MOBILE PLAYFUL LEARNING ENVIRONMENT

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MOBILE PLAYFUL LEARNING ENVIRONMENT

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I’m not super. Any talents I have, I worked for – it seems a long time since I thought of myself as a hero.

Oliver Queen

For my cousin Kara

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Abstract

In practice, most learning is done in a classroom environment including face to face instruction and training. Classroom-based learning and teaching has several advantages but frequently also faces difficulties. It might be difficult to gain attention from everyone in a large class and motivate all learners due to the “one size fits everybody” approach usually applied. On the other hand, there is the ever-widening accumulation and access to information technologies. In theory, this could lead to a world where no boundaries to knowledge construction exist anymore. With a tap on a smartphone or a computer, people are able to search for relevant facts on any topic. The hyperlink structure of digital information spaces makes it possible to interactively explore related content. Search results can generate insights which in turn result in associations for new queries creating infinite trails of information and knowledge. A new generation of learners is growing up who seems to navigate these complex information environments with ease. In the literature, they are called Digital Natives, Generation Y or Net Generation, born after the 1980s and naturally drawn to social networks, search engines or instant messaging systems to access, communicate and share information. They immerse in digital technologies, not only to be entertained but also to develop a collective understanding of politics, culture and society. Learning in these spaces is much more driven by personal goals and interests. Opposed to formal school learning, this type of learning, also called informal learning, is not centered around the examination of educational goals and does not lead to a certification. It ~~is~~ forms an important part of lifelong learning which is the ”ongoing, voluntary, and self-motivated”, pursuit of knowledge for either personal or professional reasons. This type of learning could mitigate some of the disadvantages of classroom-based learning and offer tailored learning experiences to every student. Based on personal interests and learning aims, students could access information autonomously and self-directed.

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While independent and informal e-learning is an admirable aspiration, many learners will still need guidance in their informal learning process. Especially, the so-called Digital Native learners have an ambivalent relationship with the overabundance of information and tools available. On the one hand they are used to a wide range of information technologies in their daily life, but on the other hand they seem to miss the necessary information literacy skills. Leaving them entirely alone in learning activities can result in a loss of motivation or even a cynical attitude towards learning in general and increased school dropout rates, as confirmed ~~The~~ by the current Corona crisis ~~has confirmed this~~. Even with the guidance of the school and teachers, ~~at lot of~~ many youngsters ~~has~~ have a hard time to adapt to the online learning situation and to stay motivated. Without guidance, it would only become even worse~~n~~. Therefore, we argue for a supporting digital learning environment for informal learning in the same vein as formal learning is supported by a Learning Management System. Such a learning environment should provide ways and guidance for people to explore interests and exploit them for future opportunities for ? from a personal, professional or educational perspective. It should also show ways to integrate informal learning practices with the (digital) classroom in order to mitigate the digital divide ~~which still exists~~ between classroom~~-~~based learning and informal online learning. A conceptual framework for such a learning environment is the subject of this dissertation. We introduce the Mobile Playful Learning Environment model that aims to provide a reference model for such a ~~type of learning~~ environment. To come to this model, we investigated the major requirements for such an environment. For this we formulated different research questions and performed an extensive literature study to provide answers to these questions.

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Based on all the findings, we defined and motivated the main features of our Mobile Playful Learning Environment (MPLE) model and explain how the different components interact with each other to achieve their goal. In this way, we ~~reached~~ achieved our research objective: a conceptual framework for creating digital environments that offer opportunities for lifelong learning and can support informal as well as formal learning activities, and which

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are suitable for digital natives. Based on the defined MPLE model and as a proof of concept of such an environment, we developed TICKLE, a mobile playful learning environment for youngsters who are at risk for school dropout. Our research followed the design science approach which means that we generate scientific knowledge through cycles of sketching and evaluating different versions of our conceptual framework with the means of a proof-of-concept application (TICKLE). Theoretical findings from literature and practical insights from user studies are incorporated into the design of our conceptual framework and indirectly tested ~~with~~ through the proof-of-concept application with a number of user evaluations. TICKLE itself is developed using a User Experience (UX) design methodology which addresses more than just the functionality and usability — it also considers how users feel about a product. Starting from the "Why", the needs and emotions of the user are clarified and then used to specify the so-called Be-and Do-Goals, where Be-goals capture a person's emotion and attitude about using a particular software and the Do-goals refer to ~~the~~ pure functionality. TICKLE has been evaluated in different contexts and for different purposes and shows to be promising.

CHAPTER 1

INTRODUCTION

Generally, a classroom environment with face-to-face teaching is the traditional way of learning. With this type of learning, the teacher or ~~the~~ instructor can explicitly observe the real-time interaction and participation of the learners. The advantage is that the instructor can provide the appropriate intervention immediately. However, in classic classroom learning one may face some difficulties. For example, in a large classroom the instructor may find it difficult to gain attention from everyone or motivate everybody due to the "one-size" fits all? approach usually applied, and the use of specific teaching methods, such as flipped classroom, problem-based learning, or active learning, can be challenging with a large class size. On the other hand, in an ideal world, the ever-widening accumulation and access to information facilitated by modern communication technologies could lead to a situation of no boundaries to knowledge construction. Indeed, we can just take the smartphone out of our pocket and follow up the infinite trails of information. This way of learning could be used to complement classroom-based learning and mitigate some of the issues with ~~class-based~~ ww learning. In addition, this way of knowledge construction could also be important in lifelong learning which is the "ongoing, voluntary, and self-motivated" pursuit of knowledge for either personal or professional reasons (M. Sharples, 2000).

However, in practice, most people are often overwhelmed by the sheer amount of information faced in the digital world. They do not always possess the skills to make sense of all of it (Bawden & Robinson, 2009). in particular? Especially, digital literacy skills (Ng, 2012), i.e. the ability to locate, filter, compare and judge digital information, as well as skills in data analysis become increasingly important for this kind of learning (Gallardo-Echenique et al., 2015). At the same time, a new generation of learners is growing up who seems to navigate complex information environments with ease (Koutropoulos, 2011). In the literature, they does that mean the 1990s and later?

are called Digital Natives, Generation Y or Net Generation, born after the 1980s, grown up with digital technologies and naturally drawn to social networks, search engines or instant messaging systems to access, communicate and share information (Prensky, 2001; Tapscott, 2008). They immerse in digital technologies, not only to be entertained but also to develop a collective understanding of politics, culture and society (Ito et al., 2013). This knowledge acquisition is mostly driven by personal goals and interests. Often knowledge is co-created within an online community as means to follow up a certain hobby or interest. Opposed to formal school learning, this type of learning, also called informal learning (Maarschalk, 1988a; Tamir, 1991), is not centered around the examination of educational goals and does not lead to a certification. ~~However,~~ it ~~is~~ forms an important part of lifelong learning.

emph ?

In formal education, Learning Management Systems (LMS) are the main tools to provide structure and support for traditional forms of learning. A LMS allows teachers to quickly distribute course content, assignments and announcements. Students can submit assignments to the LMS through digital dropboxes and teachers can grade their work and return feedback within the system. Traditional LMSs are teacher or institution centric because the course structure and content are created by the teacher. Student-initiated activities and interactions are mostly limited to content consumption. Whereas LMSs help to make teaching processes more efficient by streamlining content management, delivery, grading and analytics, they neglect informal learning activities. Attwell, 2007 and Vassileva and Sun, 2008 also observed that modern learners have different patterns of information access, attention, and learning preferences which cannot be satisfied by traditional LMSs. Therefore, they proposed the concept of *Personal Learning Environment (PLE)* in which learners utilize a collection of resources and tools (search engines, bookmarking, blogging, social networks) that they manage to take control over their own learning. To bridge the the gap between a PLE and a LMS, *Open Learning Networks (OLNs)* (Mott & Wiley, 2009) were introduced, which combine~~s~~ the best elements of each approach. They consist of a

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consistency

series of modules that leverage the open architecture of the Web. Existing LMSs are connected with web-based tools, applications, content stores, and a service layer that allow them all to function together seamlessly. Until now, not many implementations of OLNs have been realized. (Wilson et al., 2009) described an extension of the Moodle LMS using the W3C Widget and the Google Wave technology which enabled the user to use informal learning functionality inside Moodle. Unfortunately, Google Wave was discontinued in 2012. (Conde et al., 2013) present a service-based framework to facilitate interoperability between a OLN and a LMS. In this way, OLN remains mainly a theoretical concept and has not been widely adopted by schools or universities. There are several reasons for this. First, LMSs often lack interoperability functionality to classify and track learner data on/of ? ~~in~~ other platforms. Second, the distributed nature of informal learning makes it hard to validate and represent learning activities meaningfully in the OLN. Often, the user is not aware in which situations they are learning. To gain awareness, the user should have means to reflect about what he or she they has done and then find a way to classify and publish the knowledge gained (Conde & Hernández-Garcıa, 2019). Third, students are rarely willing to use an additional tool to support their learning because they might be already using a set of tools as PLE, or are sceptical about institutional IT solutions - they find them boring to use because they do not have engaging ways to interact with content. In addition, and similar to PLEs, using an OLN requires skills in dealing with complex information tasks. Not everybody has the courage, self-discipline, knowledge, or motivation to engage in these activities (Wu & Cheng, 2019; Throuvala et al., 2020; Wakefield & Frawley, 2020). Even for highly motivated users who have strong skills in information management, an OLN can be complex and overwhelming. With a steady stream of information and tools available, ? it is likely to miss out important information. Moreover, when information is scattered across different tools, it is hard for users to create a mental model of the complete learning environment. Especially digital native learners have an ambivalent relationship with this overabundance of information and tools (Selwyn, 2009). On the one hand, they are used

neutral they (instead of he or she)

to a wide range of information technologies in their daily life: "They use search engines and social networks as a first port of call for knowledge unlike older generations who were used to printed press, radio and television" (Helsper & Eynon, 2010). Information is received really fast and activities are frequently switched. High visual content, animation and interactivity is preferred over static textual content (Prensky, 2001; Dresang, 2005). Digital native learners expect information to give answers as well as to be engaging (Radford et al., 2007). However, the apparent familiarity and competence with computers disguises some worrying problems in information literacy (Pettenati et al., 2009; Y. Li & Ranieri, 2010). Fast switching between activities often results in a superficial view rather than an in-depth understanding of information. The speed of young people's information seeking suggests that little time is spent in evaluating information, either for relevance, accuracy or authority (Selwyn, 2009; Bowler et al., 2018). Due to the sheer amount of information available nowadays, digital learners have a poor understanding of their information needs which makes it difficult to access information target oriented.

While independent learning is an admirable aspiration, many learners will still need guidance in their learning process. Leaving them entirely alone in learning activities can result in a loss of motivation or a cynical attitude towards learning in general (Ferrando et al., 2012) and increased school dropout rates. Therefore, we argue that even for informal learning, a learning environment could provide added value. Such a learning environment should provide ways and guidance to explore interests and exploit them for future opportunities from a personal, professional or educational perspective. A conceptual framework for such learning environments is the subject of this thesis.

In the following sections, we discuss the research objectives of the thesis, the research methodology used, and the structure of the thesis.

1.1 Research Objectives

As already mentioned, many learners will continue to require guidance in the learning process, even for informal learning. Moreover, students do ~~not~~ neither learn all at the same speed nor have all the same learning style or habits (Jonassen & Grabowski, 2012). An ideal learning environment should consider students' background, needs, characteristics and guide them accordingly. It should provide ways to allow user s to explore interests and hobbies in a self-regulated way and exploit them for future opportunities. Our work aims to contribute to the design and development of such ideal learning environments. The focus is on learning environments that can stimulate the intrinsic motivation for informal as well as formal learning while mitigating the previously mentioned problems of PLEs and OLNs (~~as mentioned above~~).

Our main research objective is **to create a conceptual framework for creating digital environments that offer opportunities for lifelong learning and can support informal as well as formal learning activities, and which are suitable for digital natives.** the full stop should not be in bold

In order to reach this objective, we propose the concept of a *Mobile Playful Learning Environment (MPLE)* that aims to provide a reference model for such a type of learning environments. To realize this, a number of research questions need to be answered. We formulate and justify ~~them~~ the questions in the rest of this section.

Reflection seems to be essential for learning. Reflecting on past experiences can lead to new insights and changes in behavior. Lately, interest emerged on how technology can support human reflection to increase self-knowledge and inform actions to change behavior (Rowanne Fleck, 2010). Therefore, a special emphasis will be put on supporting reflection related to areas of personal and social li~~v~~fe for the purpose of learning. This resulted into the following research question:

- **RQ1: How to empower the learner to realize that learning is not only a way to succeed in a formal school context but also a way to improve other areas of personal and social li~~v~~fes from a lifelong learning perspective?**

On the other hand, guiding and motivating the learner is also important for successful learning. To realize this, the following research question needs to be answered:

- **RQ2: How can we guide the learner in the learning process and persuade ~~him~~ them to be active while maintaining the openness and non-committal character of informal learning?**

To answer this question we look into ~~P~~p persuasive emph technology. Persuasive technology can help to reduce the cognitive effort to embark on learning activities through the use of social influence principles (Müller et al., 2012). As one of the first, JB Fogg studied the concept of persuasive technology (Fogg, 2002) and how we can design systems that impact the user on an affective level. He propose~~s~~d? the Fogg's Behavior Model (FBM) (Fogg, 2009) that studies the factors that can induce a certain behavior (Muntean, 2011).

Applying persuasive technology and reflective technology for answering RQ1 and RQ2 yields the following additional research questions:

- **RQ3: What is the role of reflection in the persuasion process and what techniques are available to facilitate reflection?**

- **RQ4: Which aspects of existing persuasive and reflective technology can be applied?**

Information visualization techniques have been proven to be a powerful means to enable reflection, persuasion and decision making in various domains such as business or scientific research (Liu et al., 2014; Choe et al., n.d.; Medler & Magerko, 2011). Building on our human perceptual capabilities, information visualization makes use of computer-supported, interactive, visual representations to understand the meaning of large amounts of abstract data without overburden ~~human~~ cognition (Card et al., 1999). However, most practitioners approach information visualization from a technical and analytical perspective: visualizations are, for instance, used to gain insight in customer data to maximize profits or to support analysis of scientific experiments. Only recently, visualizations for reflection and decision-making have been applied in learning. Learning analytics platforms have shown that through tracking, analyzing and visualizing learner-related data, the student's performance can be improved. For instance, (Charleer et al., 2013) improved awareness and reflection through collaborative, interactive visualizations of badges, and the Blackboard LMS offers tools that allow students to monitor their level of online course engagement to reinforce learning behavior ("Blackboard Data & Analytics", n.d.). In this context, visual accounts can help to raise awareness about personal strengths and shortcomings, which can help to set up learning goals and improve learner development (Duval, 2011). However, learning analytics tools are often embedded in a course context (Verbert et al., 2013). They do not necessarily establish a link to informal learning. Often, they rely on data collected by an LMS, such as the total time spent on the course, the average time spent on a document, or the number of documents used. To apply visualization techniques to our solution, the following research questions need to be answered:

- **RQ5: Which visualization techniques are suitable for self-monitoring in the context of informal learning?**
- **RQ6: What kind of data can be accumulated in the learning process and how can this data be transformed into a meaningful visualization?**

Note that developing applications for informal and formal learning is a broad topic that cannot be captured in its entirety in a single thesis. Therefore, our research and conceptual framework will focus~~es~~ on key aspects of informal learning activities in terms of discovery of activities and reflective practices. It also includes techniques to scaffold the learning process and make it more appealing. Last but not least we will also explore ways to interoperate with traditional LMSs.

1.2 Research Methodology

Our research will follow the design science approach which means that we will generate scientific knowledge through cycles of sketching and evaluating different versions of our conceptual framework with the means of a proof-of-concept application (POC) which is a reference implementation of our framework. (Offermann et al., 2009). In this context, a design science methodology means that we follow the follwing six steps of the methodology: (1) problem identification and motivation, (2) definition of the objectives for a solution, (3) design and development, (4) demonstration, (5) evaluation, and (6) communication.

By performing user studies of our POC we indirectly test whether our conceptual framework succeeds in providing guidance to fellow developers in creating a learning environment focusing on facilitating informal and non-formal learning as main objective. Theoretical findings from literature and practical insights from user studies will be incorporated into the design of our conceptual framework. The POC will be developed using a User Experience (UX) design methodology which addresses more than just the functionality and usability — it also considers how users feel about a product (Hassenzahl, 2013). Starting from the Why, UX design clarifies the needs and emotions involved in an activity by specifying Be-and Do-Goals. The first refers to the perceived ability to support the achievement Space of a task, whereas the second denotes non-functional aspects such as being autonomous, competent, related to others, stimulated, and popular (Hassenzahl, 2008). Only then, it determines the functionality to provide the experience and how it can be realized. In the past, this UX design methodology has been used for different user-oriented systems (Hassenzahl, 2013; Hassenzahl et al., 2010), but rarely in an Information Visualization design context, which focuses too often on low-level analysis tasks such as information retrieval, filtering or sorting. However, The personal dimension, i.e. why the user wants to obtain a certain insight and how we can stimulate the motivation to do so, is equally important in the design process (Brehmer & Munzner, 2013).

1.3 Contributions

important to add soon!

1.4 Publications

1.5 Structure of the thesis

Next to this introduction, the thesis consists of five chapters: Background: Technology Enhanced Learning, Mobile Playful Learning Environment Model, Related Work, Proof of Concept Application: The TICKLE Case, and Conclusions. Their role and content is as follows:

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Background: Technology Enhanced Learning

By performing a literature review, we will gain a first insight into how a MPLE solution can be realized. Different types of Lifelong Learning will be analyzed and popular and relevant learning paradigms will be reviewed. Subsequently, information/learning needs, and literacy of digital native learners will be discussed in terms of problems faced when these digital natives engage in learning activities. We conclude the chapter with an overview of technology-enhanced learning environments. The findings will serve as the theoretical foundation for Our ~~solution (i.e. our~~ Mobile Playful Learning Environment Model) ~~will be based on the findings from this literature review~~.

Mobile Playful Learning Environment (MPLE) Model

In this chapter, we define our novel model for Mobile Playful Learning Environments (MPLE). We motivate the main features of the model and then present its learning pipeline to indicate how the main features interact with each other. The motivation for the model's features builds upon already known work in the domain of HCI, namely Reflection Models, Information Visualization and Persuasive Technologies.

Related Work

We describe the components of the MPLE in detail in terms of Reflection, Information Visualization and Persuasion. Furthermore, we compare interactive systems from various for their value of persuasion. We will further investigate the needs and demands for MPLE systems from a user's perspective. Because we follow the UX design approach, the first step is to acquire a full picture of digital learners' Do ? and Be-Goals which refer to pragmatic and hedonic quality of a product, Do-Goals are the product's perceived ability to support tasks such as making a telephone call. Be-Goals are personal achievements which are mediated through technology such as being competent or being close to others (Hassenzahl et al., 2006). more detailed than when you described it before → more to earlier description

Proof of Concept Application: The TICKLE Case

In this chapter, we describe the proof-of-concept application developed for our MPLE model, called ~~i~~.e. TICKLE. TICKLE aims to empower learners to perform and reflect on informal/formal learning activities. We describe and motivate the principles, the main modules of the environment, as well as its iterative development by means of cycles of creating and evaluating different prototypes. The goal was to verify:

- Whether we can create a learning environment that combines informal and formal learning practices based on design principles established in the Mobile Playful Learning Environment Model?
- Whether such an environment would be used by youngsters?

Conclusion

In the Conclusions, we provide a summary of our work and we reflect on the contributions of the thesis. We also discuss limitations and possible directions for future work.

CHAPTER 2

BACKGROUND: TECHNOLOGY-ENHANCED LEARNING

In this chapter we provide theories, knowledge and systems related to our research. The focus is on technology-enhanced learning for Lifelong Learning. We describe relevant types of learning and theories for Lifelong Learning with a special focus on Mobile and Playful Learning (section 2.1 and 2.2). We also discuss how learners access digital information today in terms of their digital literacy, their information needs and their information seeking (section 2.3). Furthermore we consider different types of current technology-enhanced learning environments and analyze them according to aspects of Lifelong Learning (section 2.4). This chapter prepares for the definition and specification of Mobile Playful Learning Environment later in chapter 3.

2.1 Relevant Types of Learning for Lifelong Learning

The knowledge-based economy, the growing speed of technological changes and globalization demand that people acquire skills, knowledge and competences throughout their lifetime to meet constantly changing information needs and to enhance inclusion and employability in our society and labour market. It has become increasingly common for people to undertake so-called Lifelong Learning which is a form of self-initiated education that is focused on personal development and covers the whole range of types of learning, including: formal, informal and non-formal learning (Laal & Salamati, 2012). (Huffaker & Calvert, 2003) argue that new forms of learning such as mobile learning, playful learning, and blended learning are likely to occur in interaction with complex social and technological environments where students take control of their own learning experiences by monitoring the mastery of skills, comprehension and implementing strategies to improve their learning (metacognition). Figure 2.1 visualizes the relationship between these concepts.

Where the distinction between informal, non-formal and formal learning refers to the degree of formality of the context in which the learning takes place, blended learning, mobile learning and playful learning refer more to the principles used for the learning. Blended learning is often used in a formal context whereas mobile and playful learning are situated in the informal learning and non-formal contexts. Ubiquitous leaning takes advantage of digital content, physical surroundings, mobile devices, pervasive components, and wireless

why a longer dash?

communication to deliver teaching–learning experiences to users at anytime, anywhere, and anyway (). Therefore, it can be used in formal, non-formal and informal learning. In the following subsections, we ~~will~~ describe each concept in detail and give examples where and how they take place.

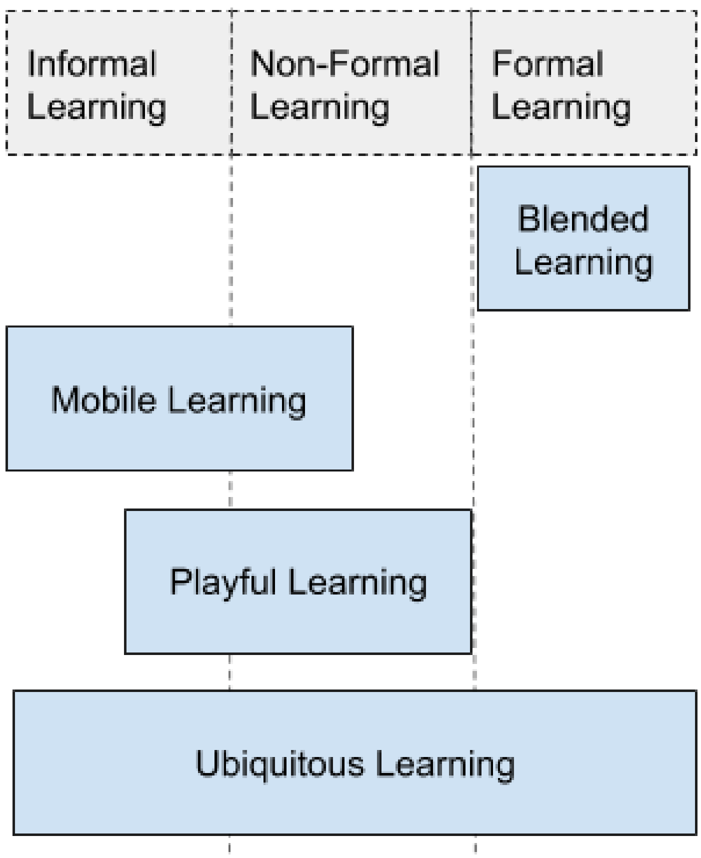

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Figure 2.1: Overlap of learning types according to Informal, Non-Formal and Formal Learning

2.1.1 Informal Learning

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Informal Learning takes place outside formal learning institutions, with friends, family, peers, etc.. From the learner's perspective, the learning is not deliberately organized around learning goals or learning outcomes. Informal learning applies to situations throughout life that arise spontaneously; for example learning a foreign language while living in the country where that language is spoken through conversations with a friend or family member or movies, songs and using the Web, is a form of informal learning (Marsick & Watkins, 2001). Informal learning is distinguished from formal and non-formal learning by having no authority figure or mediator. The learner is motivated intrinsically and determines the path taken to acquire the desired knowledge, skill, or abilities. Informal learning takes place outside formal learning environments and it is often unintentional, i.e. it can happen as a byproduct of some other activity related to leisure or work such as surfing on the Web to pass time. The learner is often not aware that they ~~(s)he~~ actually gain~~s~~ knowledge. Therefore, it is often unstructured in terms of learning objectives, time, and learning support (that normally does not exist). (Marsick & Watkins, 2001; Callanan et al., 2011) identified five dimensions of how informal learning is presented in literature:

- learning as the result of self-regulation and integration into daily routines;
- learning as inductive process of reflection and action;
- learning as embeddedness in a meaningful and personalized activity;
- learning initiated by the learner's interest or incidental;
- learning in the absence of external assessment as open-ended activity.

