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Designing for User Engagement in Wearable-technology Enhanced Learning for Healthy Ageing

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Abstract. Today's demographic changes with the rising number of the elderly require new forms of health promotion and innovative approaches to increasing physical fitness. Physical activity is considered as one of the key factors of ageing healthy and at the same time one of the key motivational challenges for the elderly. Supporting healthy ageing through sustained physical fitness requires interventions that promote healthy levels of physical activity as part of everyday life. Wearable devices, such as activity trackers or smart wristbands, are body-worn and may be seamlessly integrated into everyday activities to track fitness data, thus bearing the potential of supporting healthy living habits at older age. Although wearable technologies have been used by younger adopters to optimise physical fitness, little is known so far how these emerging technologies may be leveraged to improve well-being and overall fitness of seniors. In this paper we present the multi-layer approach to designing for user user engagement in wearable-technology enhanced learning for healthy ageing as part of an R&D project called "Fitness MOOC - interaction of seniors with wearable fitness trackers in the MOOC (fMOOC)". fMOOC is a wearable-technology enhanced learning solution combining the MOOC (Massive Open Online Course) approach with embodied learning experience enhanced by wearable activity trackers used to track and monitor physical activity of senior learners. The paper proposes an adaptation of a standard User Experience (UX) model to the context of learning and instructional design and describes how methods for user engagement design have been applied on five different levels, i.e. conceptual, requirements, instructional, architecture and interface design, in the fMOOC project.

Keywords. Wearables, Wearable-technology enhanced learning, User Engagement, User Experience, MOOC

1. Introduction

Mobile health (mHealth) has been considered as one of the biggest technology breakthroughs of our time [21]. According to recent studies the percentage of adults in the USA tracking fitness data through a smartphone has grown approximately 100 percent during the last two years [25]. With wearable technologies becoming more widespread - in 2014 about 21% of US consumers already owned a wearable technology product [20], wearable devices and services are beginning to enhance the mHealth trend. Whilst wearable health and fitness technologies such as activity or fitness trackers (e.g. Jawbone, Fitbit, Nike, Garmin) have been used by younger audiences to measure and improve physical fitness, little is known so far about how senior users interact with wearable devices and which approaches may be effective for sustained user engagement of this user group. Recent studies point out that most wearable fitness devices fail to drive long-term sustained engagement for a majority of users independent of age [13], [14], [24]. Some of the key factors impeding user engagement are considered to be (a) limited functionalities (e.g. currently available fitness trackers provide only basic health metrics such as steps taken and calories burnt), (b) missing activity triggers (e.g. activity trackers capture data but do not inspire action), and (c) unclear utility (e.g. lack of clear purpose and benefits from long-term use). Also missing mechanisms for social interaction, goal reinforcement, contextual intelligence, bio-sensing, healthcare and digital health ecosystem integration, seamless interoperability, have been discussed as possible reasons for wearable devices and services not providing a significant impact on fitness habits yet [14], [20], [25]. One of the key research questions in this area is thus how wearable fitness technologies may be used to ensure sustained physical activity and practice as part of the daily routine, enhancing habit formation and making a long-term impact on users' health and well-being [13]. In this paper we present a novel approach for designing for user engagement as part of wearable-technology enhanced learning solution with the aim of promoting sustained engagement of senior users for healthy ageing.

2. Wearable-technology enhanced learning

Wearable-technology Enhanced Learning (WELL) is beginning to emerge as one of the earmarks of the transition from the desktop age through the mobile age to the age of wearable, ubiquitous computing [4]. While mobile devices are carried to a location and used in a state of temporal stationarity (e.g. standing, sitting), wearable, body-worn devices are used when the user is moving or engaging in other tasks (e.g. running, riding) [3]. In consequence mobile learning and wearable learning may be differentiated by (a) the type of physical activity of the learner, and (b) the type of physical fixture of the device. While mobile learning may require the learner to take a state of temporal stationarity and a device used for learning is not attached to the body of the learner, wearable learning is possible in the state of physical activity and the device is body-worn. Consequently, wearable-technology enhanced learning can be defined as learning in a state of physical mobility with support of devices which are body-worn [5].

