements: Researchers often employ subjective measurements to measure subjective behaviour with instruments such as questionnaires, rating dates and experimental sampling. Scholars have also developed systematic subjective behaviour measurement approaches, including the Positive and Negative Affect Schedule (Watson et al. 1988). In such measures, users are asked how they currently feel (e.g., nervous, scared, inspired). Other methods, like the Stress Appraisal Measure (Peacock and Wong 1990), measure the user's stress level. Finally, with the help of Experience Sampling Methods (Conner et al. 2009), it may be possible to capture people's emotions.

Behavioural measurements: Behavioural methods focus on the observational analysis of the user's behaviour. The behavioural measurement that this study firstly focuses on is the Facial Action Coding System (FACS) (Ekman and Friesen 1978), which measures facial poses. For example, when experiencing happiness, we tend to smile. The second used measure is the Specific Affect Coding System (SPAFF) (Coan and Gottman 2007), which measures emotions during interaction (e.g., between couples). Thirdly, emotions can also be identified by analysing users' text or speech (Strapparava and Mihalcea 2008). In this study, we applied this in transcript coding of interviews.

Physiological measurements: In physiological measurement, researchers measure how the user's body behaves when emotions change. For example, we might consider using sensors to measure the autonomic nervous system (Kreibig 2010), brain waves (EEG) (Teplan 2002), or anxiety level (electromyography, eye movements and pupillometry) (Tichon et al. 2014).

EEA Measurement Criteria

Traditional emotion measurements, as illustrated in the previous section, are typically based on psycho-physiological instruments where as our emotional engagement analysis (EEA) is grounded on the user experience factors. The initial evaluation parameter targets users' acceptance of the application with a focus on usability, which we measure by effectiveness, efficiency and satisfaction.

The details of the proposed Emotional Engagement Analysis (EEA) measurement goals and criteria are presented in Table 2. The criteria that we elaborate below are based on the pilot application performance and users' attitudes toward the application usage. Evaluation of learning performance is out of scope of this paper.

Table 2. *EEA criteria for the measurement of user experience in m-learning*

UX Factors	Goals	EEA Criteria
Delightfulness	Learners can successfully perform the tasks defined in educational components: presentation, activities, communications and administration (Brusilovsky and Miller 2001). The application supports learners in performing tasks without difficulty. Learners enjoy and have fun using the application and the content. Learners consider the application as an efficient and preferred medium for performing educational tasks	***Subjective measurements*** Learners feel that the application is fun to use. Learners feel that the application's educational component provides delight and allows them to achieve their goals. Learners may use words, such as great, fun, fantastic, and easy, etc. ***Behavioural measurements*** Observers find that the learners are having fun while using the application. Additionally, observers notice that the learner demonstrate that the tasks are easy and fun to perform.
Reliability	Supports learners in trusting the application, especially regarding data integrity and reliability. Learners are able to successfully upload and download educational materials, Learners receive proper feedback on their actions from the system, such as notification of successful submission. Learners are able to communicate with other individuals, peers or a group securely.	***Subjective measurements*** Learners feel that the application is trustworthy. They verbally or in the written feedback demonstrate this feeling. ***Behavioural measurements*** Observers realize that the learners trust the application by entering information as the test tasks progressed
Adjustability	Supports learners in adjusting and customising the application theme, user interface and content based on each learner's own preferences. Learners are able to customise the presentation types and format. Learners have the choice of an individual or a group communication medium. Learners are also able to select the communication format, such as email, chat, or newsgroup.	***Subjective measurements*** Learners feel that they have control of the application. They emotionally express as though the application is their own application (feeling of ownership). ***Behavioural measurements*** Observers find the learners being relaxed and do not express signs of stress or being lost with the application. Additionally, the learners have done the tasks before the allotted time expires.
Satisfaction	Supports learners in performing essential education tasks. The application meets learners' educational expectations and preferences. In addition, students may study the material conveniently with the m-learning application. The m-learning application contains the preferred functionalities so that learners	***Subjective measurements*** Learners express their satisfaction with the application functionality. Learners express verbally that the application satisfies their educational needs in all the educational components (presentation, activity,

	are capable of carrying out all the educational tasks, such as uploading assignments, providing answers and receiving feedback from instructors.	communication, and administration). ***Behavioural measurements*** Observers find that the Learners do not express any frustrations while using the application.