Informal learning has the potential to bring wide benefits to young people who are struggling in school. Finding opportunities in informal learning practices that happen outside of school can lead to a huge confidence boost, which is the first step towards a return to formal learning or finding a pathway to employment. Different forms of informal learning can be distinguished (Boileau, 2017):

- Incidental learning takes place without any intent to learn. It is an accidental by-product of another activity that occurs outside of the learner's current focus (Marsick & Watkins, 2001).

- Tacit learning – tacit knowledge can only be acquired through practical experience in the relevant context which occurs at the subconscious level based on intuition, personal experience, or emotion (Durrance, 1998).

2.1.2 Non-formal Learning

Non-formal learning is an educational activity which happens alongside the formal education system to meet a variety of learning needs which cannot be satisfied in the school alone. Typically, it takes place during school trips (museum visits, zoos, aquariums) or community settings (sport clubs, music lessons) with educational and training purposes (Maarschalk, 1988b). Opposed to informal learning, non-formal learning is set up by an institution or organization. It consists of learning embedded in planned activities that are not explicitly designed as learning but contain an important learning element. Non-formal learning is intentionally planned with specific goals in mind. This type of learning is typically guided by a teacher or supervisor but it arises usually from the learner's motivation to master a particular activity, skill, or area of knowledge (Eshach, 2007). Students usually participate on a voluntary basis in these activities, and as a result, the learner takes an active role in the learning process. Non-formal education gives students the possibility to develop their values, skills and competences other than the ones developed in the framework of formal education. A related instructional strategy is *Self-directed learning* where the students, with guidance from the teacher, decide what and how they will learn. Students take ownership of their learning and initiate their own learning activity including goal setting, resource identification, strategy selection, and evaluation of outcomes (Knowles, 1975). According to (Steffens, 2006) self-regulation is achieved in cycles consisting of:

- The Forethought phase that consists of task analysis and self-motivation beliefs. Task analysis refers to planning processes such as goal setting and strategic planning. Self-motivational beliefs comprise a student's self-efficacy beliefs, his outcome expectations, intrinsic interest, and goal orientation.

- Performance control describes the strategies which are implemented to monitor the progress of the student. For instance, self-control refers to regulatory processes like self-instruction, imagery, attention focusing, and task strategies.

- In the Self-reflection phase, the student tries to evaluate the outcome of his efforts and construct new knowledge.

2.1.3 Formal Learning

According to the EU Counsel (Eberhard & Harribey, 2002), formal learning is typically provided by teaching institutions such as schools or certified training programs in the workplace. It is structured in terms of aims, time, and learning support by a teaching facility. It is also intentional in the sense that all activities are centered around learning outcomes and certification. Learning in schools is what immediately comes to mind when people envision formal learning. It is structured and typically led by instructional designers and trainers and often happen in a classroom setting. Educational systems exist to promote formal learning, which follows a syllabus and is intentional in the sense that learning is the goal of all the activities learners engage in. Learning outcomes are measured by tests and other forms of assessment. In formal learning, learning content is "pushed" to the learners according to a set of needs or predetermined curricula (Eraut, 2000).

2.1.4 Mobile Learning

With the growth of the Internet and a world-wide adoption of mobile devices, people enjoy access to a wide range of information enabling learning everywhere and at all times. Not a single day goes by that does not lead to discovery of new information and knowledge, including skills and competences in various domains. The term mobile refers to the fact that the learning takes place while the learner is on the move. Mobile learners learn across space and time by taking ideas and learning resources gained in one situation and develop them in another. By revisiting knowledge gained in the past and relating ~~them~~ it to different contexts, they move from topic to topic in a non-linear manner instead of following a single curriculum (M. Sharples et al., 2009). In a nutshell, mobile learning provides freedom to the learners how, where and with who to access, process and construct learning materials. Mobility is not constrained to the use of mobile technology; other aspects are also essential (Ozdamli & Cavus, 2011). Mobile learning is more spontaneous and impulsive than other learning types. Based on location, time and social context information needs are created and satisfied instantly by turning attention to the mobile device. It is also possible to transfer attention across devices, moving from the laptop to the mobile phone, to the notepad. Mobile learning tools are small and portable. Students can use it them everywhere during their learning activities. The location may be used as a backdrop for learning. Students can use mobile tools for homework, projects or other formal learning activities but also to satisfy personal learning needs. With ~~B~~ b lended learning (see next section), mobile learning can be integrated into classroom-based instruction. Furthermore, mobile technologies support communication between students, teachers and peers to support collaborative learning activities and interactivity.

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2.1.5 Ubiquitous Learning

Ubiquitous learning or u-learning is a new learning paradigm that expands on previous learning paradigms as we move from traditional web-based learning to mobile learning.

Context-aware ubiquitous learning is an approach that employs mobile, wireless communication and sensing technologies to enable learners to interact with both the real-world and virtual objects in authentic environments (Mikulecký, 2012), where students gain knowledge by applying theories in real-world contexts to solve practical problems (Yahya et al., 2010). Ubiquitous learning does not longer restrict the learning to formal learning environments. Learning happens anywhere and at any time without a lot of effort on the part of the learner. Unlike in Mobile Learning, information is pushed to the learner rather than pulled. Instead of accessing information based on the initiation of the client, digital content is transmitted automatically to the client whenever an information need is detected by the learning environment. Such ubiquitous approach to information access requires modeling of different learner and environmental dimensions (Kinshuk & Graf, 2012). The learner model typically contains information about individual learners, such as their past behavior, current state, learning styles, cognitive abilities, and performance. The location model includes learner's current location and previous location history received from the various navigation systems, such as GPS or cellular network. The technology model obtains information about the capabilities of the technologies that are available to the learner at certain point in time, such as display capability, audio and video capability, available memory and bandwidth, and characteristics of the operating platform. The context model analyzes the learner's environment in real-time, including the learner's current learning goal, the atmosphere in which the learner currently is, and the recent history of learner's interaction so as to relate the next learning experience with it. (Yang, 2008) summarize the characteristics of context-aware and ubiquitous learning in the following eight aspects:

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- The continuity of computing while learners move from one position to another.
- The identification of learners' locations.
- The interoperable operation between different standards of learning resources, services and platforms.

- The seamless provision of everlasting service sessions under any connection with any device.
- The detection of learners' various situations and scenarios, and the knowledge of what learners are doing with whom at what time and where.
- The awareness of learners' social relationships, including what do they know, and what are they doing at a moment?
- The adjustability of learning materials and services depending on learners' accessibility, preferences, and need at a moment.
- The provision of intuitive and transparent ways of accessing learning materials and services, predicting what learners need before their explicit expressions.

2.1.6 Blended Learning

Blended learning is an approach to education that combines online educational material with traditional forms of teaching to personalize learning across a diverse group of students. Different delivery methods, such as collaboration software, w ~~W~~eb-based courses and knowledge management tools are used to mix various forms of learning, including face-to-face classrooms, live e-learning, and self-regulated learning. Using blended learning models can have several benefits over pure classroom or distance learning (Watson 2008):

- The integration of face-to-face and online learning can help to enhance the classroom experience and extend learning through the innovative use of information and communications technology.
- Student engagement can be enhanced through online activities that reduce lecture time.
- A blended learning approach provides flexibility in presenting content. Complex

topics can be presented in the classroom, while other subject matter can be available online.

2.1.7 Playful Learning

According to (Gray, 2008) many definitions have explored the concepts surrounding play and its role in society. Play can be seen as a free activity which is not serious and done only for the purpose of amusement without any material interest or profit. It happens within a (physical or imaginary) play space where the rules of the real world do not apply and the mechanisms and experiences of play can emerge. Play is a fundamental part of human experience and learning, providing the opportunity to practice and explore in a safe environment. Play can support spontaneous learning, facilitate social interaction, stimulate imagination, support problem-solving, reduce stress, and increase happiness. (Gray, 2008) observed five attributes of play:

- Play is self-chosen and self-directed.
- Play is an activity in which means are more valued than ends.
- Play has structure, or rules, which are not dictated by physical necessity but emanate from the minds of the players.
- Play is imaginative, non-literal, mentally removed in some way from “real” or “serious” life.
- Play involves an active, alert, but non-stressed frame of mind.

In this context, playful learning can be seen as a type of interaction with learning material that involves fun and enjoyment to facilitate engagement and motivation in the learning process thereby blurring the boundaries between play and learning. It encourages the development of the learners through the use of toys, games, and play-based teaching approaches. It is not only about using games in the classroom but about designing learning activities that can incrementally introduce concepts in a narrative framework and guide learners towards an end goal within an incentive system that might include game elements (gamification) such as competition, challenges, points or rewards (Plass et al., 2015). In addition, the visual aesthetic design and overall look and feel of the activity is crucial to provide cues and feedback. According to (Kangas, 2010) playful learning should encompass the following values:

emph?

- Creativity refers to creative knowledge building and learning creatively by using new technology and designing artefacts.
- Narration refers to understanding as a key aspect of meaning-making. It makes sense of experience through the lens of engaging stories.
- Collaboration emphasises knowledge co-creation within shared experiences among peers.
- Insight refers to the opportunity to make discoveries and to solve problems.
- Competence is when participants feel that they have mastered something well enough to make a difference in the world; when the participant no longer feels able to make a difference, he or she then seeks new ways to increase their competence.
- Autonomy is experienced when the actions and behaviors that someone engages in matches their own sense of who they are, and the extent to which someone makes his or her own decisions about behavior.
- Relatedness is based upon the connections that an individual feels with other people through their behaviors. Intrinsic motivation is a construct that combines these three concepts of competence, autonomy, and relatedness.
- Safe spaces identify that enjoyable learning takes place in spaces where students feel relaxed and comfortable with fellow students, where risk-taking and failure are encouraged within an atmosphere of playfulness and good-humour.

2.2 Learning Paradigms Relevant for Lifelong Learning

To describe how people learn and how information is absorbed, processed and retained, learning theories were created. Commonly used paradigms for technology-enhanced learning are (Boghossian, 2006):

- **Behaviorism** assumes that meaning exists in the world separate from personal experience. A learner is essentially a passive being who absorbs instructional presentations and material and uses them to create correct mental models. The instructor is the authority who takes control over the learning process and pre-defines learning outcomes by breaking content into small segments and then sequences them into a hierarchical curriculum ranging from simple to more complex tasks. It is assumed that the student has limited capability for evaluation or reflection within the learning process. Learning is considered to take place when learners manage to reach these expected outcomes through observation and repetition of appropriate activities that help them to demonstrate desired behaviors.

- **Constructivism** is the philosophy that assumes that meaningful learning occurs when people actively try to make sense of the world. Learners create their own knowledge based on interactions with their environment and other people. Rather than viewing learning as a linear process, it is understood to be complex and nonlinear in nature. Learners continuously adapt hypotheses through an experimentation and interpretation process of reality. Teachers, who use a constructivist theory, concentrate on showing students relevance and meaningfulness of their learning interests and invite them to propose their own creative solutions to problems which are discussed in the classroom.

- **Cognitivism** emphasizes the need to understand mental processes that underlie and can explain many human behaviors (see, for example, Ebbinghaus, 1885). The role of memory and perceptual effects led to many studies that eventually adopted a mental processing model similar to that used in computer science. Computer scientists who became interested in modeling human cognition developed a discipline typically referred to as cognitive science (see, for example, Anderson, 1983). The contributions of cognitive scientists have continued to expand how computers can be used to model and support human learning in the form of intelligent tutoring systems and pedagogical agents. The lessons learned from these efforts could inform the planning and implementation of smart learning environments.

In formal schooling, learners are often confronted with behaviorist teaching techniques; they become experts at consuming knowledge rather than creating it. Constructivism is much more used for informal and non-formal learning because it sees learning as an approach to construct knowledge based on personal experience and that reality is determined by the experiences of the learner. One important constructivist ~~learning~~ theory is based on experiences and was created by (D. A. Kolb et al., 2001), i.e. called the the Experiential Learning Theory. We explain this Experiential Learning Theory in more detail because it will be one emph of the foundations of our approach. A special focus will be put on the role of reflection and learner identity, two essential concepts in this theory.

2.2.1 Experiential Learning Theory

The theory of experiential learning has been introduced in the 1980s and has been well accepted as an efficient pedagogical model of learning in the digital age (D. A. Kolb et al., 2001). It defines learning as the process of creating knowledge through the transformation of experience. Knowledge results from the combination of grasping, transforming and reflecting on experience. The main principles are (A. Y. Kolb & Kolb, 2005):

- Learning is best conceived as a process, not in terms of outcomes. The primary focus should be on engaging students in a process that includes feedback on the effectiveness of their learning efforts.

- All learning is relearning. Learning is best facilitated by a process that draws out the students' beliefs and ideas about a topic so that they can be examined, tested, and integrated with new, more refined ideas.

- Learning requires the resolution of conflicts between facts and ideas of the world. Differences, and disagreements are what drive the learning process. In the process of learning, one is called upon to move back and forth between opposing modes of reflection and action and feeling and thinking.

- Learning is a holistic process of adaptation to the world. Not just the result of cognition, learning involves thinking, feeling, perceiving, and behaving.

- Learning results from synergetic transactions between the person and the environment. Learning occurs through equilibration of the dialectic processes of assimilating new experiences into existing concepts and accommodating existing concepts to new experiences.

- Learning is the process of creating knowledge. Experiential learning theory proposes a constructivist theory of learning whereby social knowledge is created and recreated in the personal knowledge of the learner. This stands in contrast to the "transmission" model of the behaviorist school of education, where pre-existing fixed ideas are transmitted to the learner (A. Y. Kolb & Kolb, 2005).

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Kolb's experiential learning theory provides clear mechanisms for teaching and designing curriculums (curricula) that are strongly based on the constructivist view on the way people learn. Kolb suggests that effective learners should undertake four types of activities:

1. Concrete Experience - a new experience or situation is encountered, or a reinterpretation of existing experience.

2. Reflective Observation of the new experience - analyzing experience based on inconsistencies and understanding.

3. Abstract Conceptualization reflection gives rise to a new idea, or a modification of an existing abstract concept.

4. Active Experimentation; the learners apply their ideas to the world around them to see what happens.

Thus, effective learning is happening when a person progresses through these four stages shown in (see ~~figure~~ Figure 2.2): (1) having a concrete experience followed by (2) observation of and reflection on that experience which leads to (3) the formation of abstract concepts (analysis) and generalizations (conclusions) which are then (4) used to test a hypothesis in future situations, resulting in new experiences. Kolb views the activities as an integrated process with each stage being mutually inclusive of and feeding into the next. It is possible to enter at any stage and follow it through its logical sequence. However, effective learning only occurs when a learner can execute all four stages of the model. Therefore, no single stage ~~alone~~ is effective as a learning procedure on its own.

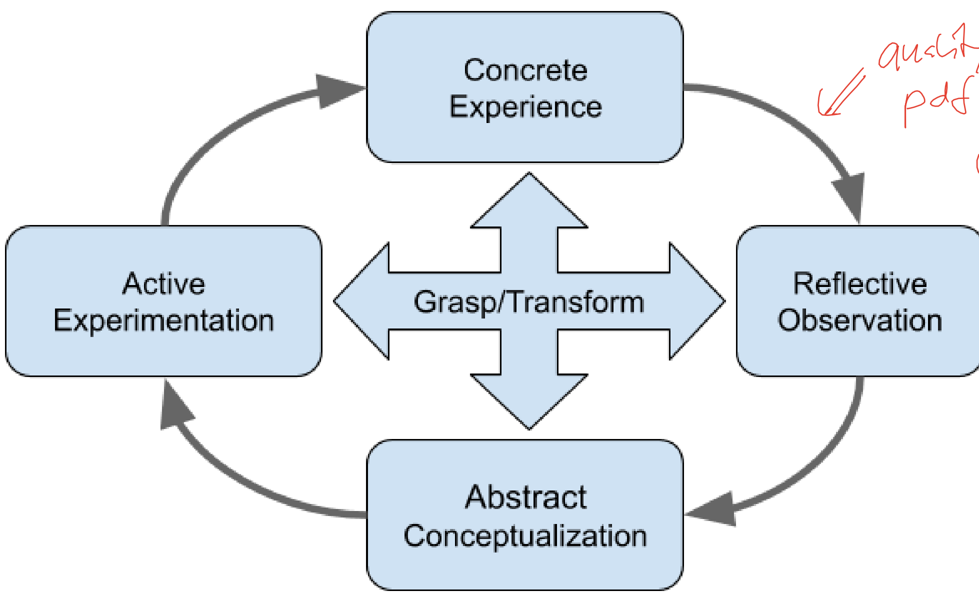

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Figure 2.2: The phases of ~~the~~ experiential learning. After (A. Kolb & Kolb, 2009)

A.Y. at other places?

2.2.2 Learner Identity

Learner Identity (A. Y. Kolb & Kolb, 2012) is defined as the process of becoming and being a learner. In essence, it is about enabling students to review themselves as learners and to foster their understanding of how their actions, emotions, thoughts and motives about themselves in learning are interconnected. People with a learning identity see themselves as learners, seek and engage life experiences with a learning attitude, and believe in their ability to learn. Having a learning identity is not an either-or proposition. A learning identity develops over time from tentatively adopting a learning stance toward life experience, to a more confident learning orientation, to a learning self that is specific to certain contexts, and ultimately to a learning self-identity that permeates deeply into all aspects of the way one lives their life. This progression is sustained and nurtured through growth-producing relationships in one's life (A. Y. Kolb & Kolb, 2012). Becoming a learner is not accomplished overnight. One's self-identity is shaped by experiences that support and contradict it. Learner identity is a mix of fixed and learning beliefs. For instance, a learner feels that they are good at learning some things such as sports and not good at others such as mathematics. Every success or failure can trigger a reconfiguration of one's learning identity. Self-identifying as a learner means trusting one's ability to learn from experiences, seeking new experiences and challenges that reinforce learning (A. Kolb & Kolb, 2009). Figure 2.3 compares a negative fixed self with a positive learner identity. It shows how a negative fixed self can hamper the learning ability and how a positive learner identity can mitigate these risks.

When we reflect, we recollect an experience that we might not otherwise have given much attention to. Reflection is concerned with consciously looking at and thinking about our experiences, actions, feelings, and responses, and then interpreting or analyzing them in order to learn from them. From the perspective of the experiential learning approach, reflection is the key process through which individuals distill knowledge from their concrete experience. In general, reflection is defined as a cycle of inquiry for the purpose of under-

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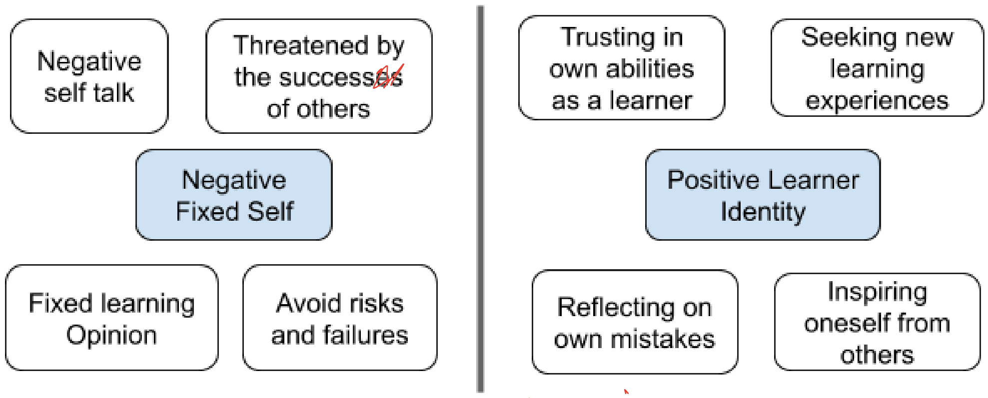

Figure 2.3: Negative fixed self versus Positive Learner Identity. Adapted from (A. Kolb & Kolb, 2009) Reflective Learning

standing or finding solutions for a troubling situation or question. Learning stimuli such as actions, ideas, or feelings are either cognitively reorganized to form a better understanding, or already learned material is reconsidered to expand existing knowledge.

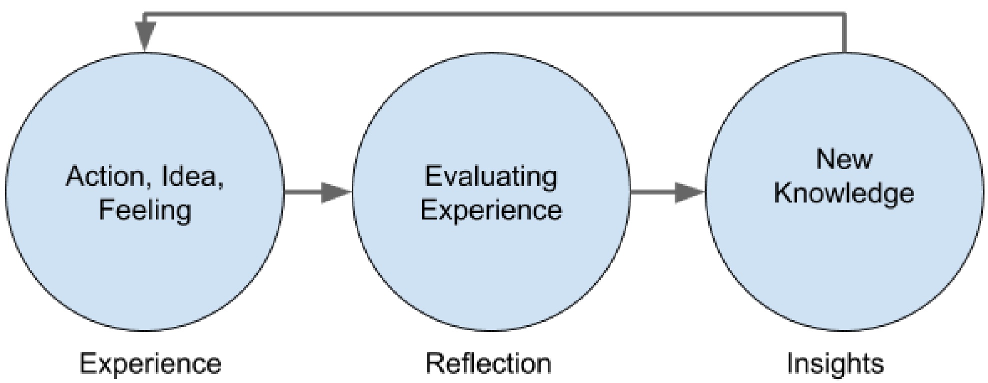

Figure 2.4: Reflection Model after (Boud & Middleton, 2003)

According to (Boud & Middleton, 2003), reflection is a form of response of the learner to experience. In his model there are three main components (shown in Figure 2.4): the experience and the reflective activity based upon that experience. Experience consists of the total response of a person to a situation or event: what ~~he or she~~ they think~~s~~, feels, does and concludes at the time and immediately thereafter. The situation or event could be part of a formal course, e.g. a workshop, a field trip, a lecture; or it could be more informal; an event arising from a personal study project or from the actions of a community group, or a totally unplanned occurrence in daily life. (Schoen, 1992) organized when reflection

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can happen into two main categories namely reflection-on-action and reflection-in-action (Moon, 2013). Reflection-on-action refers to the retrospective contemplation of practice undertaken in order to uncover the knowledge used in practical situations, by analyzing and interpreting the information recalled. Reflection-in-action on the other hand refers to thinking about the learning process while performing it and the unexpected resulting feedback called "backtalk" (Schoen, 1992). When a youngster "talks back" they undermine and change directions of future actions and therefore influence the learning outcome. Backtalk presents the learner with puzzles and surprises that need to be overcome to find an overall solution to a learning problem. It is typically stimulated by surprise, by something which puzzled the learner. The resulting insight gives the practitioner a chance to redesign the learning process while doing it.

2.3 Digital Learners' Access to Information

Through the explosive growth of Internet-related technologies, students must not only learn how to use resources to find information, they must also learn how to make sense of information and decide which sources are useful and reliable. Today, learners are expected to understand complex issues and apply them to real-world phenomena and be able to connect learning topics to wider contexts and observing them from different perspectives. Learners are also expected to know how to collaborate, to examine and elaborate different alternatives together and to construct knowledge together. Because our solution is focusing on modern, digital learners, we discuss the following:

- The characteristics of modern learners and how they see themselves (Digital Literacy and Digital Natives)
- How they access information (Information needs and Information Seeking).
- How they extract knowledge from it (Experiential Learning, Reflective Learning).