In line with the current usage patterns of digital technologies forming the backdrop of personal communications [3], wearable-technology enhanced learning is enabled by connected, portable devices and digital media accessible on these devices, all forming extended Personal Learning Environments [7]. The development of wearable devices, such as smart wristbands, smart glasses, smart watches, smart gloves or even smart balls, drives the development of new scenarios and opportunities for learning, which may harness (a) contextual information by delivering and capturing personalised, instant and context specific information, (b) contextual interaction by bringing multiple, spatially distributed learners together; and (c) contextual participation by triggering opportunities for personal learning in a given context [5].

Wearable-technology enhanced learning may enhance embodied learning experience. While computer-mediated communication has been observed to enhance conscious experiences without self-reference leading to the sense of disembodiment, wearable technologies enhance embodied experience with a strong self-reference [26]. The concept of embodiment is based on the assumption that thoughts, feelings, and behaviours are grounded in bodily interaction with the environment [18]. Embodiment through wearable devices is enabled by gathering and transmitting bodily information onto a physical dynamic display, making this information accessible to others and extending the sensorial experience [27].

Although wearable devices have limited multimodal interfaces they can act as clients to embedded services [3]. Connected services and devices equipped with mechanisms for context and location awareness, activity tracking, monitoring and sharing of data, multimedia information capture and multiple communication channels, open new opportunities for learning, interaction and enhancing healthy living. In view of research results showing that even 30 minutes of daily moderate-intensity physical activity may significantly reduce the risk of chronic diseases [24], wearable technologies combined with possibilities for learning and social interaction may play an important role in health promotion. While wearable devices seem to appeal to younger and middle-age users, little is known about how seniors interact with wearables. One of the key challenges in designing wearable-technology enhanced learning for healthy ageing is the design for user engagement of senior users age 65 and over.

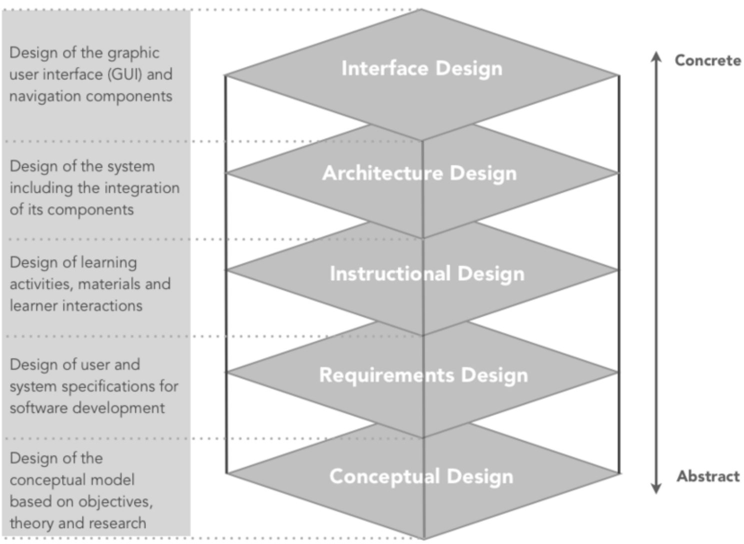

Figure 1. The multi-layer user engagement design in fMOOC

3. User Engagement Design

User engagement (UE) may be defined as the quality of the user experience (UX) that emphasises the positive aspects of the interaction, such as being captivated and motivated to use technologies [10], [12], [16]. Designing for user engagement for technology enhanced learning means designing engaging learning experiences, which may be evaluated by applying engagement metrics such as time spent on site, performed learning activities, number of comments. User engagement has been associated with specific user characteristics which can be also applied to the field of learning, e.g. focused attention, sense of control, novel and unexpected experience, positive emotions during the interaction, willingness to repeat the experience [1]. UE as the subset of UX draws on psychological theories, such as affect, arousal, engagement and flow [10]. In this section we describe multi-layer user engagement design in the fMOOC project based on the model of user experience proposed by [9], which has been adapted to the field of technology-enhanced learning and consequently includes the layer of instructional design (Figure 1). The design of user engagement takes place on all five layers as the elements affect each other to provide the overall user experience [9].

