Chapter 3

Tap it again, Sam: Harmonizing personal environments for learning

The increasing number of mobile vendors releasing NFC-enabled devices to the market, and their prominent adoption by end users have moved this technology from a niche product to a product with a large market-share. NFC facilitates natural interactions connecting digital and physical learning environments. The scaffolding of learning ecologies is a key aspect for lifelong learners in their challenge to integrate learning activities into busy daily life. The contribution of this chapter is twofold: first, a review of scientific literature in which NFC has been used for learning purposes is presented and classified according to their type of interaction; second, the NFC-MediaPlayer is piloted as an ecology to facilitate access to video content.

This chapter is published as:

Tabuenca, B., Kalz, M., & Specht, M. (2015). Tap it again, Sam: Harmonizing personal environments towards lifelong learning. In *International Journal of Advanced Corporate Learning*. Vol 8. Issue 1. http://dx.doi.org/10.3991/ijac.v8i1.4383

and

Tabuenca, B., Kalz, M., & Specht, M. (2014). Tap it again, Sam: Harmonizing the frontiers between digital and real worlds in education. In *Proceedings Frontiers in Education conference. Open Innovations and Internationalisation in Engineering Education* . 22-25 Oct. Madrid. ISBN: 978-1-4799-3921-3

3.1 Introduction

The European Commission (2007) identifies time, location and conflicts with other activities as the core barriers to lifelong learning. Lifelong learners constantly re-design their environments to optimise opportunities interacting with social and other resources towards their learning goals. However, there is little technological 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 (Kalz, 2014).

Visions of ambient intelligence emphasize on the importance in the natural interaction between user and services embedded in the environment or available through mobile devices. *Natural User Interfaces* and the *Internet of Things* have been predicted to have an impact on education in the short term (Johnson et al., 2012). Tagged objects are widely accepted and the number of connected devices could reach 50 billion by 2020 (Ericsson, 2011). Different tagging methods (e.g. visual codes, text recognition, image recognition) allow enriching physical objects with educational resources (Specht et al., 2013). In particular, the prominent adoption of Near Field Communication (NFC) readers in mobile devices has moved this technology from an innovator to an early adopter phase. The NFC Forum[1] has recently (as of October 2014) estimated that more than 70% of all smartphones will be equipped with NFC in 2018 (Bialke, 2014).

Lowering the barriers for access to relevant information and support services in frequently used living spaces represents an essential challenge to support lifelong learners. Lifelong learners normally build personal ecologies with the resources available in the environment to support their learning needs. In this scenario, the smartphone can play the role of the hub connecting smart resources coexisting in personal learning environments.

This chapter aims at gathering previous work in which NFC technology has a potential for learning. This collection aims at inspiring scaffolds to create ecologies of resources in personal learning environments. This chapter is distributed as follows. Section 2 reviews scientific literature in the field of NFC with a special focus on empirical research. Previous work is classified based on the type of NFC interaction implemented. Taking into account lessons learned in the literature review, section 3

[1] NFC Forum. Since 2004, this organization develops specifications to ensure interoperability among devices and services. http://nfc-forum.org/

pilots a NFC ecology comprising different resources in a frequent lifelong learning scenario (Tabuenca et al., 2013).

3.2 Literature review in NFC technology for learning

NFC is a radio technology that supports transactions at distances of a few centimetres. NFC standards cover communications protocols and data exchange formats based on existing Radio-Frequency IDentification (RFID) standards. In the current review, we have covered both terms since NFC is an extension to RFID technology. RFID is capable of accepting and transmitting beyond a few meters.