2.3.1 Digital Literacy of Digital Natives

Digital literacy is a term used to describe the ability to use information technologies with ease and competence. There are many concepts that describe this phenomena, for example Computer Literacy, Information Technology literacy, Digital Competence, etc. but Computer Fluency is the best fit to describe well the differences between digital natives and digital immigrants. The latter are people who are not born with information technologies and are not used to the usage. They have to learn practices to handle these technologies properly. Digital Fluency goes beyond just using computers for simple tasks. It can be defined as: "ability to reformulate knowledge to express oneself creatively and appropri- (also \emph for quotes?) ately, and to produce and generate information rather than simply to comprehend it" (Wang et al., 2012). It means to realize one's ambition to become an independent learner who discovers and shapes information online. A new generation of learners came about who appear to be familiar with all the tools, services and interfaces the digital revolution has brought us. They are called Digital Natives, Generation Y or Net Generation, born after the 1980's and naturally drawn to social networks, search engines, instant messaging systems and online games as tools to direct their life (Prensky, 2001; Tapscott, 2008). However, not everybody has the courage, self-discipline, knowledge, or motivation to engage in these activities. Even for highly-motivated users who have strong skills in Information Management, the Web can be messy and overwhelming. With a steady stream of information and tools available, it is likely (that one misses) to miss out important information. Moreover, when information is scattered across different tools, users, websites and devices, it is hard for users to create a complete mental model of the learning environment. Especially digital native learners have an ambivalent relationship with this overabundance of information and tools. On the one hand, they are used to a wide range of information technologies in their daily life. "They use search engines and social networks as a first port of call for knowledge unlike (\emph{}?) older generations who were used to printed press, radio and television" (Helsper & Eynon, 2010). Information is received really fast and activities are frequently switched. High (?) visual content, animation and interactivity is preferred over static textual content (Prensky, 2001; Dresang, 2005). Digital learners expect information to give answers as well as to be engaging (Radford et al., 2007). However, the apparent familiarity and competency with computers disguises some worrying problems in information literacy (Pettenati et al., 2009). Fast switching between activities often results in a superficial view, rather than an in-depth understanding of information. The speed of young people's information seeking suggests that little time is spent in evaluating information, either for relevance, accuracy or authority. Over 18 months, the Stanford History Education Group has been testing the ability of 7.800 Digital Natives to judge the credibility of online information. They found that students often could not distinguish between a news story and an advertisement. Faced with long search results they find it difficult to assess the relevance of information and often skim through pages with no more than a perfunctory glance (Rowlands et al., 2008). Due to the sheer amount of information available nowadays, digital learners have a poor understanding of their information needs which makes it difficult to access information target oriented. Too often they get lost in hyperspace.

2.3.2 Information Needs and Information Seeking

Searching for information on the Web is a fundamental task undertaken daily by millions of people. Computer usage is expanding into more and more aspects of everyday life; people increasingly turn to the Web as an immediate source to support learning activities by looking up background information, definitions, or finding distractions from work. Information sources range from practical information about health and money, information to support academic achievement, information that helps with relationships, and the development of identity and place in society. Therefore, information need is a person's recognition of information that marks the beginning of the process of finding it. An information need can originate from the following mental processes (Moon, 2013):

- development of a need to resolve something;

- clarification of the issue;
- review and recollection;
- review of the emotional state;
- processing of knowledge and ideas;
- eventual resolution and possible action and transformation.

The application of skills in finding and using information is critical to youngsters' development as learners. Information seeking research aims to better understand how people search for, access, and make sense of information resources, with the goal to build better information systems. It does not only emphasize professional contexts, but also information practices in everyday life, such as for instance the value of serendipitous discoveries on pleasure and positive emotions (Dörk, 2012). Today's youngsters are exposed to information from more sources and in more formats than ever before. They constantly seek, consume and share information with their peers, not only to be entertained but also to develop a collective understanding and critical stance towards topics in the media. Moreover, they also use the Internet and related technologies to work out issues of identity construction. For instance, (Ito et al., 2013) describe the case of Clarissa who is a 17-year-old aspiring fantasy screenwriter. Through friends she discovered an online role-playing site that involved writing fiction interactively. Online, she found a community of like-minded peers who shared her interests, and who collaboratively wrote stories and critiqued each other's work. As one can see, information access in these spaces is much more driven by personal goals, interests and information needs (often shaped by online communities) and developed throughout the whole life. Information seeking is one of the most popular online activities for teenagers (Shenton & Dixon, 2004) and can provide them with an additional information channel to enhance informal and formal learning activities. Everyday life information seeking can be defined as "the acquisition of various informational elements which people employ to orient themselves in daily life or solve problems not directly connected with the performance of occupational tasks".

2.4 Technology-Enhanced Learning Environments

First of all, learning environments refer to the diverse physical and digital locations and contexts in which students learn. Traditional examples are classrooms, work-places, labs, museums, natural sites, or home. These environments can be enhanced with technology to transform the learning experience from being physically present in the classroom to distance education in which the students can participate wherever they find it appropriate. In general, these so-called *Technology-Enhanced Learning Environments* (TELEs) refer to the use of socio-technical applications to support and enhance learning practices of both individuals and organisations (Goodyear & Retalis, 2010). They provide access to a range of materials, learning tools, and communication facilities to enable students to become more actively involved in learning. This application domain generally covers technologies that support all forms of teaching and learning activities through which students acquire skills or knowledge. Different types of TELEs can be distinguished. (Koper, 2014) identified five cases on how digital devices can be used to support and enhance learning practices of both individuals and organizations:

- *Zero case*: there are no relevant physical or digital relevant stimuli in the environment of a person.
- *Digital case*: when the physical environment includes digital learning devices, but does not provide relevant non-digital stimuli to the user. For instance in a quiet study room when using a simulation program.
- *Embedded case*: the physical environment provides relevant stimuli to the user and the digital devices are adding, augmenting information to enrich the cognitive representation.

- *Side-by-side case*: the digital devices are added to a physical environment to support additional learning functions such as information, support, tests and feedback, but the digital devices are ignorant of the actual physical environment.

- *Classical case*: the physical environment provides relevant stimuli, and there are no additional digital relevant signals.

Mobile devices and ubiquitous technology have enabled major changes in where and how learning can take place, and how TELEs can look like. Today, more and more TELEs can be situated in the embedded or digital case. In the first case, they are capable of scanning the physical environment for context-aware information to enrich the learning process. In the second case, they fully transform the learning process to the digital domain by simulating all kinds of affordances from the physical domain such as learning guidance by the teacher or social awareness of peer activity. Nonetheless, TELEs often exist side by side with the physical environment and do not take into account rich context-aware information. Especially in schools or universities they often mirror formal learning but fail to connect to informal learning spaces. In the following sections, we will take a closer look on different types of TELEs and their benefits and drawbacks regarding different forms of learning. In particular we will discuss:

- Traditional Learning Management Systems for formal learning

- Personal Learning environments for informal learning

- Open Learning Networks and Smart Learning Environments for informal, non-formal and formal learning

2.4.1 Learning Management Systems

One of the most significant and recent developments in the use of information technology has been the adoption of learning management systems (LMSs) to facilitate teaching and learning (Coates et al., 2005). LMSs are usually implemented across an entire university, faculty, or school, and then used by teachers to facilitate course management tasks in terms of:

- processing, storing and disseminating educational material;
- supporting administration and communication associated with teaching and learning.

According to (Chatti et al., 2010), LMSs have always been focused on delivery of learning objects and a standardization of the learning experience. Most LMSs today are designed to statically package online courses and modules, following the pattern of course modularization and the isolation of learning into discrete units such as lessons supported with online exercises. Therefore, the core functionalities are:

emph (as earlier)

- Content Management: store, manage and author assets such as text, video or learning objects;
- Analytics: track the user's learning behavior and performance;
- User Management: organize users into course units and assign them learning objects;
- Certification support: allow to issue reports on users learning performance and grant access to learning modules.

A LMS is an online portal where students can confidently search and obtain information regarding their courses, but it also has some drawbacks. The learning experience in a LMS is different from traditional face to face instruction because it is not based on physical presence in a classroom. In a physical classroom, learners interact directly with teachers and other learners. In a digital environment, learners often struggle to understand whether their work is of the same level as that of their peers or whether their work is in-line with the expectation of the teacher. For instance, the passive listening to or observing of class mates is a common strategy in a traditional classroom but can lead to isolation in an online context where active participation in form of note taking or online discussions are needed to succeed. Although current students are generally digitally literate, and thus able to manage basic computer tasks well, they might find it difficult to exploit the whole functionality of a LMS. Often, forums, wikis or chat rooms are part of a LMS but neglected in practice. Time management is a difficult task for learners, as online courses require a lot of time and intensive work. Whereas mostly adults prefer the asynchronicity of online-based learning programs for their place and time flexibility, youngsters might lack guidance on what, when and how to learn.

Self-motivation is an essential requirement for learning with a LMS. However, many online learners lack it. After enrolling in distance learning courses, many learners fall behind and are at risk of giving up. Students need to find the motivation to follow the new educational trends and also properly equip themselves for future challenges in their education and careers.

There is room for LMSs to improve student engagement and motivation, for instance by integrating game-based concepts, which are familiar to the students such as gaining points and rewards for learning activities, leader boards, or avatars, ~~i.e.~~ gamification. Gamification could make an application more fun to use, encourage users to interact with it voluntarily and repeatedly come back to it. Recently, more and more gamification elements have been adopted in open source LMSs, such as Moodle or Sakai, ~~or~~ as well as in commercial software, such as Blackboard or Canvas. For example, Moodle uses a badge system to reward the accomplishment of learning activities and motivate the development of a learner identity by including them in a so-called grade book.

2.4.2 Personal Learning Environments

Formal education systems have problems to prepare students for a world that requires networked learning experiences, an understanding of digital citizenship, and a way to navigate and organize a stream of information and resources from a variety of different sources

(Ash, 2013; Adams Becker et al., 2017). Being a professional in this networked field of work requires capabilities for lifelong learning, managing distributed expertise and learning across sites, participation and effective communication in environments mediated by technology (Laakkonen, 2015). (Attwell, 2007; Vassileva & Sun, 2008) acknowledge that modern learners have different patterns of information access, attention, and learning preferences which cannot be satisfied by traditional learning platforms that consider the learner as a bare consumer of information predefined by some supervisor or teacher. To target this new generation of learners, as well as the concept of informal learning, they proposed the model of *Personal Learning Environments* (PLE) in which learners draw connections from a growing matrix of resources and tools (search engines, bookmarking, blogging, social networks) that they select and organize to construct their own understanding. By definition, in such a PLE, the learner is in charge of identifying what needs to be learned (setting learning goals) and how it can be done (manage learning, both content and process). A typical PLE might, for example, incorporate Twitter where learners follow like-minded people and draw inspiration from their tweets to come up with a set of keywords to initiate a google search from. The retrieved results are translated into blog posts that may reflect personal insight. In this sense, the purpose of PLEs is to provide pointers to access the "right stuff" with respect to the characteristics of the learner, the learner's own context, such as task, nationality, language, or mood, and the external context such as time, location or educational mission (Vassileva & Sun, 2008).

PLEs have been invented to capture how learners organize their own learning spaces. The idea of a PLE is that with the advent of so many free tools such as search engines, social media, bookmarking software and others that are not formally controlled by an institution, people were constructing a set of tools that helped to structure their informal, everyday learning. A PLE may also include course resources, such as information from the lectures and assignments that happen in the classroom, but it is individualized to the needs and interests of the learner. They blur the lines between formal and informal learning. Because they are individualized to the needs and interests of the learner, each PLE can look completely different. Nonetheless, there are four main activities comprised in a PLE ("Personal Learning Environments — iTeachU", n.d.):

- *Connect* - The act of connecting to information can happen as reading from a favorite news site, listening to certain podcasts, or talking to particular people. But it also can entail the manner in which one searches for information. One can decide to find information using a single web search engine, or multiple, or none at all. One can use libraries, social media or conferences.

- *Collect* - The practice of collecting information is common among learners, as in general, they cannot remember where they came into contact with information.

- *Reflect* - People seek information because it is useful, it helps us grow intellectually, it challenges us. Reflection deals with questions such as: If one only momentarily glances at a data source how is it evaluated in terms of already acquired knowledge? How can it be improved? Does it contradict something else already known? How can it be improved? Should it be refuted in whole or part?

- *Share* - Sharing knowledge is part of being human, it is part of giving back to a community, and in some cases it is part of one's job function.

However, for users, it is often challenging to create and maintain their own PLE because a much deeper level of learning is required to find and customize content, choose a tool to use, and then use that tool to support their learning.

2.4.3 Open Learning Networks

According to (Mott & Wiley, 2009) a LMS reinforces the status quo and hinders substantial teaching and learning innovation in education. It does so by imposing artificial time limits on learner access to course content. It privileges the role of the instructor at the expense of the learner, and limits the power of the network effect in the learning process. An *open learning network* (OLN) is a hybrid of the LMS and the PLE. They are similar to PLEs in the sense that they emphasize that peers and other people are essential for the learning process. Peer networks do not only provide a means of disseminating and finding resources, they ~~it~~ also provide ~~provides~~ a space of discussing ideas and connecting with peers. For instance, you may have a well-developed network of peers on ~~in~~ Twitter that helps inform your work. This model suggests that the ”core set of functionality” remains in the learning institution. With the help of plugins, interfaces or data import/export mechanisms an OLN can integrate well with the institutional LMS. Figure 2.5 shows a typical OLN. One can see that tools which are crucial for grading and reporting remain in the LMS, whereas content acquisition for sharing and collaboration happens in the cloud. Using an OLN requires skills in complex information tasks, such as the one given in (Mott & Wiley, 2009):

- *Personal Information Management* for collecting and curating relevant resources into a meaningful structure to support learning.
- *Social interaction and collaboration* for using social media to find informal learning communities around topics of interest and understanding one’s place in it.
- *Reflection*, which is concerned with consciously looking on learning experiences, and analyzing them in order to extend knowledge, generate new learning goals or perspectives.
- *Personal Knowledge Management* for synthesis and representation of learning material and knowledge in a general form to support future learning activities.

2.4.4 Playful Learning Environments

(Kangas, 2010) coined the term “P Playful l ~~L~~earning environment”, which describes a novel, learning environment that combines learning activities with information and communica-

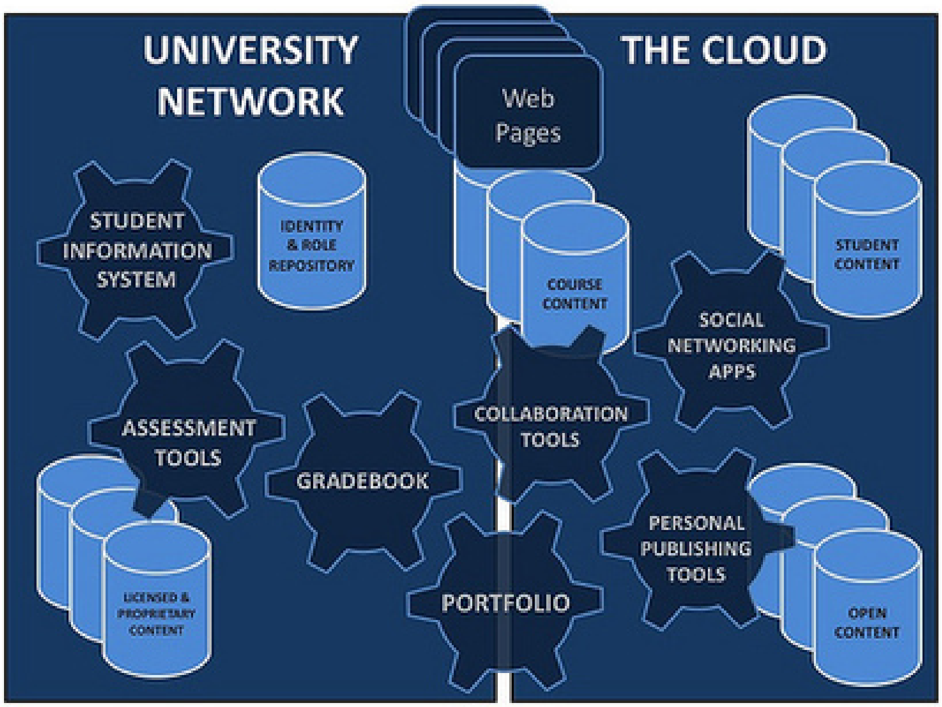

Figure 2.5: Example Open Learning Environment taken from (Mott & Wiley, 2009)

tion technologies both in the classroom and in outdoor spaces. Learning in such an environment takes the form of content creation and engagement in physical games to increase collaborative physical activity in the context of educational tasks. The PLE offers possibilities for children to learn curriculum-based topics by playing on the outdoor playground and provides more opportunities to use physical and bodily activities during the school day. Last but not least, a PLE makes it possible for children and teachers to create their own (curriculum-based) games and contents for the playground and its game applications via classroom computers (Kangas et al., 2007).

The qualities of creative and playful learning activities are summarized below, and analyzed from the perspective of the PLE: Social collaboration emphasizes knowledge co-creation and collaborative design and play processes. Collaboration with peers encourages motivation, cognitive engagement and requires the participants' commitment to the task during a learning and play process. Collaboration involves working with others both inside and outside of the classroom to obtain information, to share and discuss ideas, to exchange data and interpretations, and to receive feedback ~~on~~ of one's work. Opportunities for collaboration in the playful learning environment context are provided in the form of working in small groups with peers during learning processes when using technology and creating artifacts or playing on the playground. Places and spaces for collaboration can emerge almost anywhere in the playful learning setting. Playfulness encompasses learning activities that are based on curriculum and on physical game playing. During the learning process, active gameplay takes place on the playground where students reflect on the games and improve them by commenting and giving advice to the instructor throughout the play process. A PLE should offer ways for children to design their own game content, create their understanding and find a meaningful way to take part in their learning activities. According to (Kangas et al., 2007; Caillois, 2001) playful activities can be divided into ~~4~~ four groups, namely:

- *Agon*, or competition. It is the form of play in which players compete among each other;
- *Alea*, which denotes chance- and luck-based games;
- *Mimicry*, denoting games based on imitation and simulation;
- *Ilnix*, which stands for vertigo- and physical achievement-based games.

Learning outcomes in playful learning environments are multifaceted. They contribute to academic achievement, thinking skills, physical skills, participation skills, media skills, and knowledge co-creation skills.

- *Narration* refers to a mode of thinking and understanding by organizing real-world phenomena into a (sequential) structure that unfolds its meaning when the elements are revisited in the given order. One way to create a narrative structure is to embed learning activities in stories with plots that are created and acted out in play and games with problem-solving tasks.

- *Physical embodiment and the use of the whole body in learning activities* can create an involvement and activeness in learning that passive listening or watching does not. This increases levels of motivation and an interest in the activity or learning context. High levels of engagement can in turn affect the cognitive interaction of the learner, in terms of their attention, inquisitiveness and reflection.

- *Creativity* refers to the process of developing and refining imagination and creativity through emotions and by designing artifacts, games or media products. Knowledge is built by making discoveries, solving problems, using imagination and possibility thinking. New technology and its affordances are essential in the playful learning environment such as Virtual Reality or Augmented Reality, which can be applied in a variety of ways in creative and playful learning to support knowledge creation.

For example, the Space Treasure game concept (Kangas et al., 2007) encompasses the central elements of a playful learning environment. The game is based on children's embodiment, with physical activities enhancing mathematical calculations on the outdoor playground device. Playful learning in this case requires physical body movements and logical thinking, and a plot for a treasure hunt in space (Kangas et al., 2007). Other examples are so-called Escape Rooms where a team of players cooperatively discover clues, solve puzzles, and accomplish tasks to progress and accomplish a specific goal in a closed space (Nicholson, 2018).

2.5 Summary

In this chapter we have described the foundations and the evolution of digital learning by first accounting relevant types of lifelong learning, and next detailing ways digital learners access information on the Web. Then, we discussed different types of Technology-Enhanced Learning Environments and described ways how they related to formal, non-formal and informal learning practices.

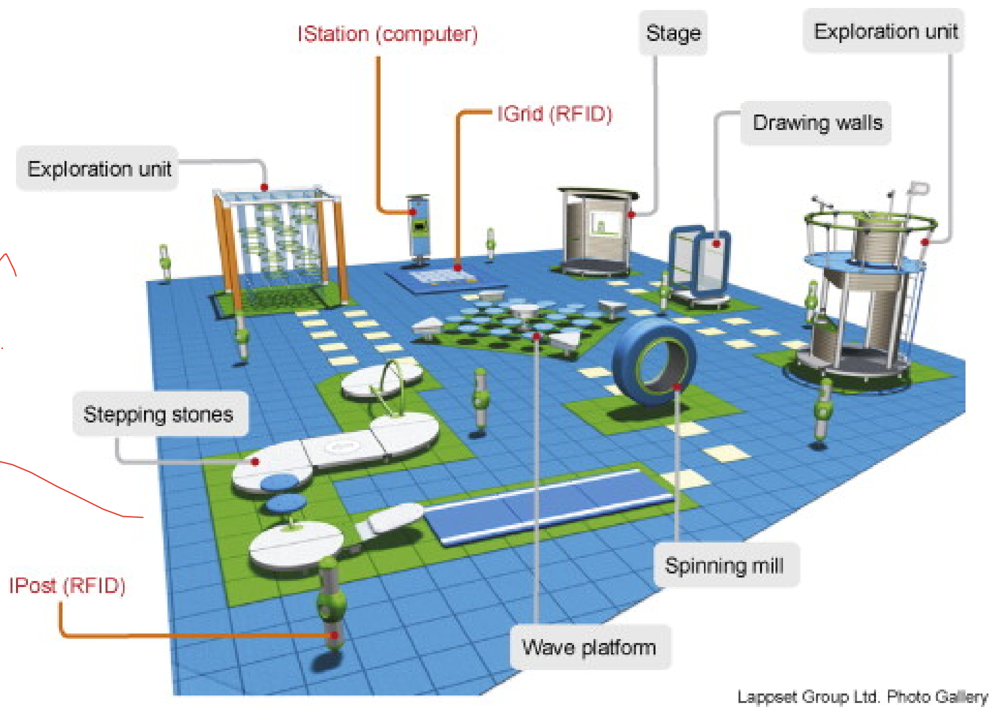

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Figure 2.6: Smart-Us Playful Learning Environment (Kangas et al., 2007)

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CHAPTER 3

MOBILE PLAYFUL LEARNING ENVIRONMENT

In this chapter we build upon the foundations presented and discussed in chapter 1 to reach our objectives. In particular, we aim to combine playful elements and physical embodiment from the Playful Learning Environment and pair them with formal and informal learning resources used in the PLE and OLN to create the concept of *Mobile Playful Learning Environment* (MPLE). We start by presenting the main features of a MPLE and we explain how they contribute to the goal of a MPLE, how they can be supported, and how they interact with each other (section 3.1). Because the main features are general concepts that can be realized by different theories and techniques from other fields, such as by the Visual Analytics Model, the Fogg Model, the PSD Model and other behavior change models, or more general user experience design models, we briefly discuss these as well. Section 3.2 will discuss models and frameworks from the HCI domain for reflection. Section 3.3 will discuss information visualizations. Section 3.4 will describe various models useful for designing and developing persuasive systems. Section 3.5 will provide the conclusions of the chapter.

3.1 MPLE: Conceptual Model

We will present the concept of a MPLE by providing a conceptual model identifying the main features of an MPLE. We give an overall picture of how these features interact with each other and describe the cognitive tasks involved. In particular for organizing the different cognitive processes, we build upon the work of (Rowanne Fleck, 2010) who defined a stage-based reflection framework consisting of levels of reflection organized by the cognitive effort they demand. She distinguishes between Description, Reflective Description, Dialogic Reflection, Transformative Reflection, and Critical Reflection as functionality among reflective applications.

Our model consists of seven features grouped into three ~~3~~ levels. The seven features are:

- *The mobile user context* is defined as the collection of information that characterizes the situation in which the learner is.

- *Data Collection and Analysis* collects and analyzes learning traces from the user's current context into a structure that can be used to extract meaning.

- *Learner Visualization* is used to display the learner's actions in order to revisit learning behavior and to provide structure, awareness and guidance in order to scaffold the self-reflection process.

- *Self-Monitoring* is supported by representing the state of interaction via a set of key events to reflect upon past behavior and establish new relationships from already known information.