3.1. Conceptual design

The conceptual design of the fMOOC combines health, learning and technology as three distinctive research fields in the interdisciplinary approach to wearable-technology enhanced learning for healthy ageing. The central objective of fMOOC is promoting health and healthy ageing. Health is viewed as a dynamic state of well-being [2] and a set of learnable capabilities, i.e. a person can develop capabilities to live healthy, e.g. learning how to enhance physical fitness, learning how to deal with stress [13]. Healthy ageing is conceptualised as the process of optimising physical, social and mental health with the aim of active participation and enjoyment of independent and good quality life. Using wearables to promote health is conceptually embedded in geriatric research which has revealed positive effect of community-based interventions on improved ratings of physical health, reduced medication use, improved social interactions, less loneliness and fewer health problems [8]. The conceptual design in fMOOC links health and healthy ageing to motivation and health resilience, i.e. the capacity to maintain good health [22], as well as to the promotion of the sense of control, which has been shown to have a positive impact on health [8]. This again is conceptually related to the TEL approach called Personal Learning Environments (PLE) which emphasises a shift towards a greater learner control in technology-enhanced learning settings [6]. The key implications for designing user engagement in WELL for healthy ageing on the conceptual level are:

- helping seniors to remain resilient and motivated to engage in physical activities,
- focusing on personal abilities and resources for self-efficacy and self-esteem,
- strengthening determination for health resilience and coping with difficulties,
- enhancing community-based activities and social learning practice.
- recognising progress for the sense of mastery and the feeling of empowerment,
- enhancing social engagement for the feeling of comfort and the sense of belonging.

The conceptual design of the fMOOC is based on the concept of extended Personal Learning Environments (eX-PLE) in sense of permeable physical and virtual spaces, which are constructed dynamically through the practice of “mobility” across spaces, contexts, concepts and time as proposed by [7]. This approach combines a blended learning approach in sense of convergence of online and face-to-face experience with learning in a hybrid learning environment, in which several learning technologies, e.g. wearable, mobile and desktop technologies, are combined to form a seamless learning experience.

3.2. Requirements design

In order to design for user engagement in wearable-technology enhanced learning settings, the fMOOC development has been based on theoretical and empirical analysis of the needs of senior users. In general, user requirements in the fMOOC encompass needs related to hardware and the needs related to software design. The requirements engineering process in fMOOC includes the elicitation, the specification and the design phase of senior user requirements. On the software level, user requirements have been elicited in pre-tests and prioritised during the specification phase according to the agile software development, SCRUM methodology. These requirements were designed in form of use cases and user stories. Figure 2 shows example user stories which capture what users want to do in the fMOOC. User stories are prioritised and reviewed in the process of software development.

Number	Product backlog	Sprint
111	As a user I want to link my Garmin account with the fMOOC account to share my fitness data.	5
170	As a user I want to sync my data from the fitness tracker to monitor my progress.	5
112	As a user I want to choose an exercise on a particular week day.	8
149	As a user I want to view the ratings of other users of the exercise to decide which exercise to choose.	8
146	As a user I want to use the fMOOC app to guide my training plan during the week.	3
148	As a user I want to adjust my training plans on different week days to be flexible in my choices.	3
174	As a user I want to have an overview of all awards (badges) to see what I can earn.	7
150	As a user I want to see the awards (badges) I have earned when I open the app.	7
151	As a trainer I want to be able to create and administer training plans in a dashboard.	6
167	As a trainer I want to be able to create and administer group training in a dashboard.	6
175	As a user I want to use forums to communicate with other fMOOC users.	10
169	As a user I want to comment on the exercise to share my experience with other fMOOC users.	10

Figure 2. fMOOC user requirements in form of user stories

User requirements related to hardware, i.e. activity trackers, mobile phones and desktop devices, were elicited in interviews and designed in form of a specification list, which was used to select the suitable software for the fMOOC. Example of requirements at the level of hardware related to user engagement with wearable technologies include:

- Wearing comfort: Senior users require the overall comfort of a wrist-worn wearable including an easy and familiar way of fastening the device around the wrist, a flexible band easy to adjust to different wrist sizes.

- Design aesthetics: Senior users want wearable activity trackers to be inconspicuous and not noticeable by others. The preference for simple and modest design aesthetics is linked to the fear of being stigmatised.
- Technical robustness: Senior users value wearable devices with a long battery lifetime and a simple syncing process, at best activated by a single button.

User requirements related to other devices such as smartphones, have been derived from research in this area and confirmed with senior users in pre-test. These requirements include a set of well-known aspects such as larger displays, haptic aids such as a pen, visual aids such as backlight, memory aids such as unified menus [11].