The underlying search was conducted utilizing the online research repositories of the ScienceDirect, Springer, as well as the IEEE Computer Society. The focus on these repositories is reasonable as they cover a sufficiently large number of relevant publications. Within the Springer digital library, an advanced search was performed in December 2014 querying all articles of type journal, proceeding, or transaction that had been published since 2007 (when the first NFC-enabled mobile phone was released[2]) and matching the keywords "*(NFC learning mobile) OR (RFID learning mobile)*" as part of the body. The first 100 occurrences ordered by relevance were selected. In a first round, these items were filtered by title and abstract. In the second round, the resulting manuscripts were filtered according to their educational potential. The rest of the repositories were analysed analogously. This review does not aim to be accurate and strict, but rather exploratory to identify suitable learning scenarios and the type of interaction among the resources that better fit the scaffolding of personal learning ecologies with NFC technology.

There are three devices that can be involved in NFC communication: 1) an NFC-enabled mobile device; 2) an NFC external-reader; 3) an NFC tag. NFC mobile phones and NFC external readers can read NFC tags but also other NFC mobile phones working in passive mode. NFC mobiles can additionally write on NFC tags (Table 3.1).

As a result of this review, scenarios and resources are classified in Table 3.1 according to the type of NFC interaction implemented.

[2] Nokia 6131 NFC phone taps into mobile payment, ticketing and local sharing. Press. http://bit.ly/1stNFC

Table 3.1 Type of interaction with NFC devices

Active device	Action	Passive device
NFC mobile phone	Reads	NFC mobile phone
NFC mobile phone	Reads and or writes	NFC tag
NFC external reader	Reads	NFC mobile phone
NFC external reader	Reads	NFC tag

3.2.1 Formal Education

Recent work (Ebner and Maierhuber, 2013), envisions some of the potentials NFC technology brings for teaching and learning materials in formal education, with a special focus on connecting digital media and printed learning resources: 1) Distributing learning materials in face-to-face classrooms. Transferring the files from teachers (NFC tag) to students (NFC mobile) avoiding printing on paper and delivering them manually; 2) Enriching printed materials. NFC tags stuck on printed materials facilitate the association of multimedia content; 3) Sharing materials among students. Peer-to-peer communication between mobile devices; 4) Signing delivered practical work and handing it in. For instance, when a student delivers a practical work, the teacher scans the student's tag with the NFC reader to confirm his/her identity and automatically submits back an email to the student as acknowledgment of reception; 5) Integration with social networks i.e. tap a tag to log in a social network the timestamp in which the student arrives to school; 6) Control materials. Teachers can tag the tools in a lab in order to control which resources are assigned to each student; 7) Examinations. NFC tags can be stuck to identity cards from students so teachers can verify their identity in exams.

An introductory course in systems engineering (Gómez et al., 2013) used hardware components enriched with NFC tags, to provide multimedia resources such as hypertext, audios, videos and animations describing their functionality within the computer. Their experiment concluded with increased learning outcomes for the group of students using this self-paced mobile approach in contrast to the group using the traditional face-to-face lecture.

Similar, Riekki et al. (2013) implemented a pilot study to support children in their efforts learning to read. Different words written on a poster and a NFC tag attached to them, provided the audio version of the word when the tags were tapped. As a consequence of the positive effect on children's emergent knowledge of letters, the results of the pilot study suggested that NFC is a suitable technology for learning to read.

3.2.2 Guided tours and field-trips

Excursions of art and museums are typical scenarios in which content is delivered based on the parameters supplied by the mobile device. Mobile-guides delivering contextualized audio, video and text, are reviewed in recent work (Emmanouilidis et al., 2013). This work claims that the current trend is to gradually abandon some of the older localization technologies such as Wi-Fi, infrared and manual user position input. Most of the times, a guide is not necessary because visits to museums are mostly in small groups, and visitors do not want to be overloaded with information. RFID interaction offers a non-intrusive and intuitive interaction in which the user can customize his own learning by approaching the smartphone to a tag attached to a physical object based on his interests on a concrete author, topic, age, etc.