- *Persuasion* is used to stimulate and positively change learning behavior.

- *Playfulness* becomes a lens through which the users can engage with their surroundings in a fun and explorative way.

- Through *MicroLearning* the learning takes place by interacting with small chunks of learning content and flexible technologies enabling easy and 'on the move' access from anywhere.

The presented MPLE model is a reference model, meaning that, in practice, it should be used together with suitable theories from other fields such as the Visual Analytics Model, the Fogg Model, the PSD Model and other behavior change models, or more general user experience design models, to realize the features. An in depth look into these models and frameworks can be found later in this chapter (from section 3.2 on). In the following subsections, we describe ~~into more deta~~il the role of the different features in a MPLE and in more detail

how they can be supported. The last subsection deals with how the features interact with each other.

3.1.1 Mobile User Context

"allows to" is not correct English → allows … to somebody

Nowadays, mobile devices provide a powerful platform for all types of learning where individualization of learning content, as well as anytime and anywhere access is critical. Mobile devices are bound to their owner, they are always on, always there, location aware and personalized. This allows to explore informal and formal learning resources in relation to the learner's current context and environment. The learner's context is defined as the collection of information that characterizes the situation in which the learner is. It comprises the information and assumptions about the learner (such as personal profile, goal, knowledge, interests, preferences, interaction and presentation history) and the information about the environment (such as location, device, time, date and weather) (Zhou & Rechert, 2008). With a mobile Internet-enabled device the student is able to connect to the MPLE from everywhere at any time. Information can be associated with locations and a wide field of topic areas such as civics, history, career, culture, or sports to extend excursions or informal strollings through the neighborhood with up-to-date content. This includes, for example, information about relevant objects aorind the current position of the learner - like an interesting point of interest in the public space holding an opportunity to learn. The time limit introduced by the use of playgrounds in the Playful Learning Environment is enlarged in our model to the whole day, as students have their smartphone all the time with them.

3.1.2 Data Collection and Analysis

Data collection involves observing and recording the interaction with the MPLE by means of so-called *learning traces*. Learning traces are granular snapshots of student activity. The most basic kind of learning trace is a page-visit trail in a learning environment where page visits and link clicks are recorded and associated with date information (Clemens et al.,

\mbox{}?

2018). Other learning traces include:

- Moving to a point of interest;
- Performing a learning activity (succeeding or failing);
- Adding an interest to own's profile;
- Logging into the MPLE.

had to read multiple times

The data collection logs these traces and store them for later processing. An activity-based analysis allows to create a historical log of student actions across time. Such an analysis involves selecting and computing one or more higher-level variables, called ? ~~i.e. termed~~ *events*, to represent the current state of interaction with the MPLE. For example, an 'agreement event' might be derived by comparing the problem solving actions of two or more students, or a 'symmetry event' might result from a comparison of participation events (Soller et al., 2005).

3.1.3 Learner Visualization

Information visualization is used to provide structure, awareness and guidance in the learning process. It has been proven to be a powerful means to present large amounts of information and is thus a perfect fit to make various types of contextual ~~context~~ information and other learning traces visible. Visualization tools can monitor the interaction state with the MPLE and provide basic support for improving awareness of actions taken on learning resources, for instance along a timeline. Moreover, they can aggregate data into a set of high-level indicators that are displayed to users such as analyzing participation rates with log in events and message reply delays (Govaerts et al., 2010).

3.1.4 Self-Monitoring

According to (A. Y. Kolb & Kolb, 2009) meta-cognitive aspects such as Self-Reflection and Abstract Conceptualization are important for the process of learning and the learner identity. Reflection is a mental process that takes as input knowledge or facts and produces an output of greater understanding that emphasizes personal value and meaning (E. P. S. ? Baumer, 2015). In this way, reflection can promote a positive self-concept whereby learners are confident and believe in their unique talents to face learning challenges. According to (Lin et al., 1999), many students can efficiently find information and memorize facts but unless appropriate scaffolds are provided, they cannot explain why information is relevant for them. They have problems to identify learning gaps and to recognize the limits of their own knowledge. To combat these problems, it is important that the MPLE offers resources for reflection on own thoughts and feelings associated with events, the learner's context, and peers. One way to do this is by providing *journaling* as a way to support self-monitor actions and gain awareness of learning behavior. This automatizes traditional manual journal keeping by gathering learning traces and augmenting them with additional media that offer advice and guidance for future learning such as highlighting missed learning opportunities or recommending new learning material. In this process, narration refers to a mode of presenting events within the context of stories that provide cognitive structures and framing perceptions of learning content. Many people perceive information as unrelated facts as long as they do not find personal value in them. But when ~~it~~ information is placed in the context of a story, it is easier to find connections to personal interest and thereby improve recall, interpretation and synthesis of knowledge. These principles should be combined with an adaptive and personalized approach, meaning that what will be offered, how and when, should be adapted to the needs of the individual learner and be dynamically responsive to the learner's behavior for achieving the strongest impact and highest learning relevance. Furthermore, because we aim for self-reflection, the use of so-called push technologies where the information is pushed to the user is preferred over the pull approach that demands user initiative and is often applied in regular education. (Lin et al., 1999) identified four types of design features that provide scaffolds for reflective thinking and that can be integrated into an interactive diary:

emph as earlier

- Process displays: displaying problem-solving and thinking processes;
- Process prompts: prompting students' attention to specific aspects of processes while learning is in action;
- Process models: displaying experts' thinking processes that students can compare and contrast with their own process in action;
- Reflective social discourse: creating community-based discourse to provide multiple perspectives and feedback that can be used for reflection.

3.1.5 Persuasion

To adopt a certain learning behavior, people need to be motivated and this is easier to achieve when people perceive social presence, relatedness, feedback, expertise and are rewarded for their actions (Fogg, 2002). Interactive information technology designed for changing users' attitudes or behavior is known as persuasive technology. Persuasive technology is broadly defined as technology that is designed to change attitudes and behaviors of the users through persuasion and social influence, but not through coercion (Smids, 2012). In this context, persuasion means the communication designed to influence the autonomous judgments and actions of people (Oinas-Kukkonen & Harjumaa, 2009). Mobile technologies create special opportunities for persuasive strategies because they are closer to the human than any other device and used ubiquitous and pervasive throughout our life. People have them with them all the time and everywhere. User interaction with such devices reflects more easily all facets of life than interactions with a desktop computer, which are often constrained to a work context. Mobile platforms have better opportunities to motivate people to achieve personal goals. According to (Fogg, 2002) it can layer information into our moment-by-moment lives in a way that changes our behavior. This persuasion power has been shown in many domains, including marketing, healthcare education and environmental sustainability (Thieme et al., 2012). Mobile devices enable access to location, personal photos, movement acceleration, or document access history. By exploiting these capabilities they can use the personal data flows coming from mobile devices to persuade the user to change behavior positively.

3.1.6 Micro Learning

consistency?

Learning in the MPLE should take place by interacting with small chunks of learning content and flexible technologies enabling easy and 'on the move' (emph?) access from anywhere. This type of interaction is based on Micro-Learning which assumes that people can learn better and more effectively when the content is broken down into digestible parts (Kovachev et al., 2011). Learning in small steps better fits the way people consume information today on the Web, ~~i.e.,~~ in terms of small text or status updates (Facebook, Twitter) (Bruck et al., 2012). Web 2.0 offers the necessary features to design learning content in smaller objects and support just-in-time learning. ~~For instance,~~ start screen apps can be used to provide micro-content, notifications, or entertaining quizzes. In this process, the content creator's role is to capture knowledge gaps, understanding them with the help of online resources, creating learning objects and integrating them into small learning activities interwoven into the daily life of the learner. MPLE should deliver learning content in small self-contained learning activities which contain context (ual?) information and provide users with instant feedback.

links to Web 2.0 is not clear

3.1.7 Playfulness

Next to the use of persuasion, the integration of game-based concepts that are familiar to youngsters, such as leveling up, obtaining rewards or gaining experience into the system, could be a way to motivate learners to use a learning environment. Through the process known as gamification, game mechanics can be integrated into environments to scaffold playfulness:

- Points (and scores) are used to compare users among each other and can be collected by performing so-called challenges which can be missions or tasks one has to accomplish.

- Teammates are mostly used for Cooperation among the users.
- Badges are issued when one has acquired a certain amount of points or a certain activity.
- Leaderboards are used to compare the performance of users and performance graphs provide statistics regarding the users' performance or/and behavior.
- Avatars are the representation of the users in the environment (e.g., to hide one's own identity).
- Story elements can be used to put the user in coherent narrative to nourish motivation.

However, note that playfulness is not the same as gamification. Adding game elements can make a system more fun but it is by no means sufficient. It is not because one can earn points or badges with a learning activity that the activity will be perceived as fun. Even worse, some people (who do not like competition), may perceive game elements such as points, badges and leaderboards, as annoying or childish. Play is an activity engaged in for enjoyment and is often a voluntary activity. When users are finding fun in learning activities, then there is no need for external gamification techniques, as the players are creating their own fun. It is the play, instead of points or rewards that brings people to become engaged in the real-world setting. (Nicholson, 2015) described playfulness as a framework consisting of:

- The freedom to explore and fail within boundaries;
- Exposition, which is the process of presenting a narrative layer through game design elements by the development and the presentation of a meaningful narrative element;
- Information that allows users to learn more about the real-world context in terms of why and how phenomena work instead of how many points a certain activity brings

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you.

- Choice, which gives the user the control of how ~~he or she~~ they engage~~s~~ with the system. A person will have a more positive sense of self-being if they have autonomy. In a playful system, this means that the player has meaningful choices to make which have a positive impact on the environment.

- Engagement, which creates opportunities for users to interact with others in meaningful ways. People have a more positive mental well-being when they feel connected to the world around them.

- Reflection that creates opportunities for players to step back and think about their game-based experiences. Users can connect what happened in the system to elements in his or her own life.

Within the process of play, it is important that users can establish and change constraints or parameters of the system to playfully define the limits to their own learning. When something is no longer fun, the players need the ability to change it to make it fun and playful again. Otherwise, they are in danger of self-imposing pressure or too ambitious learning goals, which would render the learning effort as work.

3.1.8 Learning Pipeline of MPLE

In the domain of Information Visualization, pipelines are used to describe the process of data transformation to information and knowledge. Data is usually first processed into some form of analytical abstraction which removes duplicates, cleans data and enriches it with new relationships and meta-data. This analytical abstraction is further reduced using a visualization transformation into some form of visual abstraction, which is information content that is visualizable. The purpose of the visualization stage is to empower perception to gain insight and form new knowledge which happens in the Perceptual and Cognitive space (Ed Huai-Hsin Chi & Riedl, 1998; Chen et al., 2009). To show how the user's context can generate learning traces that can be visualized to turn awareness into insight we have constructed a similar pipeline. Figure 3.1 shows this pipeline containing the components of a MPLE (which are based on the features of the MPLE model), how they interact with each other and how they contribute to the final goal. The Mobile User Context and Micro-Learning components provide all information needed for the extraction of learning traces which happens in the Data Collection and Analysis component. The Learner Visualization component is responsible to make the learning traces visible. For instance, the learner can realize that they ~~(s)he~~ crossed each week a famous monument with a long history in the city that can nurture their ~~her or his~~ interest in that topic. These events are narrated with the help of Journaling techniques that stimulate the perception of the learner in such a way that they can generate awareness of their learning actions. This awareness is needed to trigger the Self-Reflection phase where insight is formed about learning problems and opportunities. The outcome of this phase is to reinforce learning behavior by returning back to the Micro-Learning component and perform more learning activities. For example, for our learner mentioned earlier, by revisiting all informal learning activities of the past week (which included several trips to museums of city planning) the learner can realize that (s)he has a deeper interest in the history of architecture. The Persuasion component, which can be used in the Data Gathering, as well as the Visualization stage, can influence the formation of insight by applying persuasive techniques such as notifications, recommendations, rewarding, investments or tunneling. For instance, it can propose several other trips to related museums or monuments. To increase engagement of the MPLE, the Playfulness component is used to enrich the interaction with the system. For instance, the user can gain points by revisiting all learning activities of the past week or an avatar can strengthen the identification with the system. In the Micro Learning component, the user performs (voluntarily) context aware learning activities which are motivated by the insights gained in the Self-Reflection stage, and by the persuasive and playful techniques. While performing these activities, the user generates new learning data that reshape and feed back into the Mobile User Context.

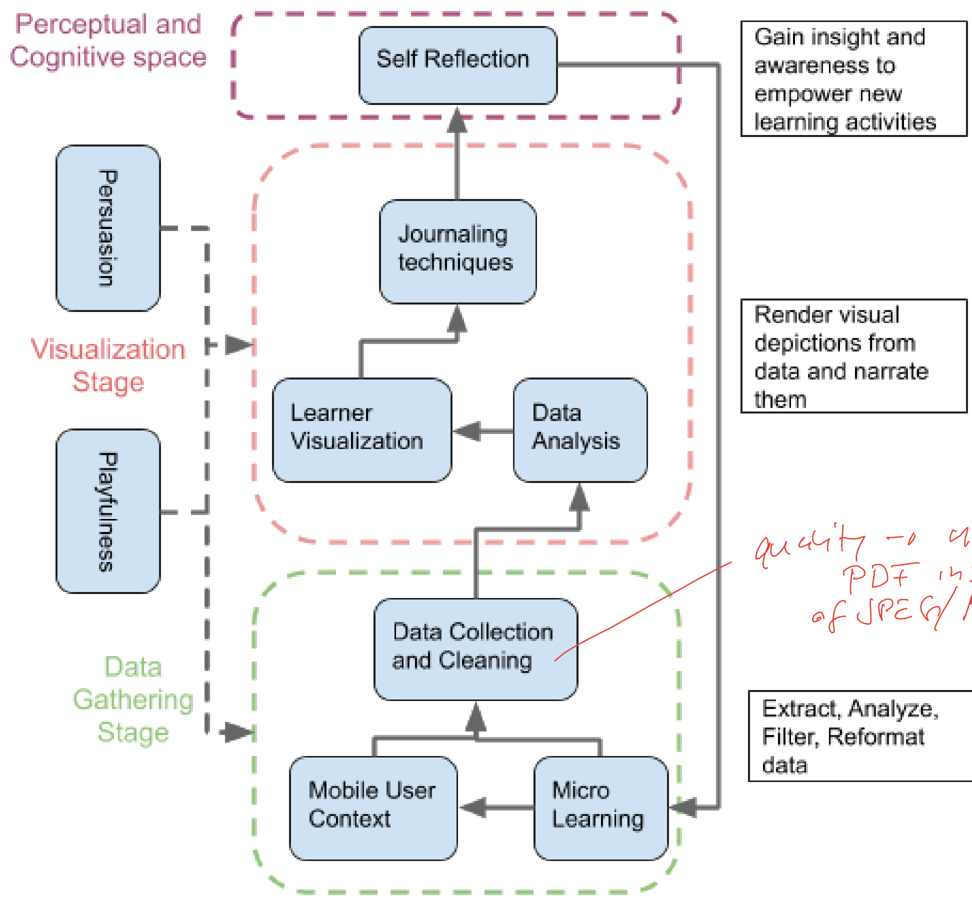

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Figure 3.1: Learning Pipeline for the MPLE Model

3.1.9 Summary

In this section we defined our conceptual model for Mobile Playful Learning Environments. This model should guide the design and development of such learning environments, which combine features from Personal Learning Environments (PLE), Playful Learning Environments, Learning Management Systems (LMS) and Smart learning Environment (SLE) to provide a learning experience that is mobile, supports informal as well as formal learning, and acknowledges information access behavior of digital natives. In particular, we tried to combine the openness of PLE/OLN with the guidance and structure of the LMS. In-

Learning Environment	Micro-Learning	User Context	Visualization	Persuasion	Playfulness
LMS	x		x		
PLE/OLN		(x)			
Playful Learning Environment	x				x
SLE	x	x	(x)		

Table X

spired by the emerging concept of SLE, we connected the user's context with Journaling and Visualization techniques to support meta-cognitive aspects such as awareness and self-reflection of learning. To lower the boundary to perform such mentally challenging tasks we apply playful and persuasive techniques that guide the user through the steps of this process. Fig X shows comparison of features of the MPLE with other learning environments highlighting the novelty of our model. One can see that Visualization and the user context have been rarely applied with persuasion and playful techniques in learning environments. The integration of the user context is a more recent development which started with context aware PLE architectures (Alharbi et al., 2012) and was made conceptually sound with the emergence of SLE. Through the holistic perspective of many SLE models, issues of how to represent information meaningfully and guide the interaction process with learning traces have been overlooked. Whereas SLE models cover many different systems including wearables and ambient technologies, our MPLE model targets the sweet spot of mobile applications to visualize and recommend learning activities for the purpose of awareness and self-reflection. In this sense, this model integrates control features from LMS, the collection of learning traces of PLE/OLN and context analysis of SLE. Through this horizontal approach, some features of these environments might be lacking but it supports a kind of learning paradigm that combines informal, non-formal and formal learning.

In the following sections, we discuss existing theories, techniques and frameworks for supporting reflection, information visualization and persuasion.

3.2 Reflection in Human-Computer Interaction

In Human-Computer Interaction (HCI) interest emerged on how technology can support human reflection on experience from technology-mediated experiences, events or stories that lead to new understandings or some sort of insight (E. Baumer et al., 2014). For this purpose, one must synthesize the diverse interpretations of reflection, derive aspects, and adapt them to the specific purpose and domain. The domain of personal informatics develops applications that help people collect, reflect on and explore personal information for the purpose of gaining self knowledge through the usage of computer assisted algorithms. These systems provide a better way for self-reflection than simply relying on remembering information about one self because people have limited memory and some behaviors are difficult to keep track of. For instance, monitoring the access of documents as an indicator for learning activity is difficult to do manually. In the following subsections we discuss different models developed to support reflection.

The Stage-Based Model of Personal Informatics Systems (I. Li et al., 2010) devised a five stage model for Personal Informatics Systems, which are needed for computer systems to scaffold reflection. The model is illustrated in Fig X 3.2 and the stages are as follows:

- The Preparation stage occurs before people start collecting personal information. This stage concerns people's motivation to collect personal information, how they determine what information they will record, and how they will record it.

- The Collection stage happens when people collect information about themselves. People observe different personal information such as their inner thoughts, their behavior, their interactions with people, and their immediate environment.

- Integration is the stage that lies between the Collection and Reflection stages, and where the information collected is prepared, combined, and transformed for the user to reflect on.

their

what about the fifth stage (Action)?

- The Reflection stage is when the user reflects on ~~his/her~~ personal information. This stage may involve looking at raw data of collected personal information or interacting with information visualizations.

- Action

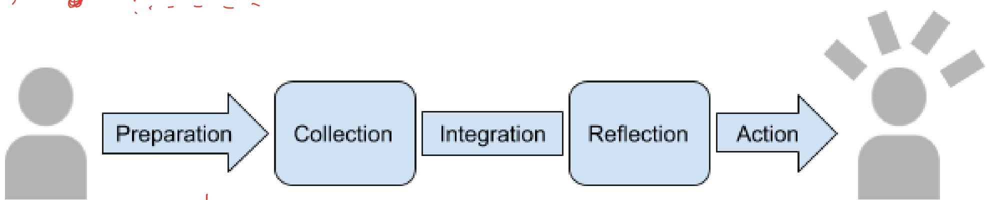

Figure 3.2: The Stage-Based Model of Personal Informatics Systems . Adapted from (I. Li et al., 2011)

3.2.1 Feedback Loop Model of Reflection

(Rivera-Pelayo et al., 2012) present another framework that combines different research areas for the technical support of reflective learning. Three main components are defined to scaffold the reflection process:

emph?

- Tracking cues: concerns capturing and monitoring raw data as the basis for the reflective learning process. Nowadays, a wide range of sensors is available to design applications that target computer-supported data analysis. The following types of data can be considered:
  - Social data: Data can be augmented with information from social media. This could be a comparison of one's own performance to that of Facebook friends or a comparison to all users of a system. Sharing in a social context provides additional data to others in expectation to retrieve more data in exchange and ultimately see one's own experiences in relation to other ones. An aggregation of data over multiple users may provide new perspectives on experiences and offer new abstraction levels.

– Spatial data: The location in terms of e.g. city and street can aid reflection by helping the users to understand the relation between place and their behavior. Wearable and mobile sensors are preferred because they accompany the user across different contexts, e.g. rooms and used tools.

– Temporal data can aid in the reflection process in terms of comparing current events to past ones to see the development of learning performance. Historic data may also help to explore related learning activities from the perspective of a certain point in time .

- Triggering: concerns fostering the initiation of reflective processes in the learner either actively or passively based on the analysis of the user's behavior. Active triggering means that the application sends a notification to grab the attention of the user. In order to support active triggering, an application must detect experiences that are suitable for initiating reflection. Passive triggering does not detect experiences for reflection automatically and does not actively contact the user. This type of triggering relies on the intention of the learner to kick off the reflection process by only presenting the collected data in a basic way.

- Recalling and revisiting experiences: concerns supporting learners in recalling and revisiting past experiences through the enrichment and presentation of data. To show important events or parts of the raw data, information visualization techniques are the main means.

In (Rodriguez Triana, Prieto Santos, et al., 2017) the authors distinguish the terms monitoring, awareness, and reflection in technology enhanced learning. Monitoring can be described as tracking learner's activities and outcomes. Learners can monitor themselves (self-monitoring) or learners can be monitored by another person, usually by a teacher or an administrator. Monitoring can be activity-~~centred~~ centered (monitoring processes) or outcome-~~centred~~ centered (monitoring products) Florian-Gaviria et al., 2013. Monitoring can take place in

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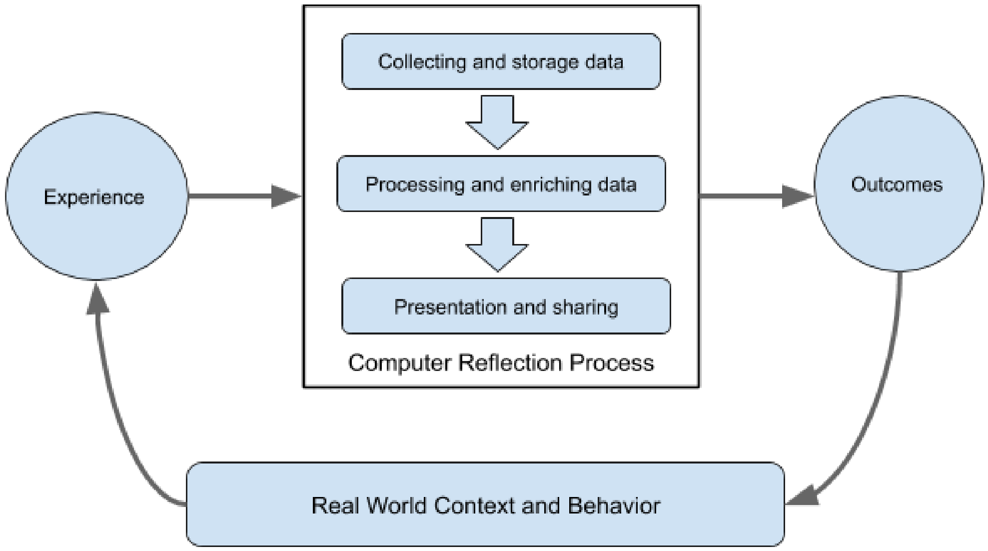

Figure 3.3: Feedback Loop Model of Reflection - simplified from (Rivera-Pelayo et al., 2012)

real-time or post-hoc. Monitoring learners' performance aims to detect trends, patterns, or changes available to stakeholders. Monitoring is a prerequisite for awareness and reflection. While monitoring focuses on learner's actions and outcomes, awareness infers the current state of either the learner's understanding or the learning artefacts. Awareness can be seen as a subsequent step from monitoring. For learners, awareness refers to the meta-cognitive process of being aware of one's own state of understanding and progress (self-awareness) as well as teachers' awareness of the state of their students and classes.