PILOT STUDY: AN ADAPTIVE M-LEARNING APPLICATION FOR DRIVING SCHOOL

Design Process

The driving school application design process was conducted in 2013 and involved driving licence candidates (n=7, 18-25 years old) and instructors (n=5, 20-55 years old). In the user study phase, we utilised a web questionnaire and a diary to learn about users' daily activities, types of smart gadgets used, most frequently downloaded and used mobile applications, and levels of computer knowledge. Next, we scheduled individual semi-structured interviews which took 20-30 minutes. After the user study phase, we applied transcript coding and affinity diagrams to explore the users' needs and requirements for the target application. We categorised a list of requirements based on priority levels, and wrote scenarios in which the requirements were presented as potential application functions. We then shared the scenarios with six (n=6) users to gather their feedback.

Next, we began designing a paper-based prototype of the target application. The paper-based prototype was re-consulted with the users for final revisions of the concept. We then conducted a usability evaluation test on the proposed functional prototype. For the design theme, user experience factors were the focal point, including delightfulness, reliability, adjustability and satisfaction of the learning application; this focus extended to all processes of the application design and development. Sample screenshots are presented in Figure 1.

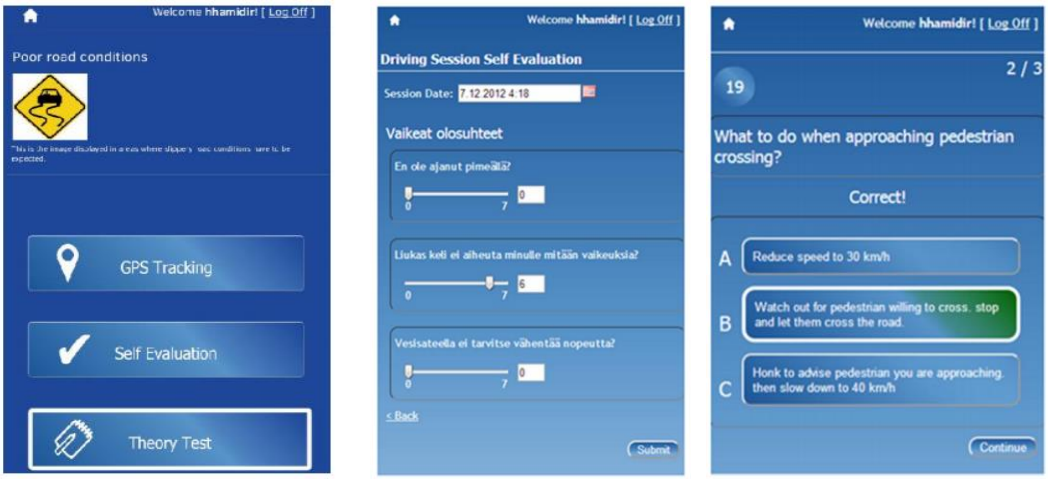

Figure 1. Sample screenshots of the adaptive driving school application

Adaptation

The need for a context-aware implementation emerged during the design process. Firstly, the application needed to perform homogeneously on a wide variety of smart devices available on the market (e.g., operating systems, settings, screen resolutions, supported technologies). Secondly, the awareness of user behaviour as well as positioning in time and space were required. Thirdly, the data and presentation had to target at individual user's needs and capabilities to maximise the efficiency and efficacy of the learning process. In short, it was necessary to escape the one-size-fits-all limitation of traditional learning platforms.

When the user connects to the application service with a web browser, the user interface rendering component performs presentation adaptation (e.g., fluid layout), therefore enabling a homogeneous and consistent user experience and user-related spatial context-awareness (e.g., geolocation). For presentation adaptation and UX tuning, the system uses open HTML5 standards and JavaScript libraries.

EVALUATION OF THE DRIVING SCHOOL APPLICATION'S UX WITH EAA

Table 3 presents a summary of our UX assessment results based on the EEA measurement criteria defined in Table 3. The subjective and behavioural measurements were conducted during usability tests at a usability lab. The optimal situation would have been to create a behavioural checklist or to rate behaviours

according to some model. However, in this study the observers took notes on users' behaviour from within the control room. Additionally, we analyzed users' verbal expressions during the post-interview.