Visitors with limited motivation prefer a broader presentation in contrast to visitors who express an additional interest. Kuflik et al. (2011) implemented different tours and multimedia presentations adapting the content delivered based on the motivation of the visitor. This work concludes the use of RFID as the simplest available technology for accurate customization and positioning inside a building. Previously, Miyashita et al. (2008) had combined RFID tags, and a mobile-PC to use already existing audio guides during a six-month exhibition on Islamic art. Similar, in the work from Garrido et al. (2011) students used NFC-enabled phones in the context of a mobile game to know the university campus. Students tapped tags whenever they wanted to communicate to the central game manager their progress within the game and get follow-up assignments. The work from Sánchez et al. (2011) presents the results of a prototype evaluation that aimed at persuading students to do physical exercise exploring points of interest in the surroundings and tapping them.

Posters can be augmented with different NFC tags to provide a specific feedback based on the tag that is tapped. In the context of a gym in a university campus, Andersen et al. (2013) created a full size smart-poster illustrating the different muscle groups. When exercising, the user can select a muscle group by tapping that part of the poster so that the information describing training tips for this muscle group is displayed as well as training videos demonstrating some possible exercises.

Interactive panels in public spaces can be used to support social activities. A novel solution (Tesoriero et al., 2014) based on the concept of collaborative interactive panels facilitates users sharing their opinions and votes about environmental concerns tapping the panels with NFC-enabled mobile devices.

The work from Tabuenca et al. (2014d) on mobile authoring stresses the importance of knowledge and skill acquisition in the same context in which they need to be performed. Hence, they pinpoint to NFC tags as a suitable storage for mobile-authored Open Educational Resources (OER) in public spaces because OERs can be easily dropped, shared or remixed by different users and inspired by the authenticity of learning in context.

3.2.3 User identification

Badges are usually integrated in identification cards to track and locate persons in buildings, floors or rooms with different access policy. Sometimes students cannot access certain resources a lab outside of a defined schedule or teachers can only access the facilities supplied by their own department. Traditional keys are increasingly being supplanted by identification cards that give access to certain places depending on the profile of the user. Sandberg et al. (2005) provide a real time unauthorized access alert to clinical staff by integrating instant messaging technology and RFID. If teachers would use this technology, students would be able to locate in which classroom a teacher is giving a lecture. Occasional changes of classroom would be detected by the presence of the teacher in a different classroom, so that a SMS notification would be sent to the students, or displayed on digital boards. Analogously, this technology can be used by parents/teachers to have a real-time account on when their children/students do go to class.

NFC tags are increasingly embedded into wearables like key-rings, bands, clocks, collars, or bracelets. Theses tags can be read through material such as wallets and clothing. The GerAmi system (Corchado et al., 2008) provides insights on how this technology can be successfully applied in wearables. The objectives of this system are to monitor patients and manage the work of the doctors and nurses. The system is configured with ID-readers above each door in rooms and elevators in the facility. Nurses and Alzheimer patients wear a bracelet containing an RFID chip. Nurses are equipped with PDAs in order to follow the information, set controllable alarms and locks. Additionally, these hospitals provide wireless access points.

In Andersen et al. (2013) key locations at the campus like cafés, lecture halls and meeting points, are tagged with NFC tags to check-in when entering these locations. This action is registered in a social network[3] that enabled a user to share his location with friends, via the "check in" so friends are aware when a person arrives to a location (i.e. check-in at the canteen during the coffee break). A smart classroom system integrates NFC technology to automate attendance management, locate students, and provide real-time feedback via personal response systems (Shen et al., 2014).

3.2.4 Activity recognition & life logging

The work from Yang et al. (2011) uses RFID technology to identify which activity the user is doing. The operations in their activity theory consider three arguments: *object, location*, and *time*. *Object* refers to tangible things that humans can interact with (e.g. dishwasher, fridge, microwave). *Location* represents the environmental information where an operation occurs. *Time* is the duration over which an operation was conducted. This information is recorded so it can be later analysed to identify behavioural patterns.

The work from Castro et al. (2014) explores behavioural data for assessing functional status and health of older adults using NFC-enabled mobile phones. Participants were provided with a deck of twenty NFC-cards depicting some of their most common activities such as going to the supermarket, cooking, watching TV, or going to the doctor. Finally, they were also given a booklet to jot down the time in which the activities were carried out.