3.3. Instructional design

The instructional design of the fMOOC combines the elements of the Massive Online Learning Course (MOOC) with elements of gamification and principles of seamless learning to create an engaging flow of learning experiences across contexts (online, offline), blending learning with everyday life. MOOCs as learning formats are massive and open per definition, i.e. they are open to everyone and possibly attract large number of learners. In practice however, only a small cohort of highly engaged learners is committed. A typical MOOC, either cMOOC (based around interactions with learners) or xMOOC (based around interactions with content), would be an online course with a specific goal, digital content, learning activities and schedule. Beyond this, MOOCs also aim at providing personalised digital learning experience, which includes options for learners to engage at their own pace and according to their preferences and goals [23]. Personalisation in MOOCs occurs to some extend naturally as distributed learners interact with the content and with each other at their own pace and through collective intelligence enabled by the interaction of the mass of learners forming social and informational networks [23]. Personalization in MOOCs may be also supported by learning analytics, e.g. monitoring login data and adaptive algorithms, which additionally enhance the user engagement.

Gamification is another method to enhance user engagement in MOOCs and mobile Health [17]. Gamified MOOCs make use of game elements such as points, levels, badges and leader boards to reduce learner drop out and draw attention of learners on crucial learning activities [28]. Since the fMOOC is dedicated to enhancing physical fitness as a healthy living habit, some typical MOOC elements have been modified to enhance user engagement. For example, the fMOOC includes not only online but also offline activities and makes use not only of desktop but also of wearable and mobile technologies.

The key principles for designing user engagement in the fMOOC at instructional design level include:

- blending online and physical learning experience in hybrid learning environments composed of wearable, mobile and desktop technologies to enable learning in extended PLEs,
- designing digital content appropriate to the fitness level of individual users and learner interactions related to fMOOC activities, such as training plans, video content and training materials,

- integrating gamification elements such as badges and battles with activity tracking data to enhance an enjoyable, embodied and motivating learning experience in a community of learners.

Figure 3 visualises the instructional design model of the fMOOC with the three aspects described above, i.e. (a) blended learning experience, (b) digital content and learner interactions focused on physical activity, and (c) gamification elements.

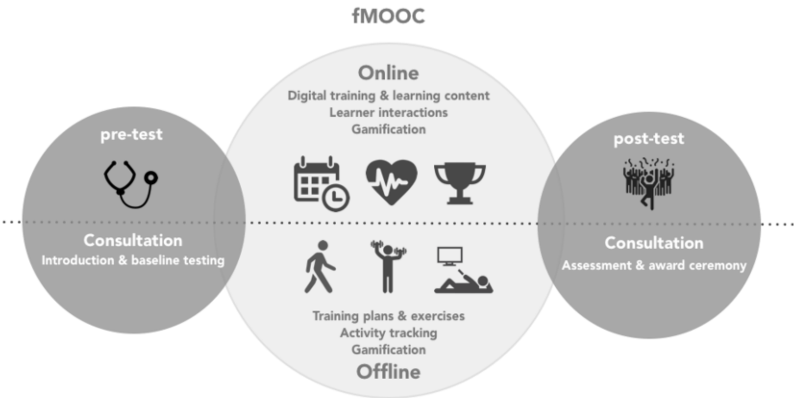

Figure 3: fMOOC instructional design

The participant in the fMOOC first takes part in a group introduction to the fMOOC combined with the demonstration of the fMOOC platform and the wearable activity tracker, followed by a medical consultation with a baseline testing of the overall physical fitness. Based on the results of this consultation, a personalised training plan with a combination of strength and endurance training and integrated rest periods is composed for each individual learner. One cycle of the fMOOC lasts for 4 weeks and is repeated for another cohort of senior learners. Learners learn and interact online and at the same time perform physical exercises such as strength training, walking and jogging in a physical context.

Gamification in fMOOC as a method of persuasive design focuses on two elements - badges and battles - to enhance user engagement. Badges are used both as triggers and as awards. As triggers badges are used to set goals and aim at calling learners to action, thus enhancing motivation [19]. Badges as awards are used to mark progress and recognise achievements. Badges are awarded for (a) specific physical activities, e.g. completing a perfect training plan with rest periods, (b) progress in steps made per day, which are captured with fitness trackers, (c) interactions with other senior users in the fMOOC, e.g. rating and commenting on posts. Battles are used as competitive gamification elements with the aim of enhancing motivation to improve physical fitness. To reduce the risk of negative emotions of those losing the competition, the battles are designed for groups and not individuals and the focus is placed on positive representations of physical activity data within the group. To enhance motivation, battles are designed to make user progress identifiable by the in-group but anonymous to the out-group [24].