Table 3. UX assessment in conjunction with EEA

UX Factors	Assessment Result
Delightfulness	***Subjective measurement:*** Learners could perform predefined tasks using educational components. There were, however, performance time differences among expert and novice users. Learners expressed their appreciation by having the driving license theory always with them as a mobile app. This was evident in learners' statements, such as "*Wow, I don't need to start from scratch, it checks how much I know and provides me content*", "*This is great, I wish to have similar app for all our courses at school*", and "*…Fun to study the boring theory on the mobile with an app*". ***Behavioural measurement:*** Observers found that learners performed tasks without any difficulties, or any signs of confusions or stress during the test. Learners showed their delightfulness when all tasks were done.
Reliability	***Subjective measurement:*** Learners showed their concerns on the trustworthiness of the application and about the reliability of data exchange, for example: "*Hope my information and the learning path are saved. I hate to start everything from beginning*". ***Behavioural measurement:*** Observers noticed that learners hesitated to enter their personal information at the beginning of the test sessions, which indicated that learners did not consider the application to be trustful. This was also mentioned during interviews. Trust developed when learners realized that messages are saved and he received feedback from the system
Adjustability	***Subjective measurement:*** In semi-structured interviews, learners showed their appreciation for adaptivity of the application. Learners also expressed their satisfaction with the application adjustability (e.g. customizable theme), for example: "*I like that I was able to change the theme"* and *"Some applications do not support this*". ***Behavioural measurement:*** Observers realized that learners customized the application. They were also able to define the learning formats, e.g., video or audio, for content.

Satisfaction	***Subjective measurement:*** In general, learners were able to perform the requested tasks and were overall satisfied: "*Interesting app. The video clip helped me a lot to learn the theory."* ***Behavioural measurement:*** Observers discovered that learners carried out the tasks without any signs of frustration or expressed signs of failure on the application's performance and the test tasks.

The subjective and behavioural measurements in Table 3 demonstrate that the application appealed to learners by fulfilling their expectations related to educational activities. Learners were specifically delightful to have their freedom to study at anytime and anyplace. Having a ubiquitous access to learning content is considered as a positive experience for users.

Furthermore, learners were delighted that they had instant access to an instructor's guidance in case they made an error. They felt that they were always connected with the school. For example, this was evident in the statement: "*Great, instructor knows how far I've studied and what assignments I have done"*. Learners, however, had some concerns about the reliability of the application in terms of whether their performance and records are saved properly and securely. Therefore, the feeling of insecurity to enter personal data at the beginning of the test was observable. However, learners developed their trust as soon as they received feedback from the system.

Learners could adjust the form of communication with instructors and classmates. Instructors found the design of students' driving activities report template to be attractive and simple. Instructors were able to choose the report format, such as Excel sheet, Word document, or a color-coded report in the browser. The results suggest that instructors were specifically delighted to be able to trace all learners' activities and learning paths at once using the automatic reporting tool. They were also delighted that they could communicate with students instantly through report notifications.

Learners trusted the application, as they did not encounter any connectivity problems or situations where they could not perform a task because of reliability issues. However, they showed some concerns about the performance of the

application in offline mode and associated cost of the application usage in online mode.

To summarize, the EEA assessment results suggest several emotional engagements through the UX factors. Learners experienced delightfulness for having access to learning resources on a familiar device, being able to customise the application, and having adaptive learning content. The adjustability of the device, the learning content, and the look and feel developed the feeling of ownership in learners. Moreover, we received many feedbacks that indicate that the application fulfilled learners' expectations in spite of concerns on trustfulness of the application. Learners felt that the application is fun to use. They were able to perform tasks without any difficulties, and were willing to use the application for a long period of time despite having other options, such as face-to-face lectures at the driving school and a web-based learning environment.

DISCUSSION

Emotional engagement in m-learning

A usable m-learning application, to which users can engage emotionally, must compete for learners' time with other applications on the smartphone. Therefore, creating a positive and happy experience for learners affect the m-learning application's sustainable usage. Positive experience with an m-learning application is associated with user experience factors satisfaction and adjustability, which represent the usability side of the application assessment, and trustfulness and delightfulness of the application, which deal with the emotional side of the learner. Therefore, usability of the application plays an important role but it is not sufficient to guarantee sustainable usage.