3.2.2 Five Stage Model of Reflection and Cognition

(Rowanne Fleck, 2010) synthesized related literature on Human-Computer Interaction into a four stage framework, consisting of levels of reflection organized by the cognitive effort they demand. Level 1 deals with revisiting data with explanation. An example is looking back at learning activities and reviewing the mistakes made. Level 2 emphasizes the explorative aspect of reflection, i.e. how can new relationships from already known data be established. One example is to discover new learning activities which are related by a common keyword. In level 3, transformative reflection inspects how reflection can lead to attitude and behavior change. For example, the fact that many mistakes have been made in a particular subject can lead to the insight that one has to improve on that subject. Last but not least, level 4 deals with wider societal consequences of reflection. It involves taking into consideration moral and ethical issues, and wider socio-historical and politico-cultural contexts. This level of reflection is hard to induce by technology alone. It demands a deep cognitive effort by the users themselves and happens often outside technology usage. The levels are illustrated in Figure 3.4

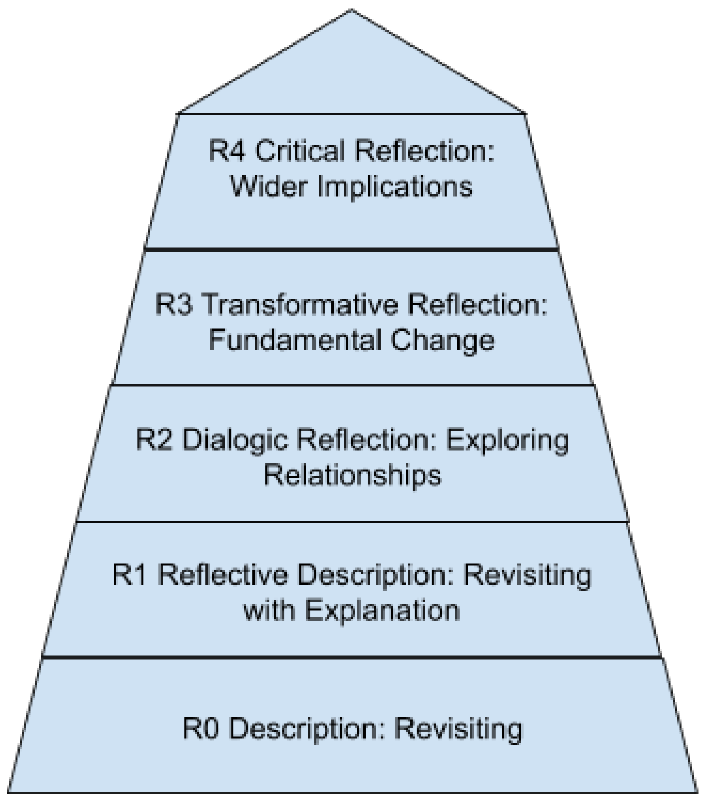

Figure 3.4: Illustration of the different reflection stages of the Five Stage Model of Reflection and Cognition (Rowanne Fleck, 2010) Conclusion

3.2.3 Conclusion

Self-Reflection as meta-cognitive activity is one of the aims of our MPLE model. Therefore, we discussed in this section several models for reflection relevant for the design and development of reflective applications. Especially the model by (Rivera-Pelayo et al., 2012) and its emphasis on the user's context is relevant for the structure and data flow of the MPLE. The model by (Rowanne Fleck, 2010) will be used in Chapter 3 to compare reflective applications and their level of reflection. ?

3.3 Information Visualization

In the Personal Informatics domain, Information visualization has been proven to be a powerful means to enable reflection and decision making. Building on our perceptual capabilities, it makes use of computer-supported, interactive, visual representations to support the understanding of the meaning of large amounts of abstract data without overburden human cognition (Card et al., 1999). However, most practitioners approach information visualization from a technical and analytical perspective: visualizations are, for instance, used to gain insight in customer data to maximize profits or support analysis of scientific experiments. However, in popular media, information visualizations are applied for another purpose, i.e. to persuade, entertain, and to tell stories (Dur, 2014). These visualizations, usually called infographics, can blend serious content with colorful designs to attract a wide audience and to embed the viewer in a playful visual narrative that creates attention, excitement and curiosity. In this way, it may convince people of an opinion, or to take action. In the following we discuss two disciplines that build upon Information Visualization, i.e. Visual Analytics and Learning Analytics, as well as several sub-domains, i.e. Casual Information Visualization, Personal Information , Visualization for Information Seeking, and Playful Information Visualization, which can support the persuasive and playful aspects of our MPLE.

3.3.1 Visual Analytics

As mentioned before, the main aim of Information Visualization is the presentation of data in a visual way in order to equip the user with a tool that allows ~~him or her~~ them to make confirmatory analysis, i.e ~~he or she~~ they can validate hypotheses by looking at the presentation.

This analysis technique is rather static. and ~~T~~The visualization only represents results. The user is not supported in incorporating ~~his or her~~ their own thoughts into the automated data analysis process. Visual Analytics integrates visualization techniques and data processing techniques into a highly dynamic approach where the visualization serves as an assistant for the user on ~~his or her~~ their way to explore the data (Keim et al., 2010). In ~~figure~~ Figure 3.5, the visual data exploration is exposed. There, visualizations are used to present the actual selection and model of the data, which is computed by automated data analysis techniques such as data mining. Then, the user is given the opportunity to reason about the data and to adjust or change the model of the data. Thereafter, data mining is applied, results are visualized and the process starts all over again. As such, the process consists of a feedback loop which is based on interaction between the visualization and the user. "Visualization becomes the medium of a semi automated analytical process, where humans and machines cooperate their respective, distinct capabilities for the most effective results. The user has to be the ultimate authority in directing the analysis." (Keim et al., 2010) emph

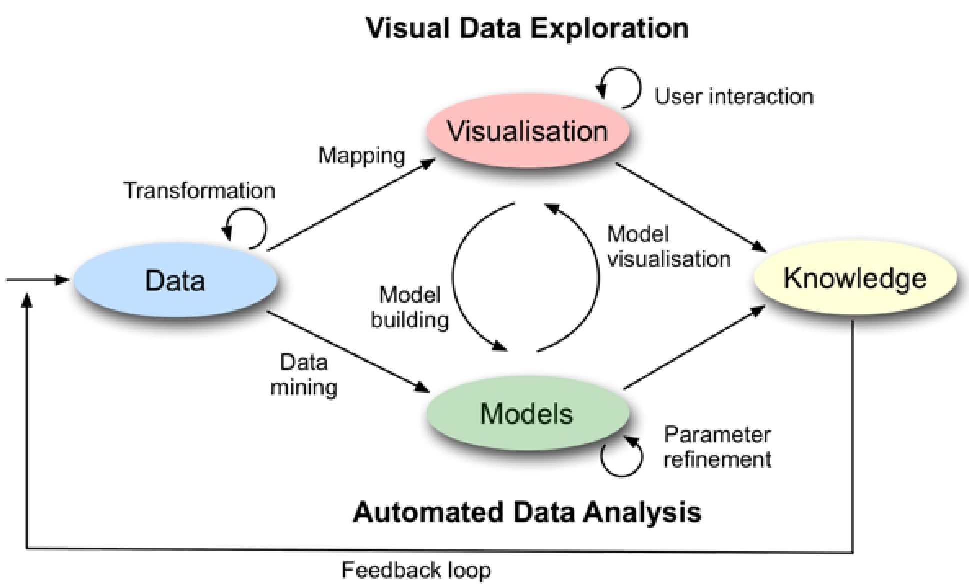

Figure 3.5: Visual Analytics feedback model, taken from (Keim et al., 2010)

3.3.2 Learning Analytics

Visualizations for reflection and decision making have also been applied in learning. Learning Analytics platforms have shown that through tracking, analyzing and visualizing learner-related data, the learner's performance can be improved. Visual accounts can help to raise awareness about personal strengths and shortcomings, which can help to set up learning goals and improve learner development (Duval, 2011). However, Learning Analytics tools are often embedded in a course context (Verbert et al., 2012). They do not necessarily establish a link to a PLE. Often, they rely on data collected by institutional Learning Management Systems, such as the total time spent on the course, the average time spent on a document or the number of documents used. In some cases they also incorporate more personal data sources such as Twitter streams to assist formal learning (Govaerts et al., 2012).

3.3.3 Casual Information Visualization

Learning Analytics systems often make use of well-known visualization techniques that demand patience, willingness and experience to scan the overall picture for correlations, distributions, outliers and details before one can obtain insight. Originally, these visualization techniques were envisioned for data scientists who are skilled and motivated to dive deep into data analysis. Some of those techniques seem to be too complex for an audience who has little experience or interest in analysis tasks. (Pousman et al., 2007) envisioned how interactive data visualizations can be made appropriate for non-expert users and different kinds of insights. They explored edge cases of information visualization and proposed a number of sub-disciplines (bundled as Casual Information Visualization) which focus on different forms of insight and non-expert users. There are several differences between traditional Information Visualization systems and Casual Information Visualization:

so are these the ones for casual infovis then? (a bit ambiguous from text)

- The target audience includes a wide spectrum of users from experts to novices. Users are not necessarily literate in analytic thinking and do not need to be required experts in reading visualizations.

- The usage expands from work or performance to other parts of life such as pass time activities and play.
- The data is personally relevant and not necessarily embedded in a formal context.
- Different kinds of knowledge that go beyond analytical insight are supported. For instance, social awareness is about what is happening with friends or family or reflective insight into personal behavior to change it for the better (see also the section on Persuasive Technology). Ambient visualization systems often produce awareness insights in data that is either user-selected, or selected by designers to be personally relevant to a community or type of individual.

3.3.4 Personal Information Visualization

Personal Information Visualization and Analytics shift the focus on meaning making of data in personal life. (D. Huang et al., 2015) argue that people may look into their data with different goals, backgrounds, and expectations from a personal perspective. They examined what types of insights people draw from their personal data and identified recall, detail, comparison, and value judgement as common types. To include the subjectivity and uncertainty of opinions, beliefs, or memories in personal life, new techniques are developed that give emphasis on local phenomenon and situations. The main research question in Personal Information Visualization is "How can the power of visualization and Visual Analytics be made appropriate for use in personal contexts — including for people who have little experience with data, visualization, or statistical reasoning?" (D. Huang et al., 2015). An example can be found in (D. Huang et al., 2014) where the authors extended a traditional calendar view with data streams from household electricity meters and Fitbit devices. Another example is given in (Thudt et al., 2016). In this paper, the authors discuss emph visual mementos as a particular type of personal visualization for the purpose of reminiscing, and sharing of life experiences. They developed Visits, a tool which relates places the user has visited and time spent there with photos taken to create a visual travel diary.

3.3.5 Visualization for Information Seeking

In the context of everyday information seeking, (Dörk, 2012) envisioned interactive visualizations as a means to make searching and navigating the Web more high-level, engaging, and exploratory. Building upon the exploratory search paradigm, they proposed Visual Exploration as a model to enable users to explore, overcome uncertainty, and learn without specific questions or tasks in mind. They introduced visualization widgets (VisGets) that integrate graphical summarization with interactive query formulation. In summary, the model looks as follows:

- Information seekers can choose the way they interact with the information space. Interactive visualizations support direct manipulation of graphical elements and underlying data.

- Visualizations summarize meaningful aspects of an information space providing high-level perspectives on the data.

- Visual exploration provides visual and interactive access to data dimensions and a way to navigate the data.

- The searcher can choose how to express an information need using visual and/or textual representations.

3.3.6 Playful Information Visualization

Many casual and personal visualization systems provide insight in a “playful” way to stimulate informal learning but rarely define it as an explicit outcome. By playfulness visualization we mean an interaction which cannot be considered as proper play but features some characteristics of it in terms of:

- Graphics and animation;
- Imagination of an abstract space;
- Providing motivating feedback, often through a storyline where choices matter;
- Spontaneous goal formation to solve problems;
- Browsing information as serendipitous exploration. (Bekker, Sturm, and Eggen 2010).

Furthermore, (Medler & Magerko, 2011) argue that data analysts and video game players share properties in the way they recombine and manipulate symbols to achieve goals and insights. Analysis tasks are already vital parts of digital games — players are asked to find patterns, manage resources, and work with incomplete information. Moreover, so-called player dossiers make use of statistics and visualizations to enable users to track achievements, analyze past gameplay and share data with in-game friends.

3.3.7 Conclusion

In this section, we reported on several sub-domains of Information Visualization that are of interest for our MPLE Visualization component. Although all these sub-domains are relevant, especially Playful Information Visualization will be important to consider in order to engage the user in a playful way in the Data Analysis process to examine learning traces for the purpose of reflection.

3.4 Persuasive Technology

In general, learners need to be motivated to perform learning activities because they require considerable cognitive effort of the user. Engaging individuals to reflect on information who are not motivated to do so is even more difficult; it may require the use of motivational strategies. One possible strategy to motivate the user to do something is persuasion. Persuasive technology is broadly defined as technology that is designed to change attitudes and behaviors of the users through persuasion and social influence, but not through coercion. Persuasive technologies are now applied in many domains, including healthcare, education and environmental sustainability (Thieme et al., 2012). In the following subsections, we describe the major theories and models developed in the context of persuasion.

3.4.1 The Six Principles of Persuasion

(R. Cialdini, 2001) studied the process of persuading people to come into line with the requests and the offers that we make them. He grouped the principles to persuade people into six basic categories which he called the six basic principles of influence. These principles are used ubiquitously in human interactions to influence and to persuade people to do, act, and think the way one wants — even if we do not recognize them as such. Note that influence can be used ethically to nudge people into a positive behavior but it can be also used maliciously. The six principles of influence are as follows:

consistent use of US English → spell checker

- **Consensus** describes the fact that people are performing the same behavio~~u~~r when a large group of other people also perform this behavior, because it is considered as appropriate behavio~~u~~r.

- People have the desire to be consistent in what they do. **Consistency** can be used in persuasion by letting people make a (small) commitment to something or someone. Afterwards they will try to be consistent with this commitment in their behavio~~u~~r.

- **Scarcity** describes the fact that people perceive something more valuable when there is a limited availability.

- **Liking** describes the fact that people tend to agree on requests from friends, or people they like.

- **Reciprocity** describes the fact that people tend to return a flavour, gift, or invitation when they have received one from somebody. Most people are feeling obligated to return something.

- **Authority** describes the fact that people tend to comply with the advice of somebody that is presented as an authority.

3.4.2 Fogg Model

consistency

JB Fogg studied the concept of persuasive technology (Fogg, 2002) and how we can design systems that impact the user on an affective level. He proposes d a ~~model, called~~ the Fogg's Behavior Model (FBM) (Fogg, 2009), which identifies the factors needed to invoke a certain behavior (Muntean, 2011). The model is illustrated in Figure 3.6:

- The Motivation axis describes how motivated the user is to perform the behaviour. Fog gives three types of core motivators: Pleasure/Pain, Hope/Fear, and Social Acceptance/Rejection.

- The Ability axis describes the ability of the user to perform the behaviour. It can be described in terms of money, physical effort, and/or brain cycles needed to perform the behavior, as well as in terms of the social deviance of the behavior, or the non-routine character of the behavior.

- In addition to the necessary level of motivation and ability, Triggers are needed to perform the behaviour. They describe the elements that could tell the person to perform the behavior. Fogg distinguishes between Sparks, Facilitators, and Signals.

When technology is used for persuasion, interactive technology has three important functions in behavior change: as a resource, as a media, and as a social actor. The persuasive strategies differ depending on their function:

- As resource: To convinces people to adopt new habits by increasing their possibilities and facilitating the target behavior.
- As media:In this role, convincing technology offers experiences that enable people to practice the intended behavior, creating a loop in learning.
- As social actor: In this role, convincing technology creates a relationship by giving social signals. People respond to social cues of computer systems as they would interact with others, this is an extra strong function.

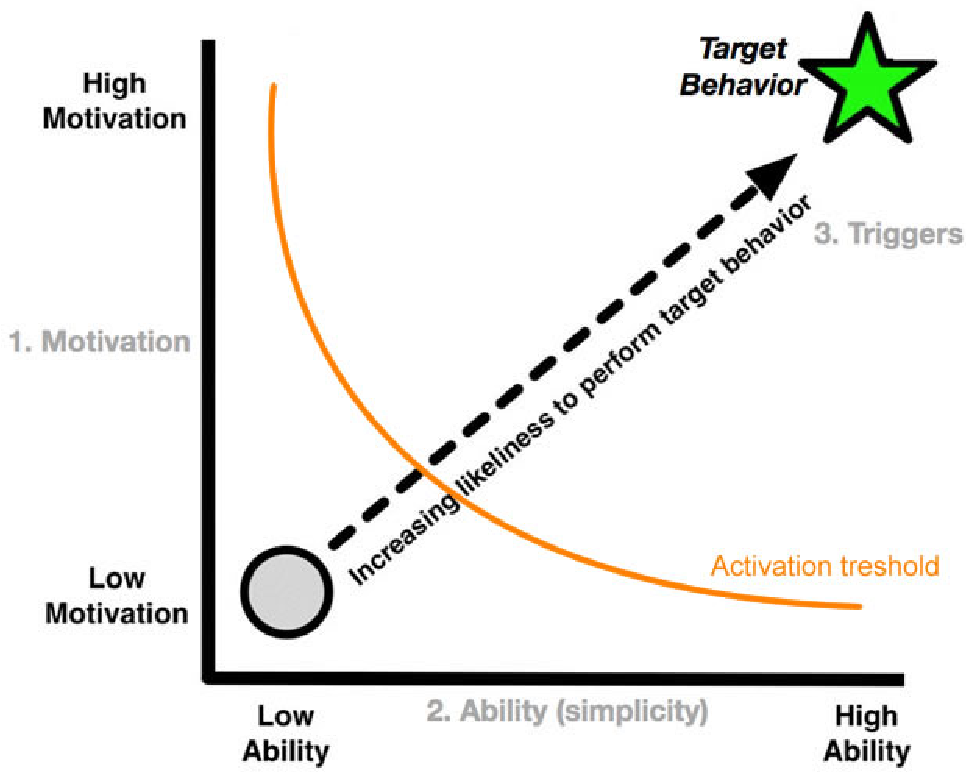

Figure 3.6: Foggs Behavioral Model (Fogg, 2002)

see comment on previous page

3.4.3 Hook Model

Nir Eyal reverse engineered the principles used by application such as Facebook to hook people to an application in his book “Hooked”. His Hook Model explains how a user can

ref?

be bound to keep on using a product or service, i.e. when it becomes a habit (Eyal, 2014). Habit-forming products are products that people keep using without the need of expensive advertising or aggressive pushing. The aim of the Hook Model is to create a habit of using a certain product. In this way, the Hooked Model can also be used to influence the user's behaviour. For a company, the adopted habits can mean more profit. For the user, adopting a new habit means a significant change of mental state. Psychological needs such as belonging, stimulation and social acceptance are directed towards the use of the product. Therefore, the Hook Model proposes a cycle through which the user must repeatedly move to gradually create those new habit. A single cycle is composed of four consecutive steps (see Figure 3.7). It starts with a trigger that should be followed by an action from the user. In accordance with Fogg, Eyal also argues that an action will only take place if the user possesses sufficient motivation and abilities to perform the action. Therefore, Eyal suggests to make the actions as easy as possible. In this way, the behavior is very likely to be performed. The next phase in the Hook cycle is the reward phase. Rewards are used to increase the likelihood of repeating the action in the next cycle; Eyal advises the use of variable awards. The last phase of the cycle is the investment. This phase is typical for the Hook Model. An investment is everything that a user puts into the system (like time and effort), or supplies to the system (like preferences and content). The more a user invests in a system, the less likely it is that (s)he will stop using the system, as then the investment will be lost. Therefore, when applying the Hook Model, it is necessary to give due consideration to these investments. The goal of repeatedly going through the cycle is to eventually remove the need for an external trigger, which is used in the first step of the cycle, and to replace it by an internal trigger, such as the feeling of boredom or loneliness, or simply curiosity. We discuss the different steps into more detail:

- Triggers can be either internal or external. The behaviour often starts with some external trigger (e.g. a push notification on a mobile device). When the cycle is followed repeatedly a habit can be formed in which case the underlying behaviour is associated with some internal trigger (e.g. an emotion) and the external trigger is not needed anymore to call for the behavior. Emails are also an example of an external trigger. Seeing your name and subject line in your inbox is an external trigger. However, the motivation for checking emails can also be triggered internally through boredom, curiosity, fear, or some other driver. In that case, reading emails has become a habit.

- Responding to the trigger should be possible by performing a simple action (e.g. pushing a button). Because of the simplicity of the action, the user should have a high ability to perform it, and therefore (based on Fogg's Model) it will be more likely that the action is performed. For example, in the case of email marketing, the email sender wants readers to perform a series of simple actions such as open your email, read or scan through it, and click on a link.

- Performing the action should be followed by receiving a variable reward. Rewards are used to increase the likelihood of repeating the action in the next cycle. Eyal claims that variable rewards work better for humans than fixed rewards. An example of a reward in the email marketing case is to offer a discount or some free points for opening the link in the email. In this way, people will look forward to the emails.

- Investment is important in habit creation, because it gives a sense of ownership and makes it harder to stop using the product. An example are collected points in a web shop, or the photos uploaded or collected in an application such as Pinterest.

Eyal proposed five questions that a designer should ask himself to build effective hooks (Eyal, 2014):

1. What do users really want? What pain is your product relieving? (Internal trigger)

2. What brings users to your service? (External trigger)

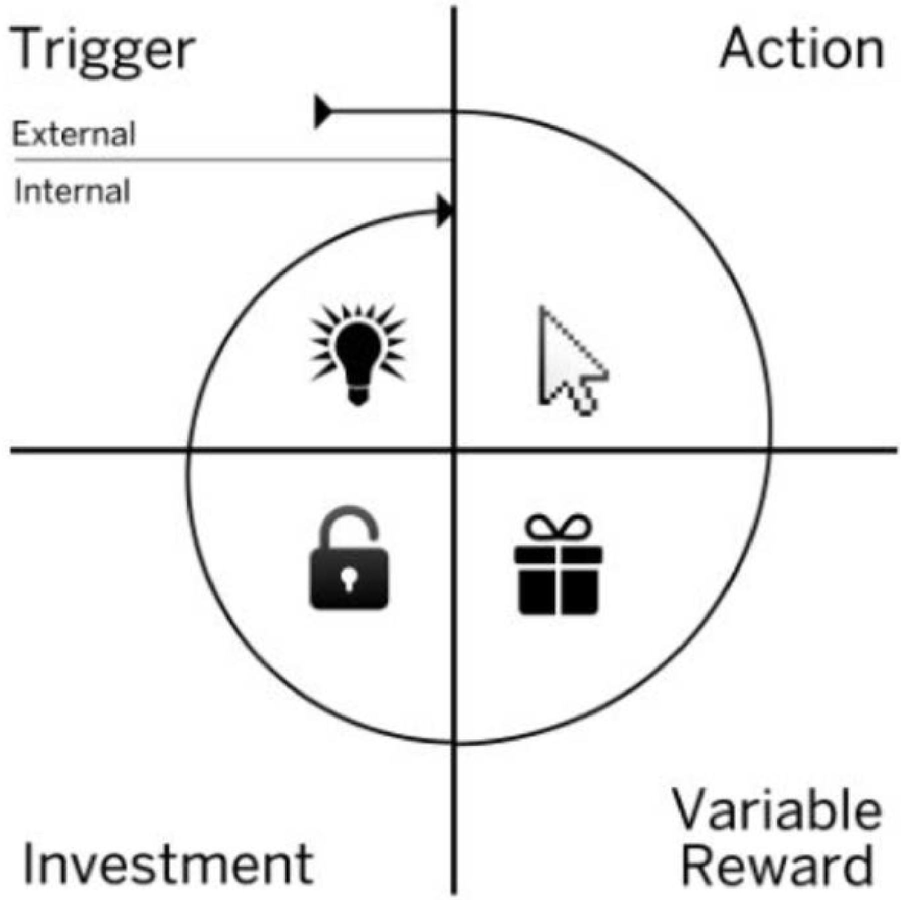

Figure 3.7: The Hooked Model according to (Eyal, 2014)

3. What is the simplest action users take in anticipation of reward, and how can you simplify your product to make this action easier? (Action)

4. Are users fulfilled by the reward yet left wanting more? (Variable Reward)

5. What bit of work do users invest in your product? Does it load the next trigger and store value to improve the product with use? (Investment)

3.4.4 PSD Model

The Persuasive Systems Design (PSD) model is a conceptual framework for analyzing, designing and evaluating persuasive systems. It builds on theories of behavior change from both psychology and computer science (Fogg, 2002). In the PSD model, the categories for persuasive system design principles are Primary task support, Dialogue support, System credibility, and Social support (Oinas-Kukkonen & Harjumaa, 2009). Primary task support features facilitate users' interaction with a system and help track their performance through features such as self-monitoring. Dialogue support features improve dialogue between the user and the system in terms of feedback to better guide the user through the intended behavior change process. Features such as authority, expertise, real-world feel, and verifiability promote the credibility of persuasive systems. Social support features foster user motivation through components such as cooperation, social comparison and social learning. Furthermore, the model is based on seven postulates that highlight some key principles behind each persuasive system (Oinas-Kukkonen & Harjumaa, 2009):

- Persuasive systems are never truly neutral and always influence their users intentionally and unintentionally.
- People prefer that their views are organized and consistent with the world. Systems should support the making of commitments and investments to initiate a target behavior. This is based on the concept of commitment and cognitive consistency (R. B. Cialdini & Cialdini, 1993).
- Direct and indirect routes are key persuasion strategies. The first are clear guides in terms of step by step process through information. The second are simple cues to evaluate the information such as tooltips or optional views on information.
- Persuasion is often incremental. It is easier to initiate people into doing a series of actions through incremental suggestions.
- Persuasive systems should also be open in announcing their intentions to influence their users in order to avoid coercion and deception.
- Persuasive systems should aim at unobtrusiveness, meaning they should avoid disturbing users while they are performing their primary tasks with the aid of the system.