3.4. Architecture design

In this section we give a short overview of how the fMOOC architecture is designed to enhance user engagement. The fMOOC architecture combines wearable, mobile and learning technologies to capture and share fitness data and content such as training plans and exercise videos within the community of senior learners. The architecture integrates mobile, wearable and desktop technologies to enhance a seamless integration of the fMOOC activities into everyday life. Figure 4 shows the architecture designed to implement the fMOOC project. Senior learners access fMOOC via the "fMOOC mobile App" using indifferently a laptop, a tablet or a mobile phone. The functionalities of the software are realized by a number of services. The content service connects to the Learning Management System (LMS) Moodle where the content such as training plans and exercise videos, is stored. The communication service also uses the communication facilities of LMS Moodle. The tracking service connects with the fitness tracking data service of the wearable devices to retrieve appropriate data such as the number of steps as measured by an activity tracker. The learning analytics module displays an overview of their fitness data to learners including the exercises of the training plans they have completed. This module makes use of the interactions data stored by Moodle and by the wearable devices. The fMOOC software includes a gamification service to incorporate rewards and playful elements in the course including badges and battles with the aim of enhance user engagement.

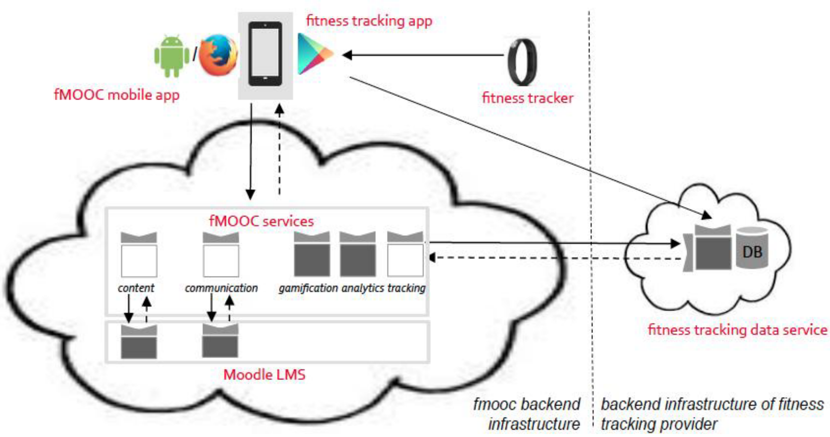

Figure 4. fMOOC architecture design

The architecture design of the fMOOC software system had to face two main challenges. The first challenge results from the fact that most of the activity trackers currently available on the market are not straightforward in supporting APIs thus impeding access to fitness data by other services that can leverage this data for specific groups of users. The available trackers come as a self-contained closed infrastructures, consisting of the actual tracking device, a backend service for storing the tracking data and usually a native mobile application that is responsible for registering users, for synchronising the data stored on the tracking device with the backend service and for providing statistical evaluations on the personal tracking data. For application in the fMOOC system it appeared necessary to obtain an individual view of the tracking data, independently of the existing evaluations of the tracking provider, and to integrate evaluations of tracking data in the fMOOC user interface. Therefore it was necessary to foresee a backend-side integration of the data service of the tracking provider for accessing raw tracking data and for making them available for evaluation in the fMOOC. The second challenge we faced was the integration of the LMS Moodle. The requirements analysis showed that although Moodle enabled some key fMOOC functionalities, it restrained the intuitive usage and senior-friendly user interface. Therefore it was decided to develop a mobile fMOOC GUI independently of Moodle and to integrate Moodle as a backend service, mainly for content management and communication of fMOOC participants.