Emotional factors are important in our daily decision-making and interactions with our surroundings, including other people, objects, and applications. Most of our decisions are based on emotions to which we apply logic for justification. This fact is also valid in m-learning application usage: learners' emotional engagement may increase sustainable usage of the application. Moreover, human beings have a tendency toward recognition, belonging (Kim et al. 2012) and effectiveness. In an m-learning application, the feelings of recognition and belonging can be achieved

by enabling learners to customize the application based on their preferences. This includes the learning content, the presentation mode and the look and feel of the application. Customizable, adjustable and adaptable applications result in mental satisfaction, which is at the root of human nature. Herzberg (2003) also recognises this issue as they elaborate on two types of human needs. The first type stems from humans' animal nature, including hunger. The other relates to desires unique to humans, including the ability to achieve and, through achievement, experience psychological growth. M-learning applications should allow users to develop the feeling of achievement by helping them to overcome problems through providing proper learning content in the context relevant to the problem.

Verkasalo et al.'s (Verkasalo et al. 2010) findings emphasise that behavioural control is an important adoption factor for users because they are able to control the application. Additionally, they suggest that enjoyment and usefulness represent second and third behavioural factors for adoption of mobile applications and services. Our findings match those of Verkasalo et al. (Verkasalo et al. 2010) who also highlight the importance of fun, reliability, satisfaction and adjustability in m-learning applications. Delightfulness, as well as reliability, adjustability, and satisfaction, appear to provide means of emotionally engaging users with m-learning applications. In terms of service delivery, a delighted customer may purchase more items (Kwong Ka Kei 2006); in terms of m-learning applications, a delighted learner may be more motivated to use the application frequently.

Improving m-learning applications' sustainable usage

The user-centered design process according to ISO 9421-210 starts from the identification of the importance of UCD. This ensures user involvement in the design process. A systematic UCD process that is conducted specifically in the context of m-learning (e.g., mLUX (Dirin and Nieminen 2015)) consists of several usability and user experience design and testing methods. The emotional engagement analysis (EEA) complements these methods (e.g., semi-structured interviews, questionnaires and observations) in order to learn about users' emotional responses and relation to the m-learning application through the analyses of subjective and behavioural aspects.

Subjective measurement is appropriate for collecting information about positive and negative feelings. Users are asked about their feelings and expectations on the application that they are using. This information can be gathered with semi-structured interviews, diaries or questionnaires. In a questionnaire, questions such as *what are the most intriguing applications in your phone* would enable the developers to reflect on the features and characteristics of those applications in relation to the m-learning application under development. In an interview, questions such as *why do I find this application engaging or intriguing* enable users to elaborate on the emotionally engaging features. A simple diary enabling users to record positive and negative incidents with the application could provide a basis for the elaboration in the interviews.

The use of these methods, however, requires further specification and research.

The collected data from users are analyzed to learn how users get intimated to use or abandon an application. These information helps designers to learn users' mental model of the potential application. Transcript coding of the semi-structured interview plays an important role in assessing the user's emotional status. Quan and Ren's (Quan and Ren 2010) approach probes how users feel about the applications they use. This approach helps identify the user's expectations of the m-learning application to be developed. Additionally, affinity diagrams help to categorise the identified emotions and feelings.

Based on analyzed data, an application concept is designed using a scenario- or storyboard-based design approach. Scenario-based design helps designers understand users' expectations and mental models of the target application. This approach is well-suited as a basis for documenting the emotions and feelings in a story. The story can be described to contain the application requirements together with the associated emotions that result in positive user experiences. The scenario is then shared with potential users to review and provide feedback. In addition to collecting user feedback on application functionalities, the designers also focus on observing users' attitudes regarding the emotional side of the story. Designers can follow the user's emotional and facial gestures. After the users have reviewed the scenario, a semi-structured interview is a sound method for uncovering users' feelings. Designers can ask direct questions on how the user feels about the proposed concept at the various stages of the scenario.

Based on the analysis results from the scenario evaluation, the developers can create a low / high fidelity prototype and assess it with potential users in a usability lab for final refinement. Testing in a usability lab with video recording provides means for recording users' facial expressions and behaviour when they perform given tasks with the prototype. In this manner, the usability test session delivers information about users' subjective emotions regarding the prototype. The EEA criteria (see Table 2 provides a framework for analyzing the results.