- Persuasive systems should aim at being both useful and easy to use. This includes responsiveness, ease of access, lack of errors, convenience, and high information quality, as well as positive user experience and attractiveness.

Figure 3.8 illustrates the development process of a persuasive system using the PSD Model. The first step is to understand the fundamental issues behind persuasive systems. After obtaining a reasonable level of understanding, the system can be analyzed and designed. Therefore, the second step is to analyze the context for the persuasive system. That means recognizing the intent, event, and strategies for the use of a persuasive system. The final step is to design the actual system qualities which lead to a behavior or attitude change. Overall, the PSD framework is a capable framework for the design and development of Persuasive Technology. It discusses the process of designing and evaluating persuasive systems and describes what kind of content and software functionality may be found in the final product.

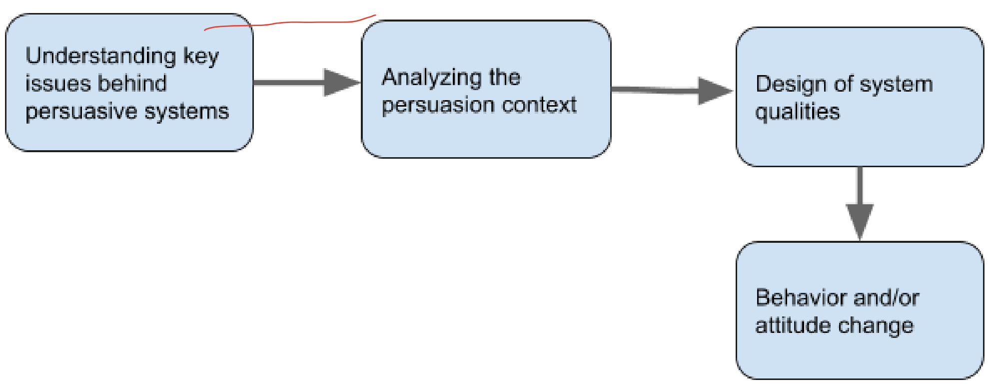

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Figure 3.8: The development process with the PSD Model

3.4.5 Conclusion

In this section we discussed several Persuasive Technology models for the design and development of such applications. The PSD model provides a framework to analyze the functionality of persuasive applications in terms of task support and context. It will be used in Chapter 5 for the design and development of the proof of concept MPLE application called TICKLE. Furthermore, the Fogg model, as well as the Hook model will be applied in this application.

CHAPTER 4

RELATED WORK

In this chapter we examine related work in terms of existing applications and frameworks. For this comparison, we choose a persuasive approach which understands events or situations with a set of concepts, definitions and propositions to influence or change human behavior for the sake of learning (Hekler et al., 2013). First, we will compare existing TELEs with features of our MPLE model from three different perspectives, i.e. systems supporting different forms of lifelong learning, systems with capability for Self-reflection, and systems providing Persuasive strategies and Playful techniques. For each perspective we will define a set of features that are informed by the literature and map to our research objectives. Second, we will review models and frameworks in the domain of informal and formal learning that not only inform the design of learning environments by defining features and interaction mechanisms but also showcase learning situations that the framework can support.

4.1 Comparison of Related Applications

Here, we compare existing applications that tackle the domain of informal and formal learning. We will discuss these applications from three perspectives, each considering a different dimension of our MPLE model. The first perspective deals with the properties and aspects directly related to achieving the informal and formal learning goals. The second perspective captures the way reflection is handled in these systems. The third perspective looks at ways to guide the user in the learning process in terms of persuasion and playfulness including gamification. We will analyze resources that describe systems based on properties and attributes that will be identified in the subsections respectively dealing with the three perspectives. To identify related systems, we searched Google Scholar for papers with the following keywords:

- Personal Learning Environment (PLN) [27 papers identified]
- Open Learning Network (OLN) [15 papers identified]
- Informal learning application [5 papers identified]
- Persuasive technology, education [7 papers identified]
- Gamification, informal learning [2 papers identified]

In this way, we obtained 56 systems. It is striking that only a few papers were found dealing explicitly with persuasive technology in the education domain. It seems that the intersection between these two research fields is still an untapped research area. Moreover, only 5 papers were found with the keyword 'Informal learning application'. This is the case because many duplicates were already found using the keywords PLN and OLN. Then, the papers were scanned for references and frameworks facilitating formal and informal learning which resulted in the following systems:

1. *Elgg* is an open source social networking engine that provides a robust framework on which to build all kinds of social environments, from a campus wide social network for a university, school or college, or an internal collaborative platform (Conde et al., 2014).
2. The *mEducator* EU funded project developed technologies that enable effective searching and retrieval of learning resources by means of Web 2.0 principles, mashup technologies, semantic linked services and persuasive techniques (Bamidis et al., 2011)
3. *Netvibes* allows the user to customize a personal Dashboard to aggregate resources online such as social networks, news, articles on the topics of interest. It also offers support for digital calendars, to do lists, emails and apps in one place ("Your Personal Dashboard" n.d.). It offers connectivity with a wide range of tools, and it adds the

social element by providing connections (“Widgets”) to Facebook, del.icio.us, Flickr and other applications.

4. The Canvas Learning Management Platform is a software application for the administration, reporting, and delivery of educational courses (“Canvas”, 2020).

5. *Moodle* is a popular open-source learning management platform that offers a powerful plugin mechanism to tailor learning solutions for a wide range of learning institutions (Conde et al., 2014).

6. *Mahara* is an e-portfolio system that permits to share learning experiences across different tools and devices (Conde et al., 2014).

7. *Mindless Change* utilizes learning theories to provide a mobile intervention system to establish healthier habits in terms of food and exercises (Vainio et al., 2014).

8. *Plotmaker* is basically an authoring environment for persuasive learning objects (Behringer et al., 2013).

9. The *KSMS* project introduces a mobile self-learning system that can be an alternative for school in countries that cannot offer normal education (Abdessettar et al., 2016).

10. *RightOnTime* is a mobile application intended as a Behaviour Change Support System for people who want to improve their punctuality and time-keeping skills (Tikka et al., n.d.).

11. *iDetective* is a mobile game that utilizes persuasive techniques to stimulate exercising by offering photo challenges on geo-location (Yoshii et al., 2011).

12. *PACARD* (Personalized Adaptive CARD-based interface) is a learning tool that combines several technologies including card-based interface, personalized adaptation, push notifications, and badges (Pham & Chen, 2019).

13. *TalentCards* is a card-based LMS that provides bite-sized learning activities targeted for learning on the job ("TalentCards", 2020).

14. *MGLS* (Mobile Gamification Learning System) is a location-based LMS that was developed and implemented in an elementary school science curriculum to improve student motivation and to help students engage more actively in their learning activities (Su & Cheng, 2015).

15. *Moin* is a mobile application to foster informal learning through face-to-face communication, supported with contextual language learning features and employing gamification as a motivator (Ngan et al., 2016).

16. The *user managed PLE* consists of a bare configuration of tools used to support learning in some way. No additional tool is used to scaffold this informal learning process in terms of reflection, persuasion or gamification. The user combines information from different resources to create knowledge independently (Attwell, 2007).

17. *Symbaloo Edu* provides methodological support to select and organize information sources, and its use favours collaborative work while helping to develop digital competencies, providing students with an environment that complements formal learning (Biel et al., 2016).

18. *Chick Clique* is a mobile phone application designed to motivate teenage girls to exercise (Toscos et al., 2006).

19. *MemReflex* is using flashcards in a mobile environment. It uses the principle of micro learning and the content delivery is adapted by the user's performance (Edge et al., 2012).

20. (Kolas & Staupe, 2007) presents the *PLExus* prototype, a PLE based on the Semantic technology of topic maps. Semantic-based navigation in e-learning will enable vari-

ation, differentiation and individualization, which are important pedagogical factors in the development of a personal learning environment.

In the next sections, these works and systems are discussed from the three perspectives mentioned. The approach used for studying the systems, as well as the results, are given for each perspective.

4.1.1 Perspective 1: Support for Formal and Informal Learning

As already described before, formal learning is marked by a behaviorist approach of strengthening the association of learning content and behavioral responses to form knowledge. Therefore, the provision of learning material and the control of the learner in terms of how they access information and the observation of learning activity are essential for a formal learning system. In particular such a system needs to support the following features:

- Content Management: store, manage, and author assets such as text, video or learning objects;
- Reporting Analytics to track the user's learning behavior and performance;
- User Management to organize users into course units and assign learning objects.

These three features will be used to compare the systems identified for their capabilities for supporting formal learning.

From the theory of informal learning (Marsick & Watkins, 2001; Callanan et al., 2011) and work on technology usage of learners (Dabbagh & Kitsantas, 2012) has resulted into the following features for our comparison of the systems identified for their capabilities for supporting informal learning:

- Self-Monitoring;
- Self-Regulation;

- Personalization;
- Exploration.

Self-Monitoring refers to the capability to inspect on past activities and to trigger a reflective process. Self-regulation links to the incidental quality of informal learning which can happen as a byproduct of some other activity and is not instructed by a learning authority such as a teacher (Pintrich, 1995). In informal learning, personalization refers to the freedom to choose the tools for learning which are deemed appropriate; no LMS or other tools are prescribed. The learners are free to configure their environment for learning and use it how they like. Exploration refers to the open ended aspect of informal learning. The lack of clear defined aims results in learning paths which are much more open ended and guided by curiosity instead of tangible learning outcomes (Meyers et al., 2013).

Table 4.1 and Table 4.2 compare the systems identified based on the core functionalities (i.e. features) identified above. For the informal learning features, it is obvious that most PLEs score well on self-regulation, personalization, and exploration. Unfortunately, most PLE frameworks neglected self-monitoring as a motor for informal learning. Exceptions are Elgg and ROLE. Elgg supports rudimentary self-monitoring whereas ROLE integrates a complete learning model based on self-reflection. On the application front, several applications focus on self-monitoring, notably Mahara which is an e-portfolio application that makes learning achievements visible to peers and employers. Mindless Change, Plotmaker and RightOnTime have also a strong focus on self-monitoring to establish new healthier habits.

As ~~to be~~ expected, most ~~of~~ the PLE systems reviewed do not score well on formal learning functionalities because they were not created for that purpose. One notable Exception is iPLE which offers an architecture that integrates well with widgets from an institutional context. On the other hand, Canvas or Moodle, which are LMSs in their own right support sophisticated content and user management. But also TalentCards, which is a flashcard based learning environment, offers user and content management. Last but not least,

System	Self-Monitoring	Self-Regulation	Personalization	Exploration
Elgg	x	x	x	x
Moodle mEducator		x	x	
Netvibes	x	x	x	x
Canvas				
Moodle				
Mahara	x	x	x	
Mindless Change	x			
PlotMaker	x	x	x	
KSMS Project				
RightOnTime	x			
iDetective		x		
PACARD		x		
TalentCards		x	x	
MGLS	x	x		x
Moin	x	x	x	x
Chick Clique	x	x		
MemReflex		x	x	
Symbaloo Edu		x	x	x
Evernote	x	x		
Plexus		x		x
Open PLE (user managed)		x	x	x

Table 4.1: Comparison of learning applications for their informal learning capabilities.

MGLS is a modern location based learning environment that offers learning challenges on real physical locations that combine informal learning practices, i.e self-monitoring, self-regulation and exploration as well as basic formal learning practices such as user and content management.

4.1.2 Perspective 2: Support for Self-Reflection

For this perspective, we utilize the categorization model of (Rowanne Fleck, 2010) which has been described before subsection 3.2.2. The comparison is provide in Table 4.3. Most systems score on 'Reflective Description' , i.e. they offer ways to inspect past activity for instance with a data log. Three exceptions are the Moodle mEducator, PlotMaker, and the user managed PLE. In the first, Moodle mEducator, the focus is on semantify course

System	Content Management	Reports and Analytics (grading, performance)	User Management
Elgg	x		
Moodle mEducator			
Netvibes	x		
Canvas	x	x	x
Moodle	x	x	x
Mahara			
Mindless Change			
PlotMaker			
KSMS Project			
RightOnTime			
iDetective			
PACARD			
TalentCards	x		x
MGLS	x		x
Moin			
Chick Clique			
MemReflex	x	x	
Symbaloo Edu	x		
Evernote	x		
Plexus	x		
Open PLE (user managed)			

Table 4.2: Comparison of learning applications for their formal learning capabilities.

documents and make them searchable and explorable instead of tracking user activity. Plotmaker is focused on the creation of learning objects that implement persuasive principles and not on ways to reflect upon these activities. The user managed PLE consists of a manual configuration of tools that are used to support learning activities. For instance, Twitter is used to acquire some opinions on a certain topic. Wikipedia is then consulted to understand some key terms better. The reflective practice can only happen in the user's minds because there is no interface available to show the user's activity among different tools. On the other hand, mEducator offers 'Dialogic Reflection' by the possibility to explore the document corpus with a search facility. Other systems that perform well in 'Dialogic Reflection' are iDetective, Pacard, and Netvibes. iDetective is a location-based game to persuade users unconsciously to have a healthier lifestyle. The user can explore freely a map and discover photo-taking missions. PACARD is a card-based interface that simulates physical flashcards and prompts the user with notification to reflect on past events and future learning opportunities in the tradition of Reflection-On-Action and Reflection-In-Action by Schoen (Moon, 2013). PACARD utilizes badges and push-notifications to trigger these reflective practices. On the other hand, Netvibes is a dashboard that allows the user to combine information from different sources such as social media, favourite websites or apps and monitor them to follow up on interesting topics and trends. Mahara is similar to Netvibes in the sense that one can track different activities from different sources but it is built with the purpose to share one's activities with others as a portfolio. Thereby, one can reach deeper levels of reflection such as to support a change of behavior (Transformative Reflection - level 3). Last but not least, Mindless Change is the only one who scores on all reflective practices. It is a tool that utilizes the learning theory of Kolb (Moon, 2013) as backbone to change habits for a healthier lifestyle. Mindless change can make the user aware about the consequences of an unhealthy lifestyle not only for the individual but also for society as a whole.

System	Reflective Description: Revisiting with Explanation	Dialogic Reflection: Exploring Relationships	Transformative Reflection: Fundamental Change	Critical Reflection: Wider Implications
Elgg	x	x		
Moodle mEducator				
Netvibes	x	x		
Canvas	x			
Moodle	x			
Mahara	x	x	x	
Mindless Change	x	x	x	x
PlotMaker				
KSMS Project	x			
RightOnTime	x			
iDetective	x	x	x	
PACARD	x	x		
TalentCards			x	
MGLS	x		x	
Moin	x			
Chick Clique				
MemReflex	x	x		
Symbaloo Edu				
Evernote				
Plexus	x	x		
Open PLE (user managed)				

Table 4.3: Comparison of learning applications for their reflection capabilities.

4.1.3 Perspective 3: Support for Persuasive Strategies and Playfulness including Gamification

(Nicholson, 2015) described playfulness as a framework consisting of play, exposition, choice, information, engagement and reflection to create a space where the learner is free to explore and fail within boundaries. Elements of Play can be mapped to gamification techniques to operationalize these elements and make them easier to apply in real-world context. For instance, gamification elements such as avatars and story elements can be related to the playful element of exposition which create stories for learners that are integrated with the real world setting. For a more detailed analysis of gamification and playfulness see (Nicholson 2015). Recently, many LMSs integrated gamification elements e.g. (Su and Cheng 2015) or persuasive techniques (Devincenzi et al., 2017). Table 4.5 and Table 4.4 show which systems deal with these strategies. The following, typical gamification elements are selected for the comparison based on their visibility to the user as proposed in (Sailor et al., 2017) and the impact they have on motivation:

- Points
- Challenges
- Cooperation
- Badges
- Leaderboards / Performance Graphs
- Avatars
- Story elements

Most systems we reviewed implement at least one gamification element, most often the triad of Points, Badges, and Leaderboards, but PLEs rarely implement gamification elements to guide the informal learning. These systems guarantee users a maximum of independence to organize their environment, which comes with some disadvantages with respect to user control and management. Other playful elements such as Story elements are rarely realized, probably because of the effort it takes to implement it in a generic way.

For comparing the systems for the persuasive capabilities (see Table 4.4), relevant persuasive techniques were selected based on our review of Fogg's design principles (Fogg, 2002) and the Hooked Model by Nir Eyal (Eyal, 2014). From the work of Fogg and Eyal, we selected five major techniques for our comparison of the systems:

- Tailoring (Reduction)
- Commitment (Tunneling)
- Surveillance (Social Comparison)
- Suggestion (Trigger)
- Reward (Conditioning)

Each state in the Hooked Model is represented in our list of techniques albeit slightly renamed to match the vocabulary by Fogg. Some attributes of the seven design principles given by Fogg were combined to minimize a conceptual overlap. Fogg's tailoring and reduction are put together because they both refer to a design strategy that simplifies functionality based on users characteristics. Tailoring is the degree of how much relevant content to individual users or user groups is shown, whereas reduction refers to the design strategy of simplifying what would otherwise be a complex process. Moreover, Commitment and Fogg's Tunneling are joined because tunneling is a technique to simplify the phase of commitment by reducing the options the user can choose from to perform an action. Commitment (Tunneling) places the user in a clear defined sequence of steps they have to perform within the system based on the principle that the commitment to the first (simple step) will persuade the user to also perform the following steps; the more the user progresses in the sequence the less likely are they to abort the effort. Social Comparison (Surveillance) can be used when the user uses the system in relation to others which can have a motivating effect since users might want to catch up on higher-performing users. Suggestion (Trigger) refers to the opportune moment to send a message to the user to suggest to perform an action. For instance, push notifications can be used to remind a user about a product they have accessed some time ago and spark an acquisition. Self-Monitoring is the cognitive task of analyzing one's behavioral traces and generating insight from it to change to trigger a behavior change. Last but not least, Rewards are issued based on some action the user did. They can be external such as real money or based on some virtual currency. The goal of rewards is to stimulate continued usage of the system. Note that rewards are also used in gamification. Because it serves the same principle and is the same technique, we only mentioned it under persuasive techniques.

On the application front, the picture is two-faced. On the one hand, the portfolio applications (Mahara, Netvibes) and the LMSs (Moodle and Canvas) do not target specifically persuasive strategies. However, with the latest updates Moodle and Canvas integrated gamification strategies such as Leaderboards, Badges and Avatars. On the other hand, Mindless Change, PlotMaker, KSMS Project, RightOnTime, Moin and iDetective are dedicated persuasive applications. They integrate a wide range of persuasive design principles such as Trigger, Commitment, Tailoring, and Social comparison. Besides those dedicated persuasive applications, PACARD and TalentCards are digital flashcard based systems for learning that also score well on gamification . MGLS, a location-based LMS that allows the creation of missions on geo-locations, has also good gamification support but lacks integration of persuasive techniques.

4.1.4 Conclusions

4.2 Comparison of Related Models/Frameworks

In this section, we review existing models and frameworks in the domain of TELE. The selection of resources is limited to articles which contain conceptual and architectural frame-

System	Tailoring, Reduction	Commitment (Tunneling)	Social Comparison (Surveillance)	Suggestion (Trigger)
Elgg		x	x	x
Moodle mEducator				
Netvibes				
Canvas				
Moodle			x	x
Mahara				
Mindless Change	x	x	x	x
PlotMaker	x	x	x	x
KSMS Project	x	x	x	x
RightOnTime		x	x	x
iDetective	x	x	x	x
PACARD	x	x	x	x
TalentCards			x	x
MGLS				
Moin				
Chick Clique	x		x	
MemReflex	x	x	x	x
Symbaloo Edu				
Evernote				
Plexus	x	x		
Open PLE (user managed)				

move to earlier

Table 4.4: Comparison of learning applications for their persuasive capabilities.

System	Points	Chall.	Coop.	Badges	Leaderb. Perf. Graph	Avatars	Story Elem.
Elgg							
Moodle mEducator							
Netvibes							
Canvas							
Moodle	x	x		x	x	x	
Mahara	x			x	x	x	
Mindless Change							
PlotMaker				x			
KSMS Project							
RightOnTime				x			
iDetective		x					
PACARD	x	x	x	x	x	x	x
TalentCards	x	x		x	x		
MGLS	x	x		x	x		
Moin	x	x	x	x	x		
Chick Clique	x						
MemReflex	x	x	x	x	x		
Symbaloo Edu							
Evernote							
Plexus	x	x					
Open PLE (user managed)							

Table 4.5: Comparison of learning applications for playful capabilities.

works, meta-models, or design guidelines. At the highest level of granularity, meta-models describe organizational structures that encompass multiple levels of influence on individual behavior. For practitioners, they offer multiple perspectives on how a system can be evaluated. In this way, novel approaches can be unearthed to highlight gaps in existing research without destroying the established world view of the meta-model. On the other hand, conceptual and architectural frameworks provide one perspective on how a system can be constructed and decomposed. They describe fundamental building blocks and their relationships to provide more specific guidance for the analysis of technologies (Hekler et al., 2013). On the lowest level of granularity, there are design guidelines which make theoretical or practical findings applicable in a clear defined context but cannot be easily generalized to other contexts of use. To deal with the fact that selected resources do not use the same terminology we will resort to three broad categories (Dialogue support, Context of use and Support of learning activities) to make a comparison between related but distinct systems possible. The selection of these categories is inspired by the design elements of behavior change systems formulated by (Oinas-Kukkonen & Harjumaa, 2009) and they are defined as follow:

- **Dialogue Support** are the techniques which the system uses to interface with the user. This does not only include the graphical depiction of the user interface but also ways to tailor, personalize, simplify, and gamify information to persuade the user and spark a learning action. Moreover, it also covers different ways to access information (push or pull) and to present learning traces (visualization). We use two sub-categories to compare dialogue support: **User interaction Scaffolding** and **Engagement techniques**.
  - **User Interaction Scaffolding** includes all techniques to simplify the interaction with resources provided by the system for the purpose of learning. These are:
    - **Reduction and Tunneling** can be used to guide the user through a complex set of tasks. People can interact with information better and more effectively when the content is broken down into digestible parts; learning thus takes the form of small steps.
    - **Tailoring and Personalization** of information can be used to meet the information needs of the learner.
    - **Structure, share and annotate resources** can be used to provide more structure to the learner and allow to to build a mental model of the resources.
    - **Information tracking** can be used to observe and record learning behavior (i.e., actions, thoughts and emotions).