3.5. Interface design

The fMOOC senior user interface has been designed to be accessible for older users (aged 65+) making use of the key usability principles from multidisciplinary usability research, e.g. psychology, computer science, economic studies, engineering [29]. Beyond accessibility, the fMOOC interface design aims at adding value and increasing the aesthetic appeal of fMOOC to enhance user engagement. As senior users experience a number of sensorial, physical and cognitive changes such as (a) visual changes, e.g. decrease in colour perception and contrast sensitivity, (b) acoustic changes, e.g. difficulties in hearing with distracting background noises, (c) tactile changes, e.g. decreasing fine motor skills and sense of touch, (d) information processing changes, e.g. more time for information processing is needed, difficulties in localizing objects and to remembering non-verbal elements, poorer memory for spatial tasks [29], the fMOOC interface design focuses on the following elements to enhance user engagement in view of the age-related changes as well as further generational issues:

- Text characteristics, e.g. larger fonts and high-contrast elements
- Navigation characteristics, e.g. uniform navigation menus, few navigation layers (reduction of complexity),
- Language characteristics, e.g. clear labels in German language avoiding English words such as “log-in”
- Task characteristics, e.g. clear structure and instructions making every step easily recognisable,
- Feedback characteristics, e.g. easily recognisable feedbacks of success or failure of every user action.

Figure 5 provides an example of user interface design optimised for mobile devices.

4. Conclusions

Healthy ageing is a significant issue which concerns all societies. As emerging technologies such as wearable activity trackers provide new opportunities for promoting health, there is a desperate need to develop innovative solutions harnessing new mechanisms for tracking physical activity and capturing personal health information that can assist in healthy ageing. This paper presented a multi-layer approach for designing user engagement for Wearable-technology Enhanced Learning (WELL) for healthy ageing. As senior users experience a number of age-related changes in terms of physical fitness, cognitive, sensory and tactile abilities, designing for user engagement within wearable-technology enhanced learning is an important research challenge. A number of the aspects addressed in this paper has been tested with senior users as part of the iterative, agile development of the fMOOC. These incremental tests inform the subsequent development of the fMOOC software. The fMOOC prototype and a the user study are planned for summer 2015. The empirical results from this research will be used to provide design guidelines for user engagement in wearable-technology enhanced learning for healthy ageing in order to leverage technology benefits for senior users. This will include issues presented in this paper as well as further issues, e.g. related to data security. The results of the user study will be used as proof of concept for the fMOOC solution.

Figure 5. fMOOC interface design

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References

[1] Attfield, S., Kazai, G., Lalmas, M., Piwowarski, B. (2011). Towards a science of user engagement (Position Paper)," in WSDM Workshop on User Modelling for Web Applications.

[2] Bircher J. (2005). Towards a dynamic definition of health and disease. Med. Health Care Philos, 8: 335-41.

[3] Bowskill, J., & Dyer, N. (1999). Wearable Learning Tools. Association for Learning Technology Journal, 7(3), 44-51.

[4] Buchem, I.; Klamma, R. & Wild, F. (2014). Special Interest Group on Wearable-technology Enhanced Learning (SIG WELL) of the European Association of Technology-Enhanced Learning (EA-TEL). Retrieved from: http://ea-tel.eu/special-interest-groups/well/

[5] Buchem, I., Merceron, A., Kreutel, J., Haesner, M., Steinert, A. (2015). Wearable-technology Enhanced Learning for Healthy Ageing: Conceptual Framework and Architecture of the "Fitness MOOC".