More recently, Curiel et al. (2013) propose a platform that interacts with NFC tags to activate the most used services on mobile devices, such as making a call, or checking the weather forecast. Thus, depending on the combination of tags read, the system recognizes the service to activate (read email, send email, telephone call, see photos, show weather forecast, see news and share information) and the parameters needed for its execution (news source, contact email, phone number).

The NFC-LearnTracker (Tabuenca et al., 2015a) is a tool for self-regulated learning that facilitates the introspection of learning patterns via analytics. This tool is built assuming that commonly used learning materials are tagged with NFC tags. The

[3] Foursquare social network. https://foursquare.com

student taps the tag every time he starts and stops learning. These timestamps are recorded, and the activities can be later analysed with chart visualizations upon their duration, time of the day or type of devices used.

3.2.5 Smart home

There is an increasing number of publications in the field of smart home. The work from Sadri (2011) surveys ambient intelligence and its application in different contexts, in particular, embedding NFC tags in different rooms. The GENIO project presented a fridge that keeps track of the (RFID tagged) goods consumed by the user (Gárate et al., 2005). Similar, Reitberger et al. (2014) uses visualizations to provide feedback on food consumption clustering its nutrients by categories.

The work from Tran and Mynatt (2003, 2004) presents a pilot in which a mirror enriched with RFID records repeated frequent tasks (e.g. *"Has anyone fed the fish?"*, *"Did I take my medication one hour ago, or did I decide to wait a bit longer?"*) for which memory-confusion could arise. This system is presented as a long-term memory system for activities that are repeated often and are not part of a strict routine.

3.2.6 Support of disabled people

This section gathers cases in which NFC technology facilitates learning for people with disabilities. The article from Ivanov (2014) presents a mobile service that enables blind-environment interaction through voice-augmented objects by tagging objects with an associated voice-based description. Users can both drop their voice recording in a tag or listen already existing ones. Blind users can later use the service to scan surrounding augmented objects and verbalize their identity and characteristics. Jafri (2014) proposes a solution for teaching Braille letter-recognition to young blind children by manipulating NFC-tag embedded blocks with Braille letters embossed on their sides. Braille letter recognition is taught and reinforced through various exercises and games, and auditory feedback is provided via a speech interface from a computer attached to the NFC readers.

3.2.7 Payment systems and simulations

The coffee card application is a combination of a prepaid service and loyalty card Andersen et al. (2013) implemented in a campus. Students can recharge 11 cups of coffee for the price of 8 so the prepaid coffee cups are stored on the NFC card. Each time a coffee is bought, the student taps the NFC reader connected to a tablet computer that records the payment. This system could be used to implement serious games to simulate money, transactions, badges or roles in schools. Indeed, RFID technology has been previously experimented supporting the simulation of roles and scenarios on interactive tables (Kubicki et al., 2011). As result of their experience, the authors highlight RFID as an interesting approach to store information within tangible objects.

3.2.8 Logistics & object identification

The ten-year academic review conducted by Ngai et al. (2008) reveals the increasing importance of this technology in the field of logistics. As a consequence of this review, the authors highlight RFID technology as a hot topic in the field of retailing, library services, animal detection, food, and supply chain management. More specific, the work from Ting et al. (2011) reviews the use of RFID in medical organizations for the purpose of managing and tracking medical equipment, monitoring and identifying patients, ensuring that the right medication is given to the right patient, and preventing the use of counterfeit medicine. Additionally, the author presents an exploratory case study conducted in a medical organization offering valuable insight on the use of RFID in medical organizations. The work from Bacheldor (2006) describes an implementation on how to locate medical assets using an RFID-based real-time location system.