      * **Visualization support** can be used to scaffold the presentation of learning behavior.
      * **Information access**. The user can decide about the opportune moment to access information (pull of information) or it can be the responsibility of the system (push of information).
  - **Engagement techniques** are used to increase the motivation for using the system.**Recommendation**, **Feedback**, **Cooperation**, **Competition**, **Rewarding**, and **Story elements** can be used as engagement techniques.

- **Context of Use** is the set of different data dimensions the system collects from its user and environment. Typical examples are location, learning styles and technology used, such as desktop computers, mobile devices, or ubiquitous technology. We distinguish the following dimensions:

  - The **personal context** contains information about past learning behavior, current progress in learning activities, learning styles, cognitive abilities, and learning goals.
  - The **location context** includes learner's current location and previous location history. This includes formal learning spaces such as the traditional classroom, informal learning spaces such as home, public transport and other mobile contexts, and blended learning spaces where informal and formal learning spaces are combined.
  - The **social context** includes information about peers in learning communities.
  - The **technology context** obtains information about type of technologies (mobile, desktop or wearables) and their capabilities (sensor range, GPS precision, touch input, screen size).

- **Support of Learning Activities** are the range of cognitive tasks promoted by the system to achieve learning goals. We distinguish between cognitive tasks and meta-cognitive tasks:

– **Cognitive tasks** require a person to mentally process new information and allow them to recall, retrieve it from memory and to use it at a later time in similar but different situations (Kester & Kirschner, 2012). Typical examples are critical thinking, content production, and (collaborative) problem solving.

– **Meta-cognitive tasks** refer to ways of framing, re-contextualizing and comparing cognitive processes for the purpose of gaining new knowledge and self-regulating future actions. Typical examples are awareness, self-monitoring, goal-setting, reframing, and self-reflection.

In order to find related work on models and frameworks in the domain of TELE we constructed our literature search as follows. We started with the general term of Technology Enhanced Learning Environment (TELE) and extended it with keywords along three dimensions to retrieve more specific work:

- Components of the MPLE namely Persuasion, Playfulness, Micro-Learning, Self-Monitoring, and Visualization

- Related learning environments which are more specific, namely LMS, PLE, SLE, and OLN, and Mobile Learning Environment

- Type of system including meta-model, architectural and conceptual framework and design guidelines

In this way we obtained 20 resources containing 20 works. Among these systems, there are 8 frameworks (mostly conceptual frameworks and one architectural framework) and 12 models including 3 meta-models. After a more thorough scan we removed 5 works because they were more concerned about the technical integration of PLEs into LMS than conceptually guiding the design and development. The following works were considered for the comparison:

1. (Nordin et al., 2010) propose a **conceptual framework for mobile learning applications** that provides systematic support for mobile lifelong learning experience design. It considers four perspectives: generic mobile environment issues, learning contexts, learning experiences, and learning objectives.

2. (Motiwalla, 2007) explored the extension of e-learning into wireless/ handheld (W/H) computing devices with the help of a **m-learning framework**. This framework provides the requirements to develop m-learning applications that can be used to complement classroom or distance learning.

3. (Bruck et al., 2012) presents the micro-learning approach, **Micro-Mobile Learning Framework**, and the KnowledgePulse system that delivers micro-content on mobile devices and allows learning anytime, anyplace and any pace.

4. (Churchill et al., 2016) propose the **RASE learning design framework** as a key strategy for utilizing multiple affordances of mobile learning technology. This learning design framework includes and integrate at least four core components, namely: Resources, Activity, Support, and Evaluation

5. (Alharbi et al., 2012) present a proactive context-aware architecture for PLE, i.e. the **Context-aware PLE architecture**, supporting two major objectives: lifelong access and learner-centric study.

6. (Sumadyo et al., 2018) propose a component model that focuses on adaptive services on improving students' meta-cognitive abilities. Components in **SLE-metacognitive** are arranged in the form of modules connecting students with awareness activities of self-knowledge and ability for self-learning.

7. (Freigang et al., 2018) deal with the design of Smart Learning Environments (SLEs). Over and above that, it is about the interconnection between SLEs and the Internet of things, i.e. **Conceptual SLE Framework**.

8. (Spector, 2014) combined philosophical, psychological and technological approaches to develop a platform for planning and implementing SLEs. In the author's view, smart learning environments have to achieve sustainable educational work at the levels Engagement, Effectiveness and Efficiency, hence the name **3Es model**.

9. (Hwang, 2014) transparently deconstructs and compares the terms "smart learning", "ubiquitous learning", and "adaptive learning" to define characteristics of a dynamic SLE system in the **SLE u-learning framework**.

10. (Koper, 2014) has developed the **Human Learning Interface Model** that shapes the design of a SLE by defining in and outputs to define the learning process. Three core interfaces must be supported to initiate a learning activity: identification, socialization, and creation. For better and faster learning to happen, two meta interfaces must be supported: practice and reflection (Kop & Fournier, 2014; Hoel & Mason, 2018).

11. (R. Huang et al., 2013) propose the **TRACE3 Functional Model** for SLEs as the learning place or an activity space that can sense learning scenarios, identify the characteristics of learners, provide appropriate learning resources and convenient interactive tools, automatically record the learning process and evaluate learning outcomes in order to promote the effective learning.

12. **PLEF** is a framework for mashing up personal learning environments. The primary aim of PLEF is to help learners create custom learning mashups using a wide variety of digital media and data (Chatti et al., 2010).

13. **Customized xLearning Environment** is a theoretical model where all the learning and e-learning elements are present and where the student is the focus and the one

who decides what should be included in this learning environment (Mesquita et al., 2017).

14. (Conde et al., 2014) have defined a service-based framework, **PLE-LMS Framework**, which facilitates the definition of a PLE with activities that returns information to the LMS. Such a framework includes a mobile device that by using Web services would include into it an institutional activity.

15. (Milligan et al., 2006) report on initial work to create a Reference Model for a Personal Learning Environment, the **Personal Information Toolkit**, where the emphasis is on facilitating learning in contrast to traditional Virtual Learning Environments which exist primarily to manage the learning process.

Table 4.6 shows a high level comparison of the selected works. Colors are used to indicate the main domain of the work: yellow = PLE, green = mobile learning, blue = SLE. The following scale is used to rate how a system meets the features mentioned earlier for a category:

- **low**, at most one feature of a category is used/supported. For instance, a system that only supports personalization, scores low on User Interaction Scaffolding (Dialogue Support)

- **partial**, at most half of the features of one category are used/supported. For instance, a system that considers the location of the learner and personal context scores partially on Context of Use.

- **high**, more than half of the features of one category are used/supported. For instance, a system that supports both cognitive and meta-cognitive tasks scores high on Cognitive tasks.

In the following sub-sections, we will describe each work further and explain which characteristics led to the final rating for the different categories.

Work	**User Interaction**	**Engagement Techniques**	**Context (learner, location, social)**	**Cognitive Tasks**
TRACE3 Functional Model	low	low	partial	partial
PLE-LMS Framework	low	-	partial	-
PLEF	high	-	partial	-
Customized xLearning Environment	-	-	partial	partial
Personal Information Toolkit	partial	-	low	partial
Context-aware PLE architecture	low	-	partial	partial
Informal Learning Portfolio	high	-	partial	-
m-learning Framework	high	low	low	low
RASE Learning Design Framework	partial	high	low	low
Conceptual Framework for Mobile Learning Apps	high	high	partial	high
Micro-Mobile-Framework	partial	partial	partial	partial
SLE-Metacognitive	partial	-	partial	high
Conceptual SLE Framework	low	low	high	low
3Es Model	high	high	partial	high
SLE u-learning Framework	partial	-	high	-
Human Learning Interface Model	low	high	high	high

Table 4.6: High-level comparison of the selected works.

4.2.1 Dialogue Support (User Interaction and Engagement Techniques)

As already explained before, our category Dialogue Support covers techniques from User Interaction Scaffolding as well as Engagement Techniques. It is quite remarkable that the works in the context of PLE (i.e. TRACE3 Functional Framework, PLE-LMS Framework, PLEF, Customised xLearning Environment, Personal Information Toolkit, Context Aware PLE Architecture, and Informal Learning Portfolio) score rather low on techniques to simplify interaction with the user interface and resources. With one exception, PLEF, these works highlight interoperability issues between LMS and PLE and how the communication can be done smoothly but they often neglect issues of the application layer, namely how to meaningfully present information that learning can aid (Visualization). The PLEF Framework does not only highlight the utility of content personalization based on the user's needs and problems but also ways to personalize and unite the set of tools the user uses for learning. Persuasive Techniques such as Tunneling or Reduction and visualization techniques are rarely present in these works which is strange because most of the PLE systems track learning traces of the user, and tracking data allows for visualization and persuasion techniques.

The second batch of systems consists of Mobile learning models and frameworks (i.e. Micro-Mobile Framework, m-learning Framework, Conceptual Framework for Mobile learning apps, RASE Learning Design Framework). They do not only support mobile devices, they also integrate micro-learning elements that permit to decompose large learning resources into small digestible chunks which do not require a high attention span. Furthermore, they offer personalizing learning algorithms that track learner responses and update the learner profile dynamically. Unlike PLE systems, mobile learning systems often rely on the push mechanism to transmit information to the user. They do not wait for the user to initiate the access of information. Instead, Mobile Learning systems push information via notifications or SMS to the user. The Conceptual Framework for Learning Apps does also support engagement elements such as enjoyment, user satisfaction, and motivation. Activities that draw on conflict and possess competitive elements might be more interesting to the learners. Indirectly, this inserts a playful element into the user interaction cycle (Nordin et al., 2010). On the other hand, SLE systems (i.e. SLE metacognitive, SLE u-learning Framework, Human Learning Interface Model, 3Es Model, Conceptual SLE Framework) also stress the importance of personalization from a more dynamic perspective. In this view, the system makes automatic adjustments when the user is facing problems and updates the user profile accordingly. The Human Learning Interface Model and the 3Es Model go one step further and offer "Conditioning" of the environment of the learner, i.e.

they provide positive and negative feedback by applying gamification techniques through points and batches thereby hoping to build associative stimuli with learning.

4.2.2 Context of Use

As one might expect, good coverage of context of Use (learner, location, social, and technology context) is often yielded by SLE models and frameworks. A smart learning environment is context-aware in the sense that the learner's situation of the real-world environment in which the learner is located are sensed, implying that the system is able to provide learning support based on the learner's online and real-world status. This does not only include learning styles, preferences, and learning performance but also social relationships to peers and learning supervisors. The most complete models are the Human Learning Interface Model, Conceptual SLE Framework, and the SLE u-learning framework, which take into account the learner, location, social and technology context of the learner. The Human Learning Interface Model sheds a special emphasis on the context of use. It defines a series of systems including Identification and Socialization interface that observe learning behavior and intervene learning by providing tasks, giving feedback and conditioning the user. In the Socialization Interface, learning is seen as a way to represent the social norms, values, customs and ideologies of social institutions and learning the skills and habits. This enables the learner to behave within the social institutions, including the dissemination of norms and values to others including family, peer groups, religion, economic system, language, and legal system (Koper, 2014). In the Identification Interface the real-world status of the learner is represented by situations, events, and learning activities how to react upon it. On the other hand, the SLE u-learning Framework is defined to be minimally context-aware, adaptive and personalized. Only the online and real-world states of learners are considered as the context of learning. The adaptivity with respect to emotional states, cognitive capacity, motivation, and socio-economic factors are not considered. Personalization is limited to content selection; pedagogy-oriented guidance to shape the way how information is accessed is not supported.

On the PLE side, with the exception of Context Aware PLE Architecture, most work focus on the learner and social context by collecting learning traces from applications that deal with informal learning, i.e. social networks, note-taking apps, word-processors. The Context Aware PLE architecture integrates a provider layer of various tools and independent service providers including physical sensors, such as a camera or thermometer, to capture information about its local environment. Unfortunately, it is not described how physical sensors contribute to improving formal/informal learning in (Alharbi et al., 2012). The green batch of the works (m-learning framework, RASE learning Design Framework, Conceptual Framework for Mobile Learning Apps, Micro-Mobile Framework) which combines mobile technology with micro-learning approaches generally integrates rather conservatively the users context with learning activities. In all works, there is some sort of personalization based on user profiles and past behavior, but the location and social context are handled only rudimentary meaning that they have a rather limited support of location awareness or social relationships in the learning process. The Micro-Mobile-Framework mentions the location context and deeper integration of collaboration as an important aspect for future work. The RASE Learning Design Framework highlights connectivity, social interactivity and context sensitivity as important aspects of mobile devices but does not provide detailed instructions how to integrate these affordances into mobile applications.

4.2.3 Support of Learning activities

Whereas models and frameworks of PLE systems often focus on informal and blended learning types (including formal learning), they rarely specify what kind of cognitive processes they actually target. This is not the case for Micro-Learning works (m-learning framework, RASE learning Design Framework, Conceptual Framework for Mobile Learning Apps, Micro-Mobile Framework). Their inherent focus on small digestible chunks of information leads to the support of the repetition of learning content and frequent feedback in form of assessment before the user can progress to the next unit. Also, the content is organized in a manner such that the systematic seeking of information is permitted to provide as few barriers to instant learning as possible. Regarding meta-cognitive tasks (i.e. self-monitoring, reflection, reframing), Micro-Learning works are less specific. (Churchill et al., 2016) often write about gaining awareness through self-monitoring but which results in terms of learning outcomes are produced through this process is often vague. In general, SLE systems are more specific about the cognitive and meta-cognitive tasks. For instance, (Sumadyo et al., 2018) provides an architectural expansion that specifies components to infer information that can be used as feedback or recommendation to foster meta-cognitive skills which solve problems of self-awareness including planning and scheduling task solving processes. (Koper, 2014) gives a detailed overview of SLE functionality in terms of interfaces, i.e. a set of learning related interaction mechanisms that humans exposed to the outside world to control, stimulate and facilitate their learning processes. These interfaces include support for the following learning activities: exploration, recognition, differentiation and generalization of stimuli labeling groups of stimuli building knowledge about the behaviors of the unknown stimuli creating mental maps of the environment. Furthermore, the Human Interface Model also includes features to create representations of knowledge and change future behaviors in form of meta-cognitive tasks, i.e. reflection, reframing of the problem and solution, evaluation of results, decision making, strategy development, and self-regulation.

4.2.4 Conclusion

Overall, one can say that the reviewed works can be divided by time and technological advances. In the early 2010, with the emergence of the Web 2.0 researchers looked frequently into ways to exploit the manifold ways users interact with information on the Internet for informal learning. As a reaction, the concept of PLE was born whose focus was solely on the learner and the services they use from a static perspective, i.e. desktop computers were the starting point to analyze and improve digital learning. Only with the shift to mobile devices and applications the peculiarities of this platform were integrated into learning tools, exemplified by micro-learning models and frameworks. They took into account the changed habits of Digital Natives to access information spontaneously and impulsively from changing locations. This resulted in learning activities that are sliced in small digestible chunks which are pushed to the user at opportune moments and do not overburden the attention span of the digital learner. Around 2012, the concept of SLE was developed which introduces a holistic, big-picture view of education as a whole to reveal the opportunities and possibilities inherent in digital technologies, particularly as personalized learning processes emerge (Freigang et al., 2018). In this view the learner's situation or the contexts of the real-world environment in which the learner is located are sensed, implying that the system is able to provide learning support based on the learner's online and real-world status.

As one of the most complete models the Human Interface model scored high on most categories (Engagement Techniques, Context, Cognitive Tasks) except on User Interaction Scaffolding. It provides theoretical foundations for different incarnations of SLE systems. It subdivides the design space into five idealtypical applications each targeting a different learning goal (identification HLI, socialization HLI, creation HLI, practice HLI, and reflection HLI) thereby providing sound conceptual guidelines for the development of SLE systems. Due to the general purpose of this model, only general help is provided for Dialogue Support including User Interaction Scaffolding and Engagement Techniques. To simplify the interaction with information provided by the system, the Human Learning Interface Model argues that a SLE has to represent knowledge faster and better by including representations of performance targets and future incentives. To achieve this, (Koper, 2014)) mentions techniques to condition and engage the user, such as the use of batches and rankings, but it neglects techniques to streamline the 'first contact' with information namely perception of information through data filtering/visualization and persuasive techniques (tunneling, reduction, tailoring). Our MPLE model tries to fill exactly this gap by providing a set of micro interaction techniques with information important for learning which includes visualization, playful and persuasive techniques alike.

CHAPTER 5

PROOF OF CONCEPT APPLICATION: THE TICKLE CASE

The objective of this chapter is provide a proof of concept for our MPLE model. We will describe the design, development and evalaluation of a MPLE solution, i.e. a persuasive system that empowers learners to perform and reflect on informal/formal learning activities. The original context of the application was the need to tackle school burnout in the Brussels region. School burnout refers to exhaustion at school, a cynical and detached attitude, and feelings of inadequacy as a student. School burnout often precedes school dropout, also named Early School Leave (ESL), which results in young people leaving education with only lower secondary education or less. Early school leavers have lower job opportunities and only qualify for jobs with lower earnings, which has a great impact on their further life. Therefore, the issue is high on the political agenda. Europe 2020 aims for a reduction of ESL to less than 10%. Although different programs exist to prevent school burnout and ESL, ranging from offering customized training projects and individual coaching time-out trajectories aiming to bring the student back into the classroom, these projects and programs have in common that they are very labor-intensive. To come to a less labor-intensive solution, in particular to deal with school burnout, our objective was to complement the existing programs with an ICT solution. The goal was to re-activate and re-motivate youngsters for learning through the recognition of non-formal learning opportunities.

The solution developed, called TICKLE, is based on the MPLE model as we believe that the features of MPLE will allow us to reach the objectives off the ICT solution. Playfulness and persuasiveness can improve engagement in learning within a non-game context. In particular, we will adopt the design values for playfulness given by (Bekker et al., 2010) (including motivating feedback, supporting spontaneous goal formation, and creating competitive or collaborative relationships) as well as the design values for persuasiveness given by (Oinas-Kukkonen, 2010) (including tailoring, personalization, reduction, and tunneling from the PSD model). Narrative techniques are used to provide guidance in the reflective process. Data traces will be interwoven with a personal profile of the learner to produce a compelling story that allows learners to look back on their activities and learn more about themselves, their interests, behavior and shortcomings, but also provide access to cultures, norms, communities and academic opportunities which are outside their own (Figueiras, 2014). Examples of learning opportunities that can be provided to the learner are:

- Civics. For instance, where is the town hall and what can I do there? Where can I find information about finding a job?
- History. For instance, what does the statue of the soldier next to my house tell me about war?
- Social engagement. How can I help my neighbours?

(consistent use of American English) → maybe check with spell checker

- Career. What kinds of training are offered in my neighbourhood and how can they improve my career?

For the design and development, we applied cycles of prototyping, testing and analyzing the results to refine the functionality and quality gradually.

The remainder of the chapter is structured as follows. We first explore why and how the Fogg model, the Hook model, and a personalized approach can be applied in the solution (respectively in section 5.1, section 5.2, section 5.3) before we specify the requirements in section 5.4. Thereafter, we present the main modules of our design in terms of a Frontend and Backend architecture (section 5.5). This section is followed by details on the implementation (section 5.6). Next the different evaluations and demonstrations are discussed (section 5.7). The chapter is ended with a summary (section 5.8).

5.1 Applying the Fogg Model

Re-activating youngsters with school burnout implies a behavior change. Therefore, we applied the principles of the Behavioral Model of Fogg (Fogg, 2002), which offers factors to determine whether a person will perform a certain behavior or not. For a detailed explanation of this model see ~~subsection~~ section 3.4.2. Studies have shown that motivation and ability are crucial requirements for behavioral change (e.g., (Lo et al., 2007)). According to Fogg, motivation can be distilled to three pairs of core motivators: pleasure and pain; hope and fear; as well as social acceptance and social rejection. These are aspects that could be taken into consideration in the development of the environment. For instance, our objective to make learning a pleasant activity is implemented by applying playful techniques such as avatars, mini games and rewards in the form of badges. However, social acceptance and social rejection are also usable in our solution in the form of ~~e.g.~~ a leaderboard. The ability in Fogg's model relates to available resources. (Fogg, 2002) uses the term ability in a broad sense, i.e., available time and/or money; required physical effort and/or cognitive effort; social deviance caused by the behavior; and the familiarity with the behavior. For a behavior to happen, the ability should be high enough. To take this into account, we should carefully adapt the activities to the abilities of a youngster. The trigger in Fogg's model is the element that sparks, facilitates, or signals the target behavior. Triggers are most effective when they are provided at the right place and time (Fogg, 1998). This is an argument in favor of keeping track of the youngsters' performance and activities within the environment in order to be able to give the trigger at the right place and time. However, the type of trigger used, as well as the content of the trigger, also seems to be important. If an app keeps sending notifications that are not considered useful by the receiver, this might be annoying, and ~~(s)he~~ they will start to ignore them (Eyal, 2014). Furthermore, what will trigger one person to perform an action may not trigger another person. This is because different users have different preferences and characteristics (Smiderle et al., 2020). This is an argument for using an elaborated user profile in order to also personalize the triggers (see also section 5.3).

5.2 Applying the Hook Model

Re-activating youngsters with school burnout implies a behavior change. To achieve this, we followed the Hook Model. As described earlier (subsection 3.4.3), the Hook Model of Eyal (Eyal, 2014) is a practical approach to create new habits or behavior. According to Eyal, a new behavior becomes a habit when the behavior becomes an automatic response to a situational cue or trigger. Unfortunately, turning a new behavior into a habit is hard since, according to Eyal, old habits die hard, while new habits quickly dissipate. In accordance with Fogg, Eyal also argues that an action will only take place if the user possesses sufficient motivation and ability to perform the action. Therefore, Eyal suggests making the actions as easy as possible, e.g., clicking on a link. In this way, the behavior is more likely to be performed. Variable rewards are used to increase the likelihood of repeating an action in the model. An important phase of the cycle is the investment. The more a user invests in a system, the less likely it is that (s)he will stop using the system, as then the investment would ~~will~~ be lost. The triggers in both the Behavior Model of Fogg and the Hook Model of Eyal aim to persuade the user to perform a certain behavior (Fogg) or an action (Eyal).

5.3 Personalised ~~a~~A approach

Research has shown that the "one size-fits-all" approach is not working to persuade all users in an effective manner. This is because different users have different preferences and characteristics. According to (Berkovsky, Freyne, Oinas-Kukkonen, 2012), there are opportunities in using personalisation in persuasive systems by:

- Monitoring and presenting information about aspects of importance to the user.
- Tailoring the content and the look-and-feel of the information in order to meet the

user's communication preferences.

- Responding to a user's susceptibility to various persuasive techniques and methods.

references ?

Different taxonomies exist to categorise individuals based on personality traits such as the Big Five Factor Model, the Bartle Model, or HeXad. These ones are those most often used in technology for the purpose of personalization. Some of these personality trait models, e.g. Bartle and HeXad, have their source in a gaming context; nevertheless, they are also useful in a broader context like TICKLE and their relationship with persuasion is also studied nowadays. The HeXad model maps well to the domain of our MPLE. Especially, the focus on achieving and mastering challenges suits the learning activities promoted by TICKLE. The HeXad model describes six gamer types:

- **Philanthropists** are motivated by purpose. ~~This means~~ meaning that these people are motivated by putting effort in the system without expecting a reward for it.

- **Socialisers** are motivated by relatedness. This means that these people want to interact with other people within the system and create relationships.

- **Free Spirits** are motivated by autonomy. They want to have the freedom to express themselves within the system without external control.

- **Achievers** are motivated by mastery. They want to progress within the system by completing challenges, they also want to prove themselves by performing difficult challenges.

- **Players** are motivated by extrinsic rewards. They will do whatever they need to do to earn a reward within the system.

- **Disruptors** are motivated by the triggering of change. They like to disrupt the system and find the system's boundaries.

Another model for describing the personalities of humans is the Five-Factor Model (Digman, 1990). With this model it is possible to characterise humans giving five categories based on their personality traits. The Five-Factor Model uses the following categories:

- **Extraversion**: These people tend to be more communicative, easy making social contact with others, and being more assertive.
- **Neuroticism**: These people tend to be more anxious, more frustrated, and in a depressed mood. WW
- **Openness to experience**: These people tend to be more curious, insightful and they have a wide range of interests.
- **Conscientiousness**: ~~These people~~ tend to be more organised, efficient, hardworking, and more careful.
- **Agreeableness**: These people tend to be kind, sympathetic, and cooperative.