Journal of Interaction Design and Architectures, Focus Section on Innovative Designs with Social, Mobile and Wearable Technologies for Creative Teaching and Learning, 2015.
[6] Buchem, I., Attwell, G., Torres, R. (2011). Understanding Personal Learning Environments: Literature review and synthesis through the Activity Theory lens. pp. 1-33. Proceedings of the The PLE Conference 2011, 10th – 12th July 2011, Southampton, UK.
[7] Buchem, I.; Pérez-Sanagustín, M. (2014). Personal Learning Environments in Smart Cities: Current Approaches and Future Scenarios. eLearning Papers, 35, November 2013.
[8] Cohen, G. D., Perlstein, S., Chapline, J., Kelly, J., Firth, K. M., & Simmens, S. (2006). The impact of professionally conducted cultural programs on the physical health, mental health, and social functioning of older adults. Gerontologist, 46, 726–734.
[9] Garrett, J. (2002). The Elements of User Experience: User-Centered Design for the Web. New Riders Publishing Thousand Oaks, CA, USA.
[10] Hart, J., Sutcliffe, A.G., di Angeli, A. (2012). Evaluating User Engagement Theory. CHI 2012, May 5–10, 2012, Austin, TX, USA. ULR: http://di.ncl.ac.uk/uxtheory/files/2011/11/5_Hart.pdf
[11] Kurniawan, S. (2008). Older people and mobile phones: A multi-method investigation, Int.J. HumanComputer Studies 66, pp. 889-901
[12] Lalmas, M. (2012): User Engagement – A Scientific Challenge. Yahoo! Research Barcelona.
[13] Law, I., Widdows, H. (2007). Conceptualising health: Insights from the capability approach. Health Care Analysis. Universit Birmingham.
[14] Ledger, D., McCaffrey, D. (2014). Inside Wearables How the Science of Human Behavior Change Offers the Secret to Long-Term Engagement. Endeavour Partners LLC.
[15] Ledger, D. (2014). Inside Wearables - Part 2. A look at the uncertain future of smart wearable devices, and five industry developments that will be necessary for meaningful mass market adoption and sustained engagement. Endeavour Partners LLC.
[16] Lehmann, J., Lalmas, M., Yom-Tov, E., Dupret, G. (2012). Models of user engagement. In Proceedings of the 20th international conference on User Modeling, Adaptation, and Personalization (UMAP'12), Judith Masthoff, Bamshad Mobasher, Michel C. Desmarais, and Roger Nkambou (Eds.). Springer-Verlag, Berlin, Heidelberg, 164-175.
[17] Lister C. et al. (2014). Just a fad? Gamification in health and fitness apps. MIR Serious Games. 2014 Aug 4;2(2).
[18] Meier, B. P., Schnall, S., Schwarz, N., & Bargh, J. A. (2012). Embodiment in social psychology. Topics in Cognitive Science, 4(4), 705-716.[19] Muntean, C. (2011). Raising engagement in e-learning through gamification. Cybernetics and Statistics, Babes-Bolyai University, Romania.
[19] PwC HRI (2014). Health wearables: Early days. Pricewaterhousecoopers 2014. Top Health Industry Issues. Wearable Devices.
[20] PwC (2014). Emerging mHealth: Paths for growth. URL: Pricewaterhousecoopers 2014.
[21] Resnick, B. (2011). The Relationship between resilience and motivation. In: B. Resnick, L. Gwyther, & K. A. Roberto (Eds.), Resilience in aging: Concepts, research, and outcomes (pp. 199-215). New York: Springer.
[22] Resnick, B. (2011). The Relationship between resilience and motivation. In: B. Resnick, L. Gwyther, & K. A. Roberto (Eds.), Resilience in aging: Concepts, research, and outcomes (pp. 199-215). New York: Springer.
[23] Schneider. E. (2013) welcome to the moocspace: a proposed theory and taxonomy for massive open online courses. In Proceedings of the 1st Workshop on Massive Open Online Courses at the 16th Annual Conference on Artificial Intelligence in Education (2013). Memphis, TN.
[24] Shih, P. C., Han, K., Poole, E. S., Rosson, M. B., Carroll, J. M. (2015). Use and adoption challenges of wearable activity trackers. In Proceedings of the iConference 2015.
[25] Technology Advice (2014). Wearable Technology and Preventative Healthcare. Trends in Fitness Tracking among U.S. adults. URL: http://healthblawg.typepad.com/files/ta-study-wearable-technology-preventative-healthcare.pdf
[26] Uğur, S. (2013). A Design Practice on Emotional Embodiment Through Wearable Technology. In: Wearing Embodied Emotions SpringerBriefs in Applied Sciences and Technology 2013, pp 61-74
[27] Weiser, M. (1991). The Computer for the 21st Century. Scientific American, 265(3), 94-104.
[28] Willems, Ch., Fricke, N., Meyer, S., Meissner, R., Rollmann, K.-A., Voelcker, S., Woinar, S., Meinel, Ch. (2014). Motivating the Masses – Gamified Massive Open Online Courses on openHPI. In Proc. 6th International Conference on Education and New Learning Technologies (EDULEARN14), Barcelona, Spain, 2014.
[29] Wirtz, S, Jakobs, E.-M., Ziefle, M. (2009). Age-specific usability issues of software interfaces. Proceedings of the IEA 2009 – 17 th World Congress on Ergonomics (Beijing, China).