Emotional Engagement

Sustainable usage of m-learning applications is linked to users' emotional satisfaction and engagement. A positive experience is developed when the learner is emotionally satisfied with the application. The learning objectives are adjusted with the learner's capabilities and competencies. Broadhurst (Broadhurst 1957) identified that there is a relationship between the learner's motivation and the difficulty of a learning tasks. Therefore, learners require an optimal emotional engagement level to sustain motivation to learn. Emotional satisfaction is developed when the learner feels that the application is trustworthy and fulfils their essential pedagogical needs and expectations. The learner's emotional engagement to the application is affected by their feelings of trust and ownership, therefore increasing the feeling of optimism for future use of the application. In contrast, if the application does not fulfill the learner's pedagogical needs or if the learner feels that the application is not trustworthy, they may develop negative feelings, such as dissatisfaction. Rational decision-making is based on the types of emotions that we experience. Humans tend to be attracted more to positive emotions than negative ones. Therefore, sustainability of an m-learning application relies on supporting users' positive emotions toward the application. A sustainable and satisfying m-learning application can be adjusted by the user to match the evolving usage resulting in positive feelings and delightful experiences through reliable interaction.

CONCLUSIONS

Students are often required to use m-learning applications for long periods of time (Liu et al. 2010), but small devices and various contexts makes m-learning

challenging. They must find it easy and effortless to interact through a comprehensive user interface, and they must be able to perform tasks with optimal pace for learning.

It is, however, insufficient to merely focus on functional factors between users, their devices, and applications. This study recommends the use of user experience factors that can transfer the m-learning application development to the next level, focusing on learners' emotions as key sustainability factors. We propose four user experience factors that have impact on application sustainability: satisfaction and adjustability arise from the direction of usability whereas delightfulness and reliability relate to emotions and feelings. In order to embed the use of the user experience factors in practical application development work, we relate the UX factors with the concept design phase of the mLUX design framework. The mLUX framework embeds those four user experience factors as the elements to design for sustainable application usage.

Addressing emotional factors in addition to instrumental needs can result in increased learner motivation. For example, an authoritative role for users can be considered an important factor for sustainable application usage. This factor involves users' psychological commitment to the application, which is not directly contributing to actual learning. Ultimately, sustainability of m-learning applications can be achieved through a usable application adhering to pedagogical principles while, at the same time, engaging users emotionally.

Learners' emotional engagement increases acceptance toward new learning content, thus affirming sustainable usage. Positive emotions impact user behaviour during learning activities. Humans are more inclined to continue doing something if they have had a previous positive experience. Therefore, m-learning applications should strive for evoking positive experiences.

Finally, our study demonstrates that users' emotional attachment is an important factor for the target users. However, the result that this study addressed is based on qualitative data. Hence, we cannot derive a general conclusion about the all mobile learning application. As a future work, we have planned to investigate the results with a larger sample and in a different context.

REFERENCES

Allen, T.F.H.; Hoekstra TW (1992) Toward a definition of sustainability. Environ Sci 15:98–107.

Ardito C, M.F. C, Lanzilotti R, F. M (2007) Towards the evaluation of UX. Int Conf HCI 2007 6–9. doi: 10.1.1.177.7089

Broadhurst (1957) Emotionality and the Yerkes-Dodson law. J Exp Psychol 54:345–352. doi: 10.1037/h0049114

Brown BJ, Hanson ME, Liverman DM, Merideth RW (1987) Global sustainability: Toward definition. Environ Manage 11:713–719. doi: 10.1007/BF01867238

Brusilovsky P, Miller P (2001) Course Delivery System for Virtual University. Access to Knowl New Inf Technol Emerg Virtual Univ 167–206.

Coan J a, Gottman JM (2007) The Specific Affect Coding System (SPAFF). Handb Emot elicitation assessment 267–285.

Conner TS, Tennen H, Fleeson W, Barrett LF (2009) Experience Sampling Methods: A Modern Idiographic Approach to Personality Research. Soc Personal Psychol Compass 3:292–313. doi: 10.1111/j.1751-9004.2009.00170.x

Dillon A, Morris MG (1996) User Acceptance of Information Technology: Theories and Models. Annu Rev Inf Sci Technol 31:3–33.

Dirin A, Casarini M (2014) Adaptive M-Learning Application for Driving Liceness Candidates Based on UCD Framework for M- Learning Application Development. In: 6th International Conference on Computer Supported Education.

Dirin A, Nieminen M (2015) mLUX :Usability and User experience development framework for m-learning.