In terms of persuasion, research has shown that three of the five types in the Big Five are more vulnerable for source persuasiveness: Extraversion, Neuroticism, and Openness to Experience. Within the two remaining types, Conscientious and Agreeableness, there is no clear relation between personality and persuasiveness (Oreg Sverdlik, 2014).

Furthermore, as already mentioned, also what is offered (i.e. content), when (time-wise) and how (medium) should be personalised to make the solution as effective as possible. See also section 5.4 for a more detailed motivation.

5.4 Requirements Engineering

The first step in a software engineering process is requirements engineering. It is concerned with the goals, functionalities, and constraints of the software. Based on (Räisänen et al., 2010) we have performed the following core requirements engineering activities:

- Eliciting requirements;

- Modeling and analyzing requirements;

- Communicating requirements, agreeing requirements and evolving requirements.

consistency with earlier em-dashes

The first activity, the elicitation of requirements aims at identifying all the stakeholders –such as customers, developers and users – as well as the objectives and tasks of the users. Hassenzahl (Hassenzahl, 2013) proposes a simple User Experience (UX) method to understand the needs of all stakeholders involved by specifying so-called Be- and Do-Goals. Be-Goals capture a person's emotions and attitudes about using a particular software whereas Do-Goals refer to the pure functionality, i.e. what can the user achieve with a software. The starting point for the specification (i.e. modeling; the second phase) of requirements in terms of Be- and Do-Goals is always the motive, i.e. what does the user want to represent with using the software. The designer tries to comprehend these Be-Goals in order to be able to envision the overall experience and to foresee the functionality. Communicating and agreeing on requirements is more concerned with the collaboration between the designer and the stakeholders. Once the requirements are modeled, they need to be communicated and discussed to the stakeholders in order to evolve them when they do not completely meet the stakeholders' expectations.

mbox

The remainder of this section mostly deals with the first two steps, i.e. eliciting and modeling requirements but the specified requirements were also presented and discussed with all stakeholders. We mentioned this in ~~subsection~~ Section 5.4.2. The presented requirements are the final ones.

5.4.1 Eliciting the Requirements

To come to the requirements, we needed to have an in-depth understanding of the main users, namely youngsters. Therefore, we started with a number of literature studies. To be able to make a grounded decision for the requirements and the technology to be used, the results of the major studies on computer and media use among youngsters were analysed. The focus was on Flanders and Brussels, as youngsters in Brussels were initially the target users of TICKLE. We provide a summary of the findings that are relevant for the design of our solution. The complete report is available online (Vlieghe & De Troyer, 2016). Youngsters appear to have more experience in media usage than the average Belgian or Flemish citizen. They seem to have ample experience performing basic operations and handling office applications like a word processor. A similar trend is visible in relation to youngsters' experience with Internet-related activities. Youngsters have more experience than the average citizen with the various kinds of activities like creating a Web page or changing the safety settings on their browser. In terms of perceptions, the results indicate that youngsters recognize the importance of using computers and their potential to make learning at school more interesting. At the same time, youngsters also indicate that they are only moderately interested in using computers in their own learning endeavors. They are also in strong disagreement about the potential of computers to increase learning enjoyment. Even though youngsters recognize the importance of computers, they appear to remain sceptical about the advantages of using computers in their own learning practices.

With regard to the Web for gathering information, searching for information about goods and services is the most popular activity, followed by reading news messages. Searching for information about job and training offers, and consulting Wiki's and other Internet resources to learn new things are two activities which youngsters seem to perform more frequently than the average citizen. Many youngsters report about performing communication activities with the help of social media. The popularity of pass time activities is reflected in the list of most frequently used applications. Facebook and Instagram appear to be most successful in inducing heavy use (i.e. more than one hour per day). Other popular applications among youngsters are a wide variety of games. These also inspire heavy use, as one in four people play games daily and one in eight play games more than one hour a day.

The actual media usage clearly shows that information seeking and learning activities are equally as important as, if not more important than, pass time and communication activities. The latter two activity types do seem to invite more frequent or heavy use (i.e. daily or even multiple hours a day). This trend is present among youngsters, but also among the population as a whole. As a consequence, it is hard to attribute these results to theories that offer simplified and stereotyping explanations of the theory of Digital Natives.

always use a ',' after i.e., e.g. etc.

Youngsters appear to have good general computer skills and experience with the Web. They also regularly share their own material online. They have a preference for smartphones and are using them daily; tablets are used less. Smartphones seem to fit best with their lifestyle, i.e., they have often limited financial resources and spend a large part of their time outside. Therefore, **we decided to adopt smartphones for our solution**. The Internet is well spread and most youngsters do have access to the Internet. Moreover, the availability of the Internet is only increasing: free Wi-Fi becomes available in public spaces and a lot of youngsters have mobile broadband on their smartphone. Therefore, **we opted for an Internet-based application**. To keep all options open, we decided to go in the first place for a browser application rather than a native app. In addition, this allowed for having the application immediately available on different types of smartphones. Furthermore, the majority of mobile operating systems can provide a Web application as an "app" on the start screen. In a later stage, a limited version of the application was turned into a true (native) app.

The initial problem that we wanted to address was school burnout in order to avoid ESL, so studies related to these topics were investigated as well. The complete report is available online (Joachim Vlieghe, 2016). In summary, it was found that a large variety of factors can play a role: factors from the youngsters' environment, as well as individual characteristics, but none of these factors seems to be conclusive. Therefore, it is recommended in the literature that prevention programs should rely on a wide body of information related to multiple influencing factors, to provide a more complete picture of the youngster. For this

added
reason, **~~we decided for~~ the requirement of an elaborated user profile** that should be used to personalize the environment and the presented content towards the situation and characteristics of the youngsters.

5.4.2 Specification of the Requirements

In this section we present the requirements formulated for the TICKLE App based on the objectives and design decisions discussed in the previous section. The initial requirements were presented to relevant organizations in meetings and with an early working prototype at the *Vlaamse Dienst Speelpleinwerk* (VDS) (translated as the Flemish Service for Playground Work). VDS was looking for a game to improve the cooperation between the animators of the playgrounds and to stimulate their creativity. We found that this need was a good opportunity to evaluate the requirements for our TICKLE app with the help of domain experts who are used to work with youngsters in a non-formal context. The aim was to evaluate whether TICKLE would allow to spark engagement and ideation among playground animators. An early working prototype of the TICKLE environment was used for this. It offered a number of learning activities that could be collected by completing a task or challenge. Figure 5.1 shows a sample learning activity depicted in the form of a card that could be collected to prove that the learner was active. This evaluation took place in August 2018 at the playgrounds of Bornem and Puurs in (Belgium).

The final requirements were formulated based on informal conversations and questionnaires given to the participants at the end of the evaluation period. Then, the requirements were categorised into the functional and nonfunctional requirements representing Do- and Be-goals. The following terminology is used: *Youngsters* will use the TICKLE environment to detect and perform learning activities; *Supervisors* are the persons responsible for youngsters; they will use the system to follow the progress of their youngsters and manage their learning activities. **Content creators** are the persons that will create the learning activities.

why is that one in bold?

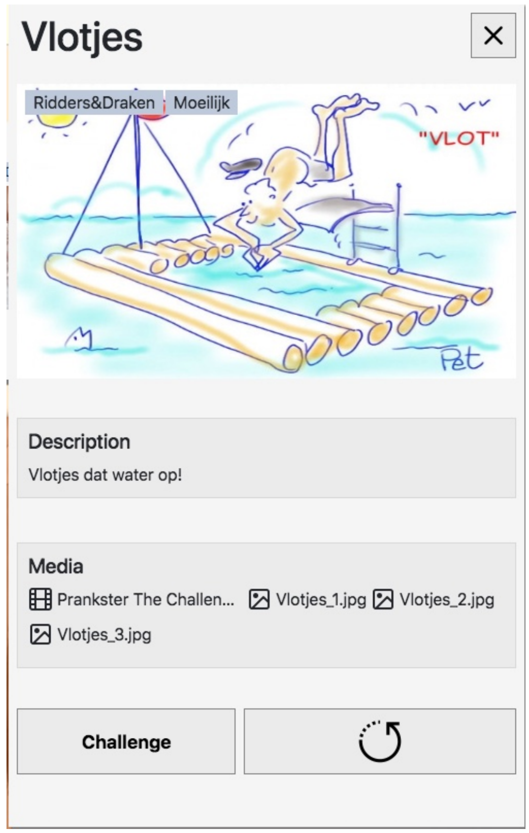


Figure 5.1: Sample card (cards are in Dutch)

Do-Goals

- The youngster is able to explore ~~his/her~~ their surrounding (neighborhood) and learn more about opportunities in terms of hobbies, career possibilities, history, social engagement, and civics:
  - The youngster is able to explore learning activities related to an environment.
  - The youngster can collect and gain points from learning activities to have sense progress in fields of interest.
  - The youngster can choose from a set of learning activities.
  - The youngster is able to inspect ~~his/her~~ their activity in terms of performed learning activities, discovered topics and own interests.
- The youngster is able to reflect on past learning activities with a digital diary:

- They can discover related learning activities based on interests or already performed activities.
- They should gain insight into their interests and deficits by a visual overview of all past learning activities.
- They should gain insight into location-based information, i.e. walked distance, discovered points of interests and neighborhoods.

- The content creator is able to create learning activities which includes choosing a mini-game, and providing background information and media (video, sound) about a learning activity.

- The supervisor can manage the youngster's profile:
  - The supervisor can consult the persuasion profile of a particular youngster.
  - The supervisor can consult the events log of a particular youngster.
  - The supervisor can enter the results of the personality questionnaires (i.e. Big-Five, HeXad) of a youngster in the youngster's profile. \mbox{}
  - The supervisor can define the block off time span for notifications for a youngster, meaning that in that time span no notifications should be send to the youngster.
  - The supervisor can define the preferred notification medium for a youngster (push or email); the preferred notification medium must be suitable for the device of the youngster (e.g. the device should allow push notifications).

- The youngster can manage ~~his/her~~ their notifications:
  - The youngster can view ~~his/her~~ their notifications.
  - The youngster can remove notifications.
  - The youngster can navigate from a notification to a related card.

- The system should be able to send notifications:
  - The system should be able to send emails to youngsters.
  - The system should be able to send push notifications to youngsters.
  - The system should be able to present the notifications as a popup and/or in the notifications panel to the youngster.
  - The system should not send notifications in the block off time of a youngster.
  - The system should be able to send personalised messages based on the persuasive profile of the youngster.
  - The system should be able to send non-personalised messages when the youngster does not have a persuasive profile.

Be-Goals

After defining the Do-Goals for the different types of users and the system, we will also present the Be-Goals by means of user experience, legality and compatibility requirements.

User Experience

- The youngster should be empowered to self-regulate informal learning experiences in their neighborhood of residence or other environments as a part of pass time activities:
  - They should be notified about learning opportunities while on the move to the school, job or while meeting friends.
  - The notification about opportunities should be as non-intrusive as possible and coupled with activities of play to make learning pleasant activity.
- The youngster should be enabled to establish a gradually more positive self-view through the usage of rewards and feedback in order to develop a more positive learning identity.

- The youngster should be able to showcase achievements in TICKLE to peers and supervisors as a means to improve the learner identity.
- Youngsters should be able to collaborate with other users to perform learning activities.
- Exploration should be sparked through usage of location-based learning activities and gamification
- Persuasive techniques should be embedded in the interaction scheme.

Legality

introduced earlier?

- The system must follow the guidelines of the GDPR. The user's persuasion profiles should be deleted upon request, as well as all other information collected about the user. Also an unsubscribe link must be included in the emails. Users should give their consent for collecting data and tracking their location while using the system.
- To receive push notifications, users first must give their consent.

Compatibility

- The user needs a recent web browser to use the application.
- An email account is required to receive emails.
- A mobile device or compatible desktop browser is required to receive push notifications.

5.5 Design

TICKLE is designed as a MPLE to stimulate youngsters to explore their environment in a meaningful and playful way. TICKLE is designed to allow youngsters to collect digital cards by performing associated challenges in their surroundings. The challenges are WW small activities intended to reactivate the youngster for learning. The main component of TICKLE is the playful environment. This is a mobile location-based application composed of a *Card Interface* and a *Card Diary*. The Card Interface module displays a (geographical) map on which cards are marked, which the youngster can collect by performing the associated challenges when (s)he is nearby. Note that in the beginning and depending on the characteristics of the youngster, the challenges can be quite simple (e.g. taking a picture) in order to not demotivate the youngster, but more advanced activities are possible, like performing a quiz or a small game. By collecting cards, the youngsters can gather points that can be used to obtain rewards (variable). In the Diary, the youngster can see his/her achievements and compare them with the achievements of peers (persuasive principle of social comparison) (if allowed).

as shown in

TICKLE is composed of a front end and a back end (see Figure 5.2). The front end is the actual learning environment and is intended to be used by the youngsters. The back end contains the *Authoring Environment*, which allows the content creators to create the actual content, i.e. cards, for the environment, as well as a *Supervisor* module to create and maintain the profiles of the youngsters, i.e. the *Profile Editor*, and to link cards to youngsters, which is needed for the personalized approach. This module also provides the Learner Analytics module. All information related to learning activities is stored in the *ChallengeCardStore*, whereas the learners' activity and profiles are stored in the *Learner Profile Store* and the *Activity Record Store*. Through the use of these multiple data collections the Frontend and Backend can communicate and separate concerns.

you seem to use 'actual' quite often → maybe some variation

consistency

Table 5.1 shows how the persuasive design principles, adapted by (Oinas-Kukkonen & Harjumaa, 2009), are used in the TICKLE environment. One can see that for almost all strategies we included a particular technique into TICKLE. For instance, for Customization we give the user the ability to create their own Challenge Cards at one point. Moreover, the user can also customize their character in TICKLE with an avatar, and include unique interests that are used for Personalization. For rewards, the user is rewarded with a variable

how did you come to this architecture?
were there any alternatives?
advantages/disadvantages

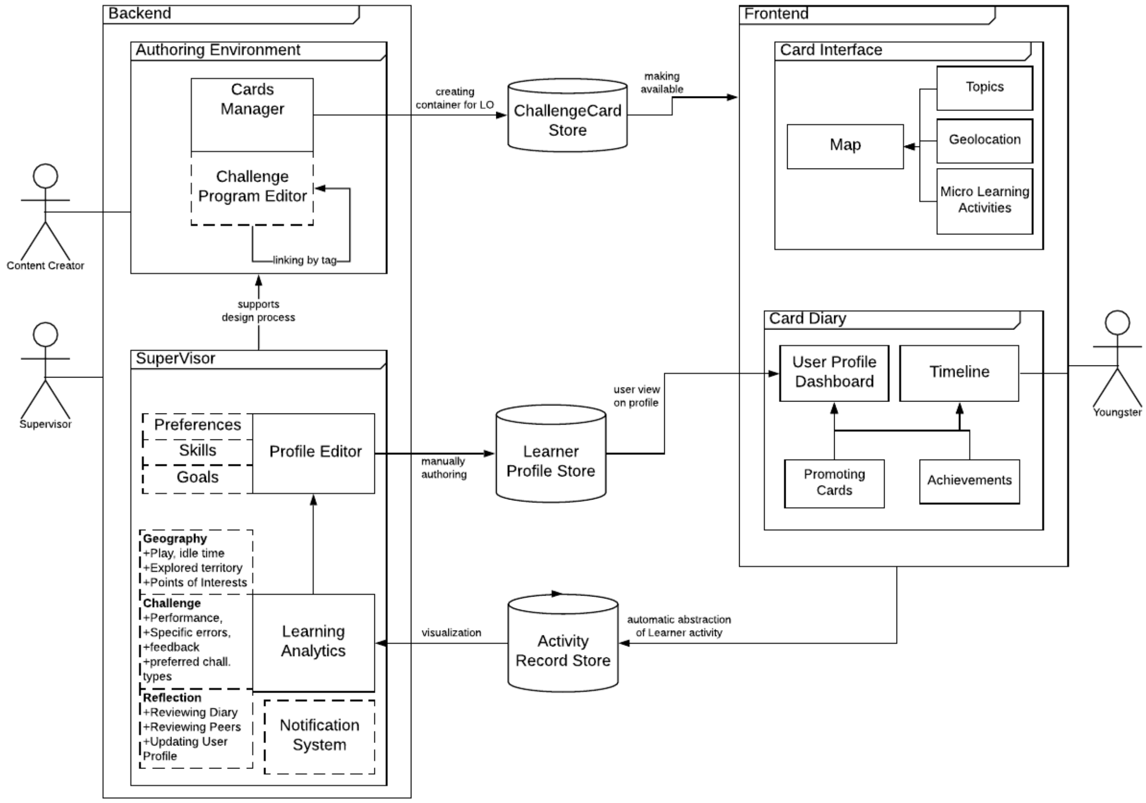


Figure 5.2: Diagram depicting the architecture, main modules and users of the TICKLE environment.

amount of points for performed learning activities. These points can be used to obtain real tangible rewards, such as a visit to the cinema (variable), or for virtual badges.

The following two sub sections describe in detail respectively the front end and back end. We end this Design section with summary and overview on how TICKLE can be used.

5.5.1 Front End

In this section we describe in more detail each component of TICKLE's front end and how they interact with each other. The main components are the Card Interface and Card Diary. They communicate to the back end by the use of database collections, which include the Activity Record Store that is populated by an event system that keeps track of the user's

Strategy	Description	Use Case for TICKLE
Customization	Giving the user the ability to customize the environment to their needs or preferences	The user can create their own cards
Self-Monitoring and Feedback	Provide the user's performance	The Diary reflects the user's performance and provides feedback
Suggestion	Give suggestions to the users regarding their behaviors	Recommendations of learning activities are given based on interests, behavior and geolocation
Personalization	Provide personalized content to the user	With the concept of environment, user groups have personalized access to a specific set of learning activities
Praise	Applauds the user when performing the target behavior	The user is praise at several occasions, e.g. when he logged in multiple times in a row
Reward	Reward users for target behavior	Points are given for successfully performing a learning activity. These can be used to obtain rewards
Comparison	Comparing the user's performance against other users	The leaderboard in Tickle provides the ability to compare the performance against others
Competition	Compete against other users	An integrated leaderboard shows the collected points of the user
Cooperation	Cooperate with other users to achieve a target behavior	Allowing to help another user with a particular challenge.
Reminders	Remind the user of target behavior	TICKLE can send reminders to the user
Tailoring	Information provided by the system tailored to the interests of the users.	Challenges in Tickle can be based on the user's interest and background

Table 5.1: Persuasive Strategies implemented in TICKLE

activity in the front end. We will first describe the Card Interface which includes the *Map View* and the *Topic View*. They serve as navigational cues to explore and discover learning activities. Next the Card Diary is described.

Card Interface

Micro Learning Activities (LA) are the core unit of interaction to provide playful learning experiences in the Card Interface. They are formed around the idea of new media (text, voice, music, graphics, photos, video) and situated in the personal context and interests of the youngster. The youngster's mobile context (i.e. location, time and the social network) play an important role. For instance, based on a youngster's personal interest in racing cars and current location, the platform could recommend a LA which can take place in a museum nearby. The LA could utilize augmented reality to better exemplify the workings of an engine of a racing car. In principle, learning activities can be located anywhere and performed anytime and they are explicitly not bound to a school context. In line with (~~P. D. M.~~ Sharples et al., 2010), youngsters can perform learning activities across physical and digital information spaces by taking ideas gained in one activity and applying or relating it to another activity. Ideally, the accomplishment of LAs should lead to new insights. Each LA is pervasive in the sense that it accesses information placed in the surroundings where it should take place. The LAs do not exist in isolation, they are interwoven in a web of links of related LAs. They provide navigational cues to move from one LA to another. LAs can be members of certain sets and refer to other LAs. In this way, it is possible to create extensive storylines or themes that offer guidance through an overall information space. Similar to the influential Hypercard software (Bowers Tsai, 1990), LAs are visually presented as cards, called *ChallengeCards*. These cards provide an intuitive way to provide and access background information (pointers to multimedia resources) needed to successfully perform the LA (called the *Challenge*). ChallengeCards can be presented either purely digital (on a mobile device) or in mixed reality. For instance, the virtual card can be accessed by a youngster on his/her mobile device while standing relatively close to the physical location associated with the ChallengeCard. Or a real physical card (e.g. made out of cardboard) can be placed ~~on~~ at a physical location and the attached QR code can be scanned to reveal the corresponding ChallengeCard on the mobile device. Overall, the cards serve three functions:

- Being a visual metaphor to ease recognition of LAs and present them as fun challenges and not as work or duty.

- They also constitute the reward system. The cards are collectible (by performing the associated LA successfully) and various cards can form sets and themes. When completed, they reveal rewards to the youngster, like unlocking new content, or setting apart the user from their peers, or providing a material reward (like a free hamburger).

- By using cards, the boundary between producer and consumer can be blurred. ChallengeCards ~~exist~~ Consist of small building blocks such as description, location, media and the actual challenge (i.e. the learning activity) which can be easily created and combined to form new cards. In this way, youngsters can produce new LAs for their peers. This process of card creation is a main part of the reactivation process because it demands creativity and imagination which are important skills for learning and for youngsters' self-esteem.

- Cards allows to achieve playfulness by a combination of gamification techniques and story elements. LAs can include mini-games which need to be succeeded in order to collect the ChallengeCard. In the current version of TICKLE, we embedded the following mini challenges (see Figure 5.3 for examples), however the generic architecture of TICKLE also allows the integration of third-party activities such as BookWidgets (BookWidgets, 2020), which offers a wide range of different learning activities from timelines to gap texts:

  - Photo Challenge: the user has to find a certain artifact and make a photo of it;

politically correct?!

  - Hangman: the user has to guess letters of a word. When too many mistakes are made a hangman is shown on the screen;

  - Quiz: a multiple choice question-answer game.

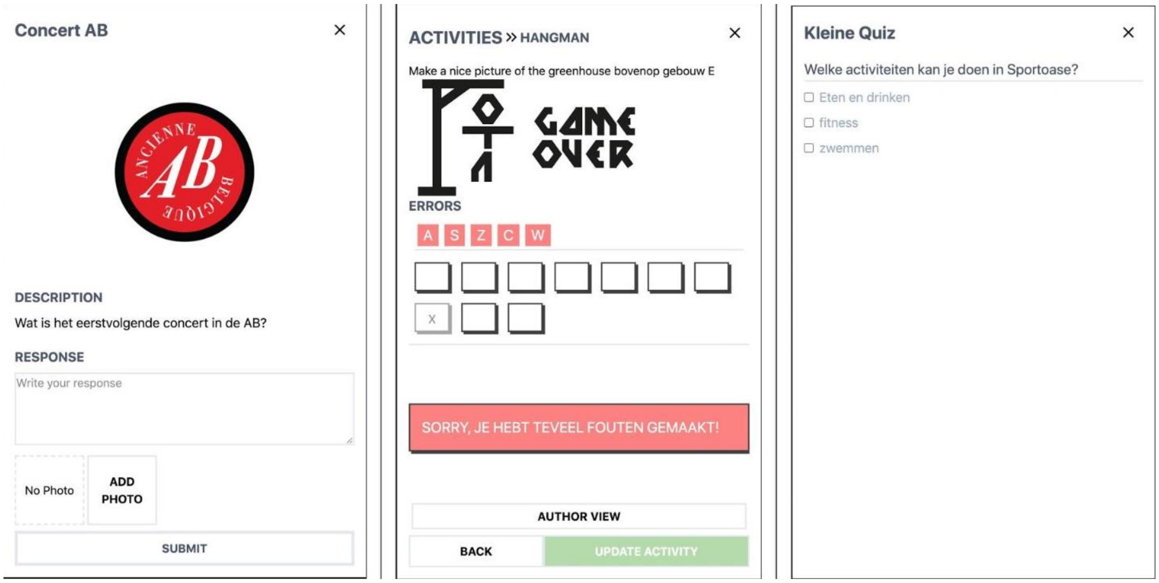
