Chapter 7

User-modelled ambient feedback for self-regulated learning

A fundamental objective of human-computer interaction research is to make systems that are seamlessly integrated into daily life activities. Hence, the challenge for technology enhanced-learning research is not only to make information available to people at any time, at any place, and in any form, but specifically to say the "right" thing at the "right" time in the "right" way. The proliferation of sensor technology is facilitating the scaffolding and customization of smart learning environments. This manuscript presents an ecology of resources comprising NFC, BLE and Arduino technology, orchestrated in the context of a learning environment to provide smoothly integrated feedback via ambient displays. This ecology is proposed as a suitable solution for self-regulated learning, providing support for setting learning goals, setting aside time to learn, tracking study time and monitoring the progress. Hereby, the ecology is described and intriguing research questions are introduced.

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7.1 Introduction

Providing in-context support and feedback is key to identify the best learning moments and self-organize the learning day. Lifelong learning implies setting aside regular time for learning during the day as well as combining learning activities (i.e. read, write, listen, watch) with daily life activities (i.e. family, work, leisure). Nevertheless, daily contingencies and their varying priorities make specially challenging to provide technological support for lifelong learners in the task to set realistic goals, set aside daily time to learn, track the time devoted to learn, and monitor learning progress. In previous research, we investigated different ways to provide feedback services fostering the competence of "learning to learn", using SMSs (see Chapter 8) and mobile chart visualizations (see Chapter 9) as channels to provide guidance from the teacher (external feedback). The differentiation among external and internal feedback is crucial if one investigates the effects of feedback on the basis of recent instructional models viewing the process of knowledge acquisition as a self-regulated learning process (Narciss, 2008). Hence, hereby we present a smart learning ecology in which lifelong learners are able to customize internal feedback based on their own occasional learning priorities and contingencies.

7.2 An ecology of resources for efficient time management

Candy and Brookfield (1991) summarized four components of self-directed lifelong learning: self-monitoring, self-awareness, self-management and meta-learning. The challenge in an information-rich world is not only to make information available at any time, at any place, and in any form, but specifically to say the "right" thing at the "right" time in the "right" way (Fischer, 2001). This ecology provides self-regulated support for lifelong learners tracking time devoted to learn, orchestrating sensor technology, and modelling ambient feedback.

The NFC-LearnTracker (Tabuenca et al., 2014b) is an open source mobile application developed for NFC-enabled devices that features learning analytics of time devoted to learn based on the timestamps recorded every time the user starts (check-in) and stops (check-out) a self-defined learning goal. The evaluation of the NFC-LearnTracker (Tabuenca et al., 2015a) concluded that it is a useful tool to set and

adjust mini-goals, to foster awareness on preferred learning environments, and to integrate learning in daily activities.

(a) Feedback Cube BLE-beacon **(b)** NFC-tags bound to learning activities **(c)** NFC-LearnTracker's learning analytics

Figure 7.1 Ecology of resources for time management

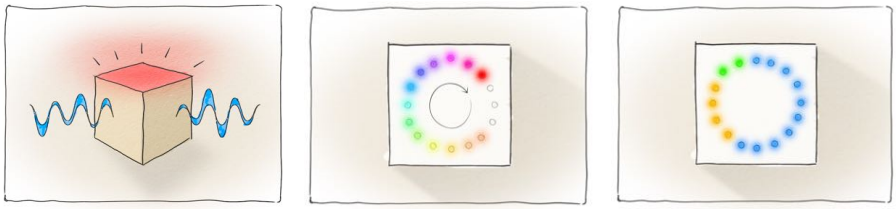
The NFC-LearnTracker interprets the information provided by the following sensors:

- NFC tags (Figure 7.1b. See blue squared). As illustrated in Figure 7.1c, an overall learning goal (i.e. learn Dutch) comprises a set of sub-goals (watch videos; write texts: read news) that are assigned a coloured tag (blue; orange; green), an estimated daily time in minutes (50; 20; 10), and a deadline date to accomplish each sub-goal (31st December of 2015).

- Bluetooth Low Energy (BLE) beacons (Figure 7.1a. See green hexagon). BLE-beacons are being novelty used to provide proximity-adapted feedback in the field of shopping , access control, and home entertainment. Hereby, we use BLE-beacons to monitor student's progress when he approaches or moves away from the beacon (e.g. desktop at home; office at workplace).

The Feedback Cube illustrated in Figure 7.1a (Börner et al., 2015) is an ambient learning display (Börner et al., 2013a) built-on an Arduino microcontroller that provides visual and audio feedback (Figure 7.2a). The used LEDs are capable of displaying the full RGB colour space with 16777216 colours at 256 bright-ness levels (Figure 7.2b). All 16 RGB LEDs on the ring can be controlled individually, which allows programming various visual patterns (e.g. the feedback illustrated in Figure

7.2c matches the pie chart in Figure 7.1c) and effects, such as fading, blinking, or colour transitions. The used mini speaker can reproduce programmatically created audio patterns and effects, such as playing single tones, complex melodies, or even encoded audio files.



(a) Sound and color **(b)** Rainbow **(c)** Pie chart

Figure 7.2 Feedback Cube's effects

7.3 Mapping events and feedback

The NFC-LearnTracker lets the user configure which feedback signal[1] fits better each one of the events listed below. Hereby we present the events supported and their default set-up (Table 7.1):

In further research, the quality of the learning analytics via mobile visualizations and ambient displays will be contrasted and evaluated (Scheffel et al., 2014). Additionally, we will explore to which extent internal feedback services improve self-regulated learning.

[1] Feedback Cube effects in video:
https://sites.google.com/site/lifelonglearninghubproject/home/feedback-cube

Table 7.1 Default configuration of events in the ecology

Event	Action	Feedback
On approach to the beacon	The user with BLE-enabled smartphone approaches to the beacon.	Summarize remaining tasks. The cube lights a pie chart indicating the distribution of pending tasks/time (Figure 7.2c)
On check-in tapping the NFC tag	The user taps on the NFC tag every time he starts a learning activity.	Start! As the user has tapped the blue tag bound to the tablet (Figure 7.1b), the cube lights the blue colour (See 7.1a) to indicate he is working on the learning goal configured with the blue in the NFC-LearnTracker (Figure 7.1c)
On check-out tapping the NFC tag	The user taps on the NFC tag every time he stops a learning activity.	Stop! The cube switches off the existing light
X minutes before expiring the estimated time for a goal in a day	X minutes before accomplishing the learning time estimated for the day	Time to wrap up! The cube slowly fades X times to gently advice that time will expire in X minutes.
On expiry time estimated for a goal in a day	The user gets to the time that initially estimated to devote per day.	Time just expired! The cube beeps once to provide an intrusive sound warning.
Y minutes after expiring the time estimated for a goal in a day	Y minutes after expiring	Overworking! The cube fades fast Y times warning that the user exceeded Y minutes the initially scheduled time.
On complete all goals in a day	On check-out the last goal	All daily goals accomplished! The cube lights a rainbow to congratulate the user
On expiry the deadline date for one goal	On the date schedule to finish one goal	Learning goal accomplished! The cube plays a melody indicating the goal is finished.
On expiry the deadline of the last pending goal date	Scheduled date to finish the last goal	All goals accomplished! The cube lights a rotating rainbow to congratulate the user.
On move away	The user moves away from the BLE beacon	Summarize! The cube beeps Z times (Figure 7.2a) summarizing pending study time (e.g. 30 minutes pending beeps 3 times)