NFC LearnTracker

NFC LearnTracker: Seamless support for learning with mobile and sensor technology

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Abstract—Lifelong learning activities are scattered along the day, in different locations and making use of multiple devices. Most of the times adults have to merge learning, work and everyday life making it difficult to have an account on how much time is devoted to learning activities and learning goals. Learning experiences are disrupted and mobile seamless learning technology provides new solutions to integrate daily life activities and learning in the same process. Hence, there is a need to provide tools that are smoothly integrated into adults' daily life. This manuscript presents the *NFC LearnTracker*, a mobile tool proposing the user to immerse within his autobiography as a learner to identify successful physical learning environments, mark them with sensor tags, bind them to self-defined learning goals, keep track of the time invested on each goal with a natural interface, and monitor the learning analytics. This work implies a suitable tool for lifelong learners to bind scattered activities keeping them in a continuing learning flow. The NFC LearnTracker is released under open access licence with the aim to foster adaptation to further communities as well as to facilitate the extension to the increasing number of sensor and NFC tags existent in the market.

Keywords: lifelong learning, feedback, self-regulation, natural interaction, NFC

1. Introduction

Self-organized lifelong learning is one of the critical competences for individuals to cope with societal challenges and resulting changing demands on job markets. A survey by the European Commission has identified time, location and conflicts with other activities as the core barriers to lifelong learning [1]. Nowadays, lifelong learners are confronted with a broad range of activities they have to manage everyday. In most cases they have to combine learning activities and their professional and private life linking formal and non-formal learning activities. In the setting of an adult lifelong learner this is especially difficult as in most cases interests might be highly distributed over different domains and keeping up learning needs an extra effort. One of the main challenges here is the bridging of learning activities between different contexts.

Mobile seamless learning technology can offer solutions to address this problem. Seamless learning was first defined as a learning style where a learner can learn in a variety of scenarios and in which they can switch from one scenario or context to another easily and quickly, with the personal device as a mediator [2]. Succeeding, Wong et al. [3] identified ten gaps in seamless learning support: 1) Encompassing formal and informal learning; 2) Encompassing personalized and social learning; 3) Across time; 4) Across locations; 5) Ubiquitous knowledge access; 6) Encompassing physical and digital worlds; 7) Combined use of multiple device types; 8) Seamless switching between multiple learning tasks; 9) Knowledge synthesis; 10) Encompassing multiple pedagogical or learning activity models. Lately, a learner-centric view of mobile seamless learning [4] suggests that *a seamless learner should be able to explore, identify and seize boundless latent opportunities that his daily living spaces may offer to him (mediated by technology), rather than always being inhibited by externally-defined learning goals and resources*. For lifelong learners several key aspects have to be highlighted that are essential problems:

- No support for learning activities across locations, devices, and environments. There is very little research on how to link the different everyday contexts of lifelong learners and their learning activities in these different settings. (Seam 3, 4)
- Linking learning activities with everyday life activities and the physical world objects. Everyday life events trigger different activities that lead to learning events. The linking between the self-directed learning of lifelong learners and their everyday environment is not foreseen in todays learning technology (Seam 1, 2, 7, 8)
- Supporting reflection on learning activities and personal project in heterogeneous environments making use of different technologies (Seam 6, 9, 10).

In summary there is little support for lifelong learners that typically try to learn in different contexts, are busy with multiple parallel learning tracks, and must align or relate their learning activities to everyday leisure and working activities. Candy [5] has summarized four components of self-directed lifelong learning. These are self-*monitoring*, *self-awareness*, *self-management* (planning of learning) and last but not least *meta-learning*. To date, there is little technological support to enable learners in conducting these different activities across contexts and locations. A recent survey to lifelong learners on mobile usage habits reveals that there is an association between the type of learning activity being performed (read, write, listen, watch) and the concrete location where it takes place [6]. Hence, there is a need to provide suitable tools for lifelong learners to facilitate bridging learning experiences in a seamless flow. In this paper Near Field Communication (NFC) is proposed as an instantiation for natural interaction with mobile devices and for seamless integration of technology in lifelong learning. The following section reviews previous research of scientific work where NFC has been used with learning purposes. Section 2 identifies the four pillars sustaining the design of a mobile tool for self-regulated support: the NFC Learn-Tracker. In section 3 the core features are described and the results of a prototype formative evaluation are presented. Finally, conclusions are discussed and future work is described.