Du X, Jiao J, Tseng MM (2006) Understanding customer satisfaction in product customization. Int J Adv Manuf Technol 31:396–406. doi: 10.1007/s00170-005-0177-8

Dunn JR, Schweitzer ME (2005) Feeling and believing: the influence of emotion on trust. J Pers Soc Psychol 88:736–748. doi: 10.1037/0022-3514.88.5.736

Eaton SE (2010) Formal, non-formal and informal learning: The case of literacy and language learning in Canada, Heather L.

Ekman P (1999) Basic emotions. Cognition 98:45–60.

Ekman P, Friesen W V. (1978) Facial Action Coding System: A Technique for the Measurement of Facial Movement.

Entwistle N (1998) Motivational factors in students' approaches to learning. Learn Strateg Learn styles 21–51.

Fontijn W, Hoonhout J (2007) Functional fun with tangible user interfaces. In:

Proceedings - DIGITEL 2007: First IEEE International Workshop on Digital Game and Intelligent Toy Enhanced Learning. pp 119–123

Glanznig M (2012) User Experience Researcb: Modelling and Describing the Subjective. INDECS 10:235–247. doi: 10.7906/indecs.10.3.3

Gorlatch S, Kameda T, Fujita IH, et al (2006) Towards Developing Adjustable Software: A Case Study with the Lyee Approach. IOS Press, Inc. Nieuwe Hemweg 6B,Netherlands

Hassenzahl M, Eckoldt K, Diefenbach S, et al (2013) Designing moments of meaning and pleasure. Experience design and happiness. Int J Des 7:21–31.

Haverila M (2011) Mobile phone feature preferences, customer satisfaction and repurchase intent among male users. Australas Mark J 19:238–246. doi: 10.1016/j.ausmj.2011.05.009

Hertzum M (2010) Images of Usability. Int J 26:567–600. doi: 10.1080/10447311003781300

Herzberg F (2003) One More Time: How Do You Motivate Employees? Harv. Bus. Rev.

Ibrahim ENM, Walid N (2014) Trust Contributing Factors in M-Learning Technology. Procedia - Soc Behav Sci 129:554–561. doi: 10.1016/j.sbspro.2014.03.713

Keinonen T (2008) User-centered design and fundamental need. Proc 5th Nord Conf Human-computer Interact Build Bridg - Nord '08 211. doi: 10.1145/1463160.1463183

Kim KJ, Park E, Sundar SS, del Pobil AP (2012) The effects of immersive tendency and need to belong on human-robot interaction. Proc seventh Annu ACM/IEEE Int Conf Human-Robot Interact - HRI '12 207–208. doi: 10.1145/2157689.2157758

Kreibig SD (2010) Autonomic nervous system activity in emotion: A review. Biol Psychol 84:394–421. doi: 10.1016/j.biopsycho.2010.03.010

Kwong Ka Kei K (2006) Effects of Service Delivery on Customer Delight : An Experimental Approach in a Restaurant Chain (Dissertation). City University of Hong Kong

Law EL-C, Roto V, Hassenzahl M, et al (2009) Understanding, scoping and defining user experience. Proc 27th Int Conf Hum factors Comput Syst - CHI 09 719. doi: 10.1145/1518701.1518813

Lee U, Lee J, Ko M, et al (2014) Hooked on smartphones: an exploratory study on smartphone overuse among college students. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. pp 2327–2336

Liu Y, Li H, Carlsson C (2010) Factors driving the adoption of m-learning: An empirical study. Comput Educ 55:1211–1219. doi: 10.1016/j.compedu.2010.05.018

Marcus A (2007) Fun! fun! fun! in the user experience we just wanna have fun...don't we? interactions 14:48.

Morse N. (1997) Satisfactions in the white - collar job. Satisfactions in the white - collar job

Nicolás O, Carlos J, Aurisicchio M (2011) The Scenario of User Experience. In: DS 68-7: Proceedings of the 18th International Conference on Engineering Design (ICED 11), Impacting Society through Engineering Design,. Copenhagen, Denmarik, pp 1–12

Nielsen J, Norman D (2015) The Definition of User Experience. In: NNG Artic.

Norman DA (2004) Emotional design. Ubiquity 2004:1–1.