3.2.9 Results of the review

The results of the review presented in this chapter envision a trend in which mobile devices are mostly used for reading tags in the last years in contrast to early years in which fixed static external readers were used to decode RFID tags. Table 3.2 shows that mobile-to-mobile NFC transfer does not seem to be a frequently implemented practice yet. On the other hand, the most common implementation is the enrichment of tangible objects with NFC tags to be later interpreted as a command by a mobile device (e.g. counting time, register identity). These commands are normally associated with third party resources that trigger a subsequent action like inserting data on a database, providing feedback, a description of the object that is tapped or sharing the action in social networks. Additionally, we have observed that mobile devices are mostly used for reading other tags, but not yet commonly used for dropping (writing) information on them.

Table 3.2 Classification of previous work by type of NFC interaction

NFC Interaction	Mobile to mobile	Mobile to tag	External reader to mobile	External reader to tag
Formal education	Ebner and Maierhuber (2013)	Gómez et al. (2013), Riekki et al. (2013), Ebner and Maierhuber (2013), Shen et al. (2014)		Shen et al. (2014)
Guided Tours & Field Trips		Andersen et al. (2013), Emmanouilidis et al. (2013), Kuflik et al. (2011), Miyashita et al. (2008), Sánchez et al. (2011), Tesoriero et al. (2014)	Garrido et al. (2011)	Kuflik et al. (2011)
User identification		Shen et al. (2014)		Corchado et al. (2008), Sandberg et al. (2005)
Activity recognition		Castro et al. (2014), Curiel et al. (2013), Tabuenca et al. (2015a), Wang and Wu (2011)		
Smart home		Reitberger et al. (2014)		Gárate et al. (2005), Sadri (2011), Tran and Mynatt (2003), Tran and Mynatt (2004)
Disable support		Ivanov (2014), Jafri (2014)		
Payment and simulations		Andersen et al. (2013)		Kubicki et al. (2011)
Logistics				Bacheldor (2006), Ngai et al. (2008), Ting et al. (2011)

3.3 A seamless learning ecology for video casting

In the literature review we have presented different ways on how NFC technology can facilitate seamless interactions in different contexts. Harmonizing personal learning environments is key to enable smooth access to learning contents, in particular, with natural interactions and suitable visualizations.

Nowadays, video contents comprise a big proportion of the learning materials provided in online courses, i.e. in Learning Management Systems (LMS) or Massive Open Online Courses (MOOCs). Most of the times, these videos are provided to be downloaded from a LMS, or publicly shared to be streamed from repositories (i.e. YouTube, Vimeo). Starting a learning activity in an online course normally requires the user to switch-on the device (or unlock it), open the browser, login the platform, navigate to look for the desired resource, and finally display the video. This approach presents the following barriers for seamless access to video content:

1. Time. Sometimes reaching the learning content might require more time than watching the video itself (i.e. booting a computer). Access to learning content should be guaranteed in the least time possible to facilitate the embedment of learning activities in spontaneous scattered moments along the day (i.e. waiting times, commercial breaks).

2. Interaction. Reaching a learning content within the learning platform (LMSs or MOOCs) manually requires multiple clicks. Access to learning content should be accomplished in the least number of clicks possible otherwise the student would not bother to start a learning activity.

3. Visualization. The screen of mobile devices, tablets, or even laptops are not big enough to display some videos. Indeed, videos should be streamed with a quality that guarantees the user can smoothly accomplish objectives of the learning resource with the least visual overload.

Hereby, we present the NFC-MediaPlayer, an ecology of resources (Luckin, 2008) that aims at lowering these barriers inspired on the work presented in the literature review.