Using NFC sensor tags for bridging seams and natural interaction

Natural User Interfaces and the *Internet of Things* have been predicted to have an impact on education in the short term [7]. Tagged objects are widely accepted and the number of connected devices could reach 50 billion by 2020 [8]. Different tagging methods (e.g. visual codes, text recognition, image recognition) allow enriching physical objects of the world with educational resources [9]. Moreover, the prominent adoption of NFC readers in mobile devices has moved this technology from an innovator to an early adopter phase. This frictionless technology will enrich our environment facilitating natural interactions with daily physical objects. NFC simplifies and reduces several actions to a single action of narrow contact (zero click overhead). These small exchanges of information between devices that occur almost instantaneously have been recently coined as *micro-interactions* [10].

Recent work [11], presents some of the potentials NFC technology brings for teaching and learning materials in formal education: distributing learning/teaching materials in face-to-face classrooms; enriching printed materials; sharing materials among students; delivery of practicals; integration of social networks; access to control materials; examinations. Likewise, there is an increasing number of empirical studies using NFC technology in field trip excursions [12, 13], connecting digital and physical worlds [14–16] or combining this technology within Learning Management Systems [17]. Nevertheless, NFC has not been used to tackle the problems of lifelong learners. In the following we will frame and integrate these approaches according to the model of Candy [5] introduced in section 1.

2. Design of the NFC LearnTracker

The NFC LearnTracker is a standalone application developed for NFC-enabled Android (4.03 or above) devices released in March 2014 in Google Play[1]. The NFC LearnTracker uses an embedded database for local/client storage in the same application software to avoid privacy issues. The NFC LearnTracker project has been released trusting open code license available in an open source repository[2] to be downloaded, customized and further extended to different learning environments, LMSs, or communities. This section presents the NFC LearnTracker as mobile seamless tool for developing self-regulated learning that aims to cover the following gaps in lifelong learners' learning process:

1. No support for learning activities across locations, devices and environments.
2. No linking between learning activities and everyday life.
3. No feedback on lifelong learning activities.

[1] NFC LearnTracker in Google Play.
https://play.google.com/store/apps/details?id=org.ounl.lifelonglearninghub
[2] Lifelong Learning Hub's code repository. https://code.google.com/p/lifelong-learning-hub/

The NFC LearnTracker has been designed based on the seamless notion that lifelong learners can learn in a variety of scenarios and can switch from one scenario or context to another easily and quickly, using the personal device as a mediator. Figure 1 illustrates how daily life activities and learning activities are combined in a continuing process. The tool presented in this section has been conceptualized on the idea that mobile technology can be smoothly integrated in daily life activities whenever interacting with it requires the least number of clicks (zero) possible and the duration of any action with the tool lasts not longer than 20 seconds.

Butler and Winne [18] describe the self-regulated learning model as an iterative process comprising four sequential stages: 1) interpretation of own learning paths and task queuing; 2) cognitive process of defining goals and monitoring the progress; 3) perform the learning activity; 4) interpretation of external feedback. Focusing on lifelong learners, Candy [5] proposes a learner-centric model with four stages (See section 1). Hereby we describe in a narrative way [19] how these stages have been covered with the NFC LearnTracker using the scenario of Miguel Angel, a PhD student aiming to combine daily life activity (family, work, leisure) with learning activities towards the accomplishment of his doctoral degree.