O'Neill B (2012) Trust in the information society. Comput Law Secur Rev 28:551–559. doi: 10.1016/j.clsr.2012.07.005

Peacock E, Wong P (1990) The stress appraisal measure (SAM): a multidimensional approach to cognitive appraisal. Stress Med 6:227–236. doi: 10.1002/smi.2460060308

Penzenstadler B (2013) Towards a Definition of Sustainability in and for Software Engineering. 28th Annu ACM Symp Appl Comput 1183–1185. doi: 10.1145/2480362.2480585

Penzenstadler B, Bauer V, Calero C, Franch X (2012) Sustainability in software engineering: a systematic literature review. 16th Int Conf Eval Assess Softw Eng (EASE 2012) 32–41. doi: 10.1049/ic.2012.0004

Postareff L, Mattsson M, Lindblom-Ylänne S, Hailikari T (2016) The complex relationship between emotions, approaches to learning, study success and study progress during the transition to university. High Educ 1–17.

Pu P, Chen L, Hu R (2012) Evaluating Recommender Systems from the User's Perspective:Survey of the State of the Art. User Modling user-adapted Interact 22.

Pucillo F, Cascini G (2014) A framework for user experience , needs and affordances. Des Stud 35:160–179. doi: 10.1016/j.destud.2013.10.001

Qu Q-X, Zhang L, Chao W-Y, Duffy VG (2016) User experience design based on eye-tracking technology : a case study on smartphone APPs. In: Applied Digital Human Modeling and Simulation, Springer.

Quan C, Ren F (2010) Sentence Emotion Analysis and Recognition Based on Emotion Words Using Ren-CECps. Int J Adv Intell 2:105–117.

Rodden K, Hutchinson H, Fu X (2010) Measuring the User Experience on a Large Scale : User-Centered Metrics for Web Applications. Proc SIGCHI Conf Hum Factors Comput Syst 2395–2398. doi: 10.1145/1753326.1753687

Roto V, Law E, Vermeeren A, Hoonhout J (2010) User Experience White Paper: Bringing clarity to the concept of user experience. Semin Demarcating User Exp 12.

Ruth J a., Brunel FF, Otnes CC (2002) Linking Thoughts to Feelings: Investigating Cognitive Appraisals and Consumption Emotions in a Mixed-Emotions Context. J Acad Mark Sci 30:44–58. doi: 10.1177/03079459994317

Scherer KR (2005) What are emotions? And how can they be measured? Soc Sci Inf 44:695–729. doi: 10.1177/0539018405058216

Seong DSK (2006) Usability guidelines for designing mobile learning portals. Proc 3rd Int Conf Mob Technol Appl Syst - Mobil '06 25. doi: 10.1145/1292331.1292359

Strapparava C, Mihalcea R (2008) Learning to identify emotions in text. Proc 2008 ACM Symp Appl Comput - SAC '08 1556. doi: 10.1145/1363686.1364052

Sun PC, Tsai RJ, Finger G, et al (2008) What drives a successful e-Learning? An empirical investigation of the critical factors influencing learner satisfaction. Comput Educ 50:1183–1202. doi: 10.1016/j.compedu.2006.11.007

Sung E, Mayer RE (2012) Students' beliefs about mobile devices Vs. desktop computers in South Korea and the United States. Comput Educ 59:1328–1338. doi: 10.1016/j.compedu.2012.05.005

Teplan M (2002) Fundamentals of EEG measurement. Meas Sci Rev 2:1–11. doi: 10.1021/pr070350l

Tichon JG, Wallis G, Riek S, Mavin T (2014) Physiological measurement of anxiety to evaluate performance in simulation training. Cogn Technol Work 16:203–210. doi: 10.1007/s10111-013-0257-8

Tullis T, Albert B (2013a) Measuring the User Experience: Collecting, Analyzing, and Presenting Usability Metrics. Morgan Kaufmann

Tullis T, Albert B (2013b) Measuring the User Experience.

Turner CW (2011) A Strategic Approach to Metrics for User Experience Designers. J Usability Stud 6:52–59.

Turner P, Turner S (2013) Emotional and aesthetic attachment to digital artefacts. Congition, Technol Work Volume 15:403–414.

Verkasalo H, López-Nicolás C, Molina-Castillo FJ, Bouwman H (2010) Analysis of users and non-users of smartphone applications. Telemat Informatics 27:242–255. doi: 10.1016/j.tele.2009.11.001

Watson D, Clark LA, Tellegen A (1988) Development and validation of brief measures of positive and negative affect: The PANAS scales. J Pers Soc Psychol 54:1063–1070. doi: 10.1037/t03592-000

Wolpe J (1996) Cognitive therapy: Basics and beyond. J. Behav. Ther. Exp. Psychiatry

27:319.