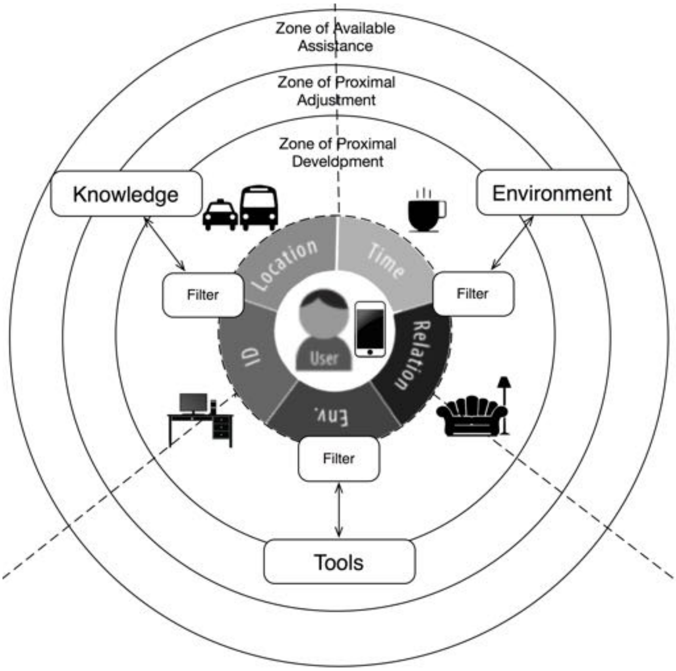


Figure 3.1 Ubiquitous scaffolding of learning activities with technology

3.3.1 The NFC-MediaPlayer

The NFC-MediaPlayer aims to support learners to play video content suing the mobile device either as a player or as a controller. The user can control the streaming and playing of video content based on the scanning of NFC tags that are integrated in daily environments (Tabuenca et al., 2013).

Hereby the NFC-MediaPlayer is described as a learner-centric approach comprising three layers (see Figure 3.1): 1) the *Zone of Proximal Development (ZPD)* ; 2) the *Zone of Proximal Adjustment (ZPA)* ; the *Zone of Available Assistance (ZAA)* (an Ecology of Resources (EoR) as defined by Luckin (2010, 2008)).

ZPD represents what the user can learn by himself with his potential ability and the interactions that can arise from previous experiences. Lifelong learners are intrinsically motivated to learn and to re-design their context with the aim to optimise opportunities for interactions with social and other resources capable of assisting learners perform towards their objectives (design of ZPA (Vygotsky, 1978)). Recognising the role of the *More Able Partner (MAP)* is fundamental for lifelong learners to identify potential types of assistance. Likewise, the relationship between User and MAP supports the progression from ZAA to ZPA. The ZAA is described as the variety of resources within the learner's world that could provide different qualities and quantities of assistance, and that might be available to the learner at a particular point of time.

For the specific case described in this chapter, NFC technology facilitates the scaffolding of learning activities bringing resources closer to the user supported by a mobile device. E.g. a user can use his/her mobile device to watch a multimedia video stored in a remote repository (ZAA) by scanning an NFC tag that is bound to the content (ZPA). Figure 3.1 illustrates the resources comprised in this model. Lifelong learners scaffold personal learning ecologies interacting with them as follows:

Environment. This resource refers to the context in which the lifelong learner is normally used to learn. A recent survey to lifelong learners on mobile usage habits for learning (Tabuenca et al., 2013) 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. More specifically, at the living room (and sitting in the sofa) was reported as the most suitable environment to watch videos using their mobile devices for learning purposes. The NFC-MediaPlayer has been implemented to provide seamless support for learning in this specific environment.

Knowledge. This resource refers to the subject, skills or anything that the user wants to learn. In this case, the NFC-MediaPlayer is illustrated with the case of a user interested to acquire knowledge on the topic "technology-enhanced learning".

Tools. This resource refers to the tools that the lifelong learner uses to learn. The NFC-MediaPlayer comprises the following tools that are further described in the following sections: HDMI display; digital media player; NFC tags; NFC-enabled smartphone.

Filters. Luckin (2010) defines filters as the constraints or restrictions that learner find to manage the *environment*, use *tools*, or acquire *knowledge*. In this manuscript, the filters for the NFC-MediaPlayer are aligned with the three barriers enumerated above: 1) time; 2) interaction; 3) visualization.