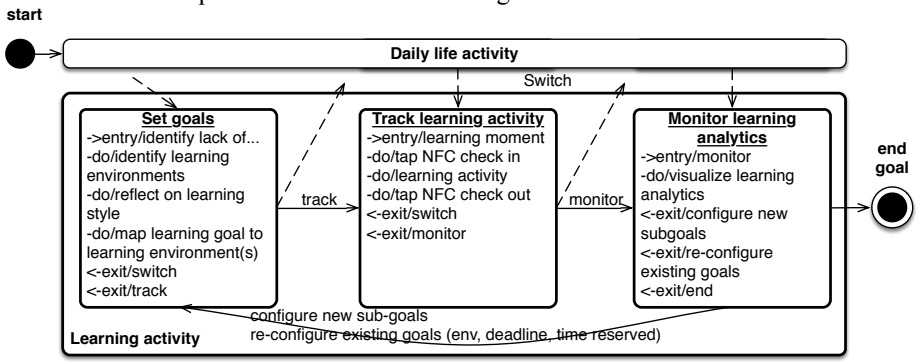


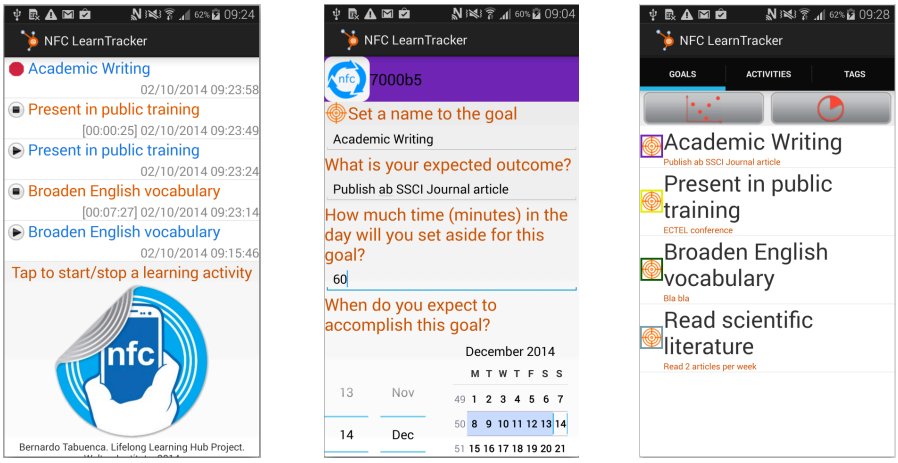
Fig. 1. Lifelong Learning goal's life cycle. UML state diagram

Set goals.

Miguel Angel knows he needs to improve his academic writing, develop his skills to make effective presentations in public, broaden his English vocabulary, and set aside time to read scientific literature. As he engages in these learning tasks, he draws on knowledge and beliefs constructing an interpretation of each task´s properties and requirements [18]. In fact, Miguel Angel frequently introspects his autobiography as a learner to identify which learning environment fits better to which learning task upon his learning style or time availability [20]. This stage (fig.1) covers the "*Planning for learning*" and "*self awareness"* stages in the self-regulation model for lifelong learners [5]. Analogously, Butler and Winne [18] situate the stage of "*setting goals*" within the cognitive system stressing its key importance in shaping the process of self-regulated learning.

In this stage (first box in figure 1), Miguel Angel reflects on his learning style mapping learning goals to frequently used learning environments and tagging them

with NFC tags (See use cases in figure 3). Whenever Miguel Angel configures his goals in NFC LearnTracker, he takes a NFC tag, taps it with the NFC enabled mobile device so that the interface in figure 2b is displayed. He characterizes the goal with a name, specifies the expected outcome when he accomplishes the goal, estimates how much time (in minutes) will he devote to this goal on daily basis, and finally indicates his expected date to finish the goal. Sticking a NFC tag on a physical learning object enables the connection of a variety of tracking data with the learning activity. For example the "check-in" at a NFC tag can track Miguel´s use of a specific resource (i.e. tablet, book, PC), at a certain time of the day, or, in a specific location (i.e. work, home).



(a) Tap to start/stop a learning activity

(b) Linking a purple NFC tag to Academic Writing learning goal

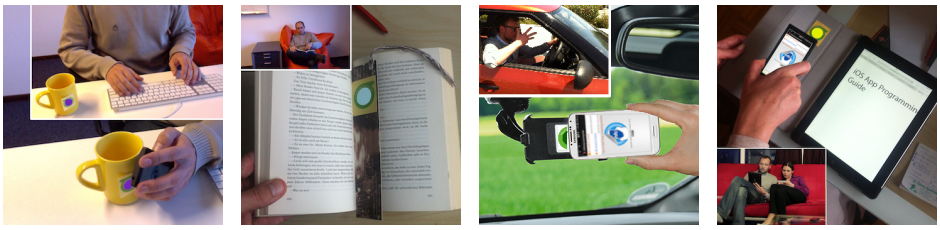
(c) Learning goals configured by the user

Fig. 2. Binding goals to NFC-tagged learning environments with NFC LearnTracker

Perform learning activity.