Figure 3.2 NFC-MediaPlayer's ecology of resources

Implementation

The NFC-MediaPlayer has been released in January 2015 as part of a larger research aiming to provide ubiquitous support for lifelong learning with ubiquitous technology. The source code of this tool is available[4] under an open license[5] to facilitate customization and extension to further learning environments, communities, etc.

Hereby we describe the *tools* that conform the ecology (See Figure 3.2):

Digital media player In the very last months, WI-FI enabled digital media players have reached the market: Google Chromecast[6] (July 2013), Roku[7] (March 2013); Apple TV[8] (January 2013). These devices broadcast audio and video content on a High-Definition display by direct streaming via WI-FI from the Internet. These devices stream multimedia content based on the commands (Play, Pause & Stop) activated from another networked device (i.e. laptop, tablet, mobile). The basic operation is that using your personal device as a remote and selecting the desired multimedia, the content can be broadcasted to the HDMI display where the digital

[4] NFC-MediaPlayer open source code repository:
https://code.google.com/p/lifelong-learning-hub/source/checkout?repo=mediaplayer
[5] Licensed under the Apache License, Version 2.0. http://www.apache.org/licenses/LICENSE-2.0
[6] Google Chromecast. http://www.google.com/intl/en/chrome/devices/chromecast/
[7] Roku streaming stick. http://www.roku.com/products/streaming-stick
[8] Apple TV streamcater http://www.apple.com/appletv/

```
{
"categories": [
{
"name": ‘‘Movies’’,
"videos": [
{
"subtitle": ‘‘Published on 5 Oct 2012’’,
"sources":
[ ‘‘https://dl.dropboxusercontent.com/u/XXXXXX/sample/btb1.mp4’’ ],
"thumb": ‘‘images_480x270/btb1_480x270.png’’,
"image-480x270": ‘‘images_480x270/btb1_480x270.png’’,
"image-780x1200": ‘‘images_780x1200/btb1_780x1200.png’’,
"title": ‘‘Prof. dr. Liesbeth Kester and drs. Bernardo Tabuenca ...’’,
"studio": ‘‘OUNL"
},
{
"subtitle": ‘‘Published on 5 Oct 2012’’,
"sources":
["https://dl.dropboxusercontent.com/u/XXXXXXX/sample/btb2.mp4’’ ],
"thumb": ‘‘images_480x270/btb1_480x270.png’’,
"image-480x270": ‘‘images_480x270/btb1_480x270.png’’,
...
```


Figure 3.3 NFC-MediaPlayer. JSON file's playlist

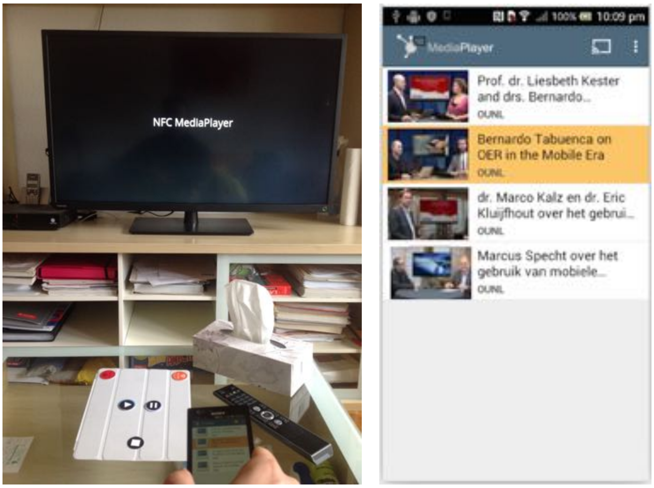
media player is plugged. The ecology presented in this manuscript has been developed with Google Cast SDK[9].

HDMI displays HDMI displays facilitate the visualization of videos independently of the dimension for which they were designed. When streaming video from the digital media player, the audio volume is controlled from the remote of the HDMI display and not from the client device (mobile device, tablet or laptop). This feature makes the interaction much more natural and integrated within daily life environment.

NFC-enabled smartphone The mobile phone plays the role of a remote communicating with all the previous elements in the ecology. A NFC-enabled smartphone is able to decode the command recorded in the tag (NDEF message), and trigger the action pre-mapped for that action.

[9]Google Cast SDK. https://developers.google.com/cast/docs/reference/

NFC-MediaPlayer app The NFC-MediaPlayer app has been developed and released[10] for Android mobile phones in January 2015 (Beta version). When the app starts, the JSON file (Figure 3.3) containing the information describing the list of videos to be presented in the playlist (i.e. title, subtitle, author, thumbnail images, and the URL where the video is stored) is requested to a remote webservice.



(a) Tapping "*positioning tag*" moves forward the orange focus within the playlist screen

(b) Playlist screen from the Masterclass series: "learning in the future"

Figure 3.4 NFC-MediaPlayer list screen

The interface navigation within the app comprises two screens:

1. Playlist screen (See Figure 3.4b). The home screen of the app. Lists the information describing the videos that can be streamcasted. When a video in the list is clicked, the cast screen with the selected video is displayed.

2. Cast screen (Figure 3.5b). Displays the information of the video selected in the list. The video starts when the play button starts or stops when in the pause button is clicked. The video can be moved forward or backward using the slider. The video is streamcasted to the HDMI Display depending on whether the Chromecast icon on the top right corner is selected or not.

[10]NFC-MediaPlayer in Google Play. https://play.google.com/store/apps/details?id=org.ounl.lifelonglearninghub.mediaplayer

(a) Tapping "*play tag*" to display selected video **(b)** Cast screen

Figure 3.5 NFC-MediaPlayer casting screen

Programmable NFC Tags This ecology includes five tags configured to trigger the following commands:

- Positioning. The (1) *positioning* tag is configured to work in the playlist screen (Figure 3.4b). When this tag is tapped (middle bottom tag in the whiteboard on Figure 3.4a/3.5a), the focus advances in the playlist marking in orange colour the active item.

- Video casting. The (2) *play* and (3) *pause* tags are configured to work in the cast screen (Figure 3.5b). When the play tag is tapped (left middle tag in the whiteboard on Figure 3.4a/3.5a), the active video is streamcasted to the HDMI display. The video is paused when the pause tag (right middle tag in the whiteboard) is tapped.

- Navigation. The (4) *playlist* and (5) *cast* tags are configured to navigate between the playlist screen (Figure 3.4b) and the cast screen (Figure 3.5b). When the playlist tag is tapped (left top tag in the whiteboard) the app presents the playlist screen. When the cast tag is tapped (right top tag in the whiteboard) the app presents the cast screen.

3.4 Discussion and conclusions

This manuscript proposes the use of NFC technology towards the harmonization between digital and physical worlds for learning.

The literature review presents daily life scenarios (i.e. formal education settings, workplaces, museums, guided tours, field-trips, life-logging, smart home, simulations, logistics) where NFC technology has been previously used with learning purposes. Findings in the literature review reveal the increasing use of NFC-mobile devices for reading tags, in contrast to external readers. This fact is probably strengthen by the proliferation of NFC-enabled mobile devices and the increasing adoption of NFC technology in the last years (Bialke, 2014). The review shows that using mobile devices to drop (write content) on tags is not a developed practice yet in contrast to reading content which is the most popular use.

On the other hand, this manuscript highlights the potential of NFC technology to facilitate the scaffolding of personal learning environments binding learning activities to daily physical spaces. The *NFC-MediaPlayer* is presented as a real instantiation of an ecology of resources in a frequent lifelong learning environment, and tackling the following three barriers:

1. Time. Reducing the time to start a learning activity.
2. Interaction. Reducing the number of clicks to access the learning content to zero clicks.
3. Visualization. Streamcasting video learning contents in a High-Definition quality in contrast to small-sized screens like mobiles, tablet or laptops.

This ecology increases the chances of learning in scattered moments (i.e. waiting times, commercial break on TV) replacing this perceived "lost time" into perceived "productive time".