Miguel Angel, as most of the lifelong learners [6], recurs to specific locations (e.g. desktop, coach) and moments (e.g. waiting times, transitions) to accomplish his learning activities. In addition, Miguel Angel is interested to know how much time he devotes to his own learning goals during the day and along the week. Hence, Miguel needs a tool with natural interaction, otherwise he will not bother to track short learning moments (e.g. fifteen minutes writing, fig. 3a; twenty minutes reading, fig. 3b; ten minutes listening podcasts, fig. 3c; three minutes watching videos, fig. 3d), and as result it will never be accounted as learning time. Both self-regulation models [5, 18] situate this stage out of the scope of the cognitive system.

In this stage (second box in figure 1) Miguel Angel taps the associated NFC-tag every time he starts/stops a learning activity (Figure 2a). Hence, the NFC LearnTracker harvests all learning moments accounting them as real learning time with frictionless interactions.



a) Write two paragraphs for a journal article taking the first coffee

b) Reading scientific literature during waiting times

c) Listening english podcasts commuting to work, college, gym…

d) Watch top presenters' videos during commercial breaks

Fig. 3. Learning activities (write, read, listen, watch) bound to daily learning environments

Monitor learning activities.

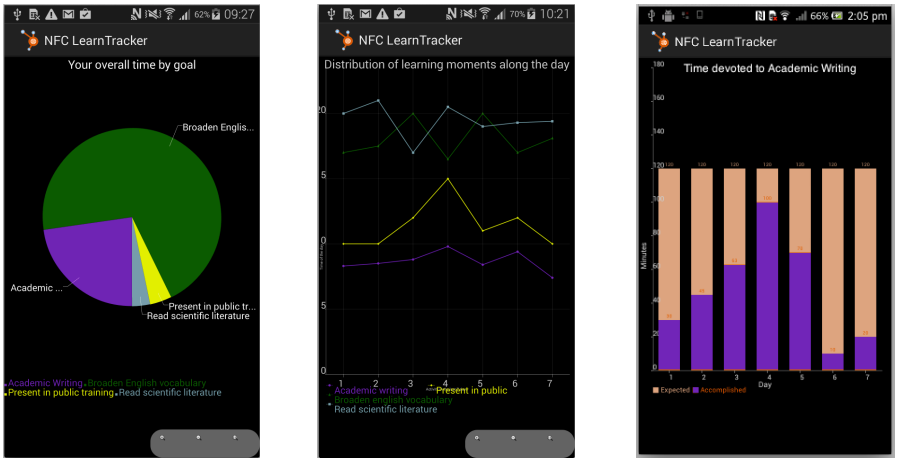
The NFC LearnTracker features learning analytics when defined as "*the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs*" [21]. Monitoring the state in learning activity can motivate the user towards the accomplishment of a learning goal. By comparing evolving states of a task to goals creates conditional knowledge that is the basis for further action. This cognitive process has been defined as "*internal feedback*" [18], "*self monitoring*", and "*understanding how to learn*" [5] in the previously cited self-regulation models. The cues identified by the user in this process facilitate the recognition of his learning patterns and as a result, the constant update of his autobiography as a learner.

In this stage (third box in figure 1), Miguel Angel can monitor his learning analytics for a specific goal, or as overall performance. Siemens [22] stressed that the focus of learning analytics is exclusively on the learning process. Hence, the NFC LearnTracker tracks and visualizes data about the learning process within the specific personal learning context for which they were configured by the lifelong learner, and independently from the content (subject, topic, etc.) that is learned in the process. The NFC LearnTracker features the following visualizations with the aim to foster understanding on learning habits, optimise learning, and, bind successful learning environments:

1. *Percentage of time invested on each learning goal*. Learning activities are scattered along the day in different locations or transitions. This feature provides lifelong learners an overall summary on how much time is devoted to learning goals. Figure 4a illustrates how percentage of total time and number of minutes are presented in a pie chart. This visualization can be used by lifelong learners to compare time invested on his learning goals, identify priorities to accomplish goals, and, patterns regarding preferences for specific learning environments, devices or learning activities (read, watch, write, listen).
2. *Distribution of learning moments along the day*. Every lifelong learners performs differently in the sense that some of us prefer to do learning activities that require a higher cognitive load or concentration in early morning (scientific reading or writing), or do the ones that require least cognitive load (watch videos

or dispatch emails) while sat on the couch at night during every commercial pause on TV. Lifelong learners are intrinsically interested to identify patterns in their learning experiences and scaffold their autobiography as a learner to better distribute learning activities in forthcoming goals. Figure 4b illustrates the distribution of the learning moments during the day (X axis 0..24) for a whole week (Y axis 1..7). Each spot (square, triangle, circle) identifies when the learning activity started.

3. *Monitoring accomplished goals*. Monitoring is of crucial importance in relation to the development as a self-regulated learner. Monitoring is the cognitive process that assesses states of progress to goals and generates feedback that can guide further action [18]. Figure 4c illustrates a representation of accomplished learning time versus expected time towards a learning goal NFC LearnTracker.



(a) Quantity of time invested in learning goals (Percentage and number of minutes)

(b) Distribution of learning moments along the day in a week

(c) Expected learning time versus invested time (in minutes)

Fig. 4. Learning analytics in NFC LearnTracker

3. Formative evaluation

The NFC LearnTracker was presented in March 2014 within a workshop for 14 PhD students. The concept of lifelong learning and the scope of the research were introduced where the problems described in the introduction section of the current manuscript were enumerated. With this focus in mind, the tool was presented for 30 minutes as a potential solution to those problems providing practical examples, making a demo with physical learning environments where the tool can be applied and highlighting the natural interaction of the NFC micro-interactions. After that, participants filled in a questionnaire containing eight 5-likert-scale questions prompting the participants to reflect and rate the potential of the tool to: manage learning goals; foster awareness on preferred learning environments; integrate learning with daily life

activities; learning activities across contexts; set aside time to learn on regular basis; adjust goals high enough to challenge, but not so high to frustrate you; set mini-goals along the way; overall rating of the mobile tool to define goals, set-aside time, bind goals to daily activities, keep track of time invested on each goal, and monitor these analytics.

Table 1. Evaluation of the tool with 5-likert scale (5:"strongly agree", 1:"strongly disagree")

	SD	AVG
Manage learning goals	0.84	3.36
Foster awareness on preferred learning environments	0.70	3.79
Integrate learning with daily life activities	0.61	3.29
Learn across context	0.78	3
Set aside time to learn on regular basis	1	3.07
Adjust goals high enough to challenge but not so high to frustrate you	1.12	3.21
Set mini-goal along the way	0.73	3.93
Overall rating	0.75	3.43

Finally an open discussion was proposed around the following two questions: (1) "*What kind of feedback do you find suitable to be provided with this tool?*". Tips for productive listening, writing or reading were highlighted as a potential feedback supplied in the form of pushed notifications. E.g. Participant#4 suggested that it might be interesting if she would receive a notification prompting to determine the learning goals before starting the lecture or suggesting tips for productive listening like taking notes or asserting. Participant#7 stressed that notifications prompting to reflect on what has been learned after accomplishing the learning activity could help to make knowledge more persistent. Participant#8 suggested that it would be interesting to rate my perceived productivity after a learning activity and correlate it with the time of the day, day of the week, duration of the task, type of device used or location where I accomplished the learning activity. Participant#3 suggested providing a notification when you should make a break.

A second question 2 proposed a discussion about (2) "*In which learning scenarios do you consider this tool can be applied?*". Participant#1 suggested extending the scope of the mobile tool from self-regulation to a scenario in formal education. "*Books in secondary school could be NFC-tagged so that the teachers could use this tool to get a grasp on which subjects do students invest more/less time in their homework*". Participant#9 stressed the importance of the tool for self-awareness "*this tool could help me to establish some limits to the time I invest in non-academic tasks versus the time I invest in academic tasks*". Participant#3 stated, "*Sometimes you are so tied up with concrete projects that you really need to stop, reflect and organize your learning goals. This tool can be not only used to organize your learning time but also any other daily life activity*". Upon all these statements, several participants pinpointed to the learning analytics illustrated in figure 4 as a very interesting feature to quantify your learning style and become aware of the time devoted to learning activities in long term.

4. Conclusions and future work

The observations on the lifelong learning process indicate that typical learning activities of continuing and further education are poorly connected to the daily activities of the learners. There is no support for learning activities across locations, devices and environments and there is a need to provide customized feedback to lifelong learning activities. The tool presented in this manuscript represents an approach to these problems. Tracking when, where and how learning occurs along the day provides rich information to infer lifelong learner's owns habits. This paper reviews previous work on educational scenarios using NFC and four pillars for seamless support of lifelong learners are identified. The NFC LearnTracker has been presented and evaluated as a tool to lead lifelong learners towards a self-regulated process: fostering awareness on learning goals and learning moments; facilitating the user to keep track of learning time with a natural interface; fostering engagement and motivation on the task providing feedback with useful statistics. The Lifelong Learning Hub Project[3] has been released under open licences with the aim to foster its adaptation to further educational communities as well as to facilitate the extension to the increasing number of NFC tags existent in the market.

As limitations, the evaluation of this tool has been performed in an artificial context (Technology Enhanced Learning workshop). The NFC LearnTracker should be tested in longitudinal studies with personal mobile devices and in lifelong learning settings. A realistic scenario must contemplate that the single decision to start using the tool should be triggered by an intrinsic motivation from the user to explore his learning patterns rather than an externally imposed tool. The effects in self-regulation and intrusiveness of logging learning time and monitoring learning patterns should be explored in further research. This tool might be an interesting approach to determine whether students with more scattered and shorter learning moments are correlated with better or worst performance.

In further research, we will investigate the effects in self-regulation of self-defined internal feedback loops [23] via ambient learning displays [24, 25] based on the patterns identified with the NFC LearnTracker. Additionally, services coexisting in smart learning environments will be orchestrated to provide customized feedback based on the type of learning task being performed (read, write, listen or watch).

The contribution of this manuscript is presenting a tool for lifelong learners to bridge scattered personal learning environments in which learners can define personal ecologies and experience the interaction with such a system in long term typical lifelong learner settings. This research aims at giving an open, flexible and low-cost prototyping framework for defining and linking everyday learning activities to contexts, physical artefacts, everyday home media solutions, and supporting to link sustainable learner tracks to these components.

[3] Lifelong Learning Hub Project site. https://sites.google.com/site/lifelonglearninghubproject/

References

1. Eurostat: Lifelong Learning Statistics. (2012).
2. Chan, T.-W., Roschelle, J., Hsi, S., Sharples, M., Brown, T., Patton, C., Cherniavsky, J., Pea, R., Norris, C., Soloway, E., Balacheff, N., Scardamalia, M., Dillenbourg, P., Looi, C.-K., Milrad, M., Hoppe, U.: One-To-One Technology-Enhanced Learning: an Opportunity for Global Research Collaboration. Res. Pract. Technol. Enhanc. Learn. 01, 3–29 (2006).
3. Wong, L.-H., Looi, C.-K.: What seams do we remove in mobile-assisted seamless learning? A critical review of the literature. Comput. Educ. 57, 2364–2381 (2011).
4. Wong, L.-H.: A learner-centric view of mobile seamless learning. Br. J. Educ. Technol. 43, E19–E23 (2012).
5. Candy, P., Brookfield, S.: Self-direction for lifelong learning: A comprehensive guide to theory and practice. , San Francisco, USA (1991).
6. Tabuenca, B., Ternier, S., Specht, M.: Supporting lifelong learners to build personal learning ecologies in daily physical spaces. Int. J. Mob. Learn. Organ. 7, 177–196 (2013).
7. Johnson, L., Brown, S., Cummins, M., Estrada, V.: The Technology Outlook for STEM+ Education 2012-2017: An NMC Horizon Report Sector Analysis. (2012).
8. Ericsson: More than 50 billion connected devices. (2011).
9. Specht, M., Tabuenca, B., Ternier, S.: Ubiquitous learning trends in the internet of things. Campus Virtuales. 2, (2013).
10. Dodson, B., Lam, M.: Micro-interactions with NFC-Enabled Mobile Phones. Mob. Comput. Appl. Serv. 118–136 (2012).
11. Ebner, M., Maierhuber, M.: Near Field Communication. Which Potentials Does NFC Bring for Teaching and Learning Materials? Int. J. Interact. Mob. Technol. 7, 9–14 (2013).
12. Kuflik, T., Stock, O., Zancanaro, M., Gorfinkel, A., Jbara, S., Kats, S., Sheidin, J., Kashtan, N.: A visitor's guide in an active museum. J. Comput. Cult. Herit. 3, 1–25 (2011).
13. Pérez-Sanagustín, M., Ramirez-Gonzalez, G., Hernández-Leo, D., Muñoz-Organero, M., Santos, P., Blat, J., Delgado Kloos, C.: Discovering the campus together: A mobile and computer-based learning experience. J. Netw. Comput. Appl. 35, 176–188 (2012).
14. Kubicki, S., Lepreux, S., Kolski, C.: RFID-driven situation awareness on TangiSense, a table interacting with tangible objects. Pers. Ubiquitous Comput. 16, 1079–1094 (2011).
15. Ailisto, H., Pohjanheimo, L., Välkkynen, P., Strömmer, E., Tuomisto, T., Korhonen, I.: Bridging the physical and virtual worlds by local connectivity-based physical selection. Pers. Ubiquitous Comput. 10, 333–344 (2006).
16. Munoz-Organero, M., Ramirez-Gonzalez, G., Munoz-Merino, P.J., Kloos, C.D.: Evaluating the Effectiveness and Motivational Impact of Replacing a Human Instructor by Mobile Devices for Teaching Network Services Configuration to Telecommunication Engineering Students. 2010 10th IEEE Int. Conf. Adv. Learn. Technol. 284–288 (2010).
17. Ramirez-Gonz'lez, G., Cordoba-Paladinez, C., Sotelo-Torres, O., Palacios, C., Munoz-Organero, M., Delgado-Kloos, C.: Pervasive Learning Activities for the LMS .LRN through Android Mobile Devices with NFC Support. 2012 IEEE 12th Int. Conf. Adv. Learn. Technol. 672–673 (2012).
18. Butler, D., Winne, P.: Feedback and Self-Regulated Learning A Theoretical Synthesis. Rev. Educ. Res. (1995).
19. Carroll, J.: Five reasons for scenario-based design. Proceedings of the 32nd Hawaii International Conference on System Sciences. IEEE, Hawaii (1999).
20. Tabuenca, B., Kalz, M., Börner, D., Ternier, S., Specht, M.: Where is my time? Identifying productive time of lifelong learners for effective feedback services. International Computer Assisted Assessment (CAA) Conference. Research into E-Assessment. , Zeist (The Netherlands) (2014).
21. LAK: 1st International Conference on Learning Analytics and Knowledge. International Conference on Learning Analytics and Knowledge. p. 2011. , Alberta (2011).
22. Siemens, G., Long, P.: Penetrating the fog: Analytics in learning and education. Educ. Rev. (2011).
23. Narciss, S.: Feedback strategies for interactive learning tasks. Handb. Res. Educ. Commun. Technol. 125–144 (2007).
24. Börner, D., Storm, J., Kalz, M., Specht, M.: Energy Awareness. Displays Prototype for personalised energy consumption feedback. In 21st Century Learning for 21st Century Skills. pp. 471–476. Springer, Heidelberg (2013).
25. Börner, D., Kalz, M., Ternier, S., Specht, M.: Pervasive interventions to increase pro-environmental awareness, consciousness, and learning at the workplace. Scaling up Learn. Sustain. Impact. (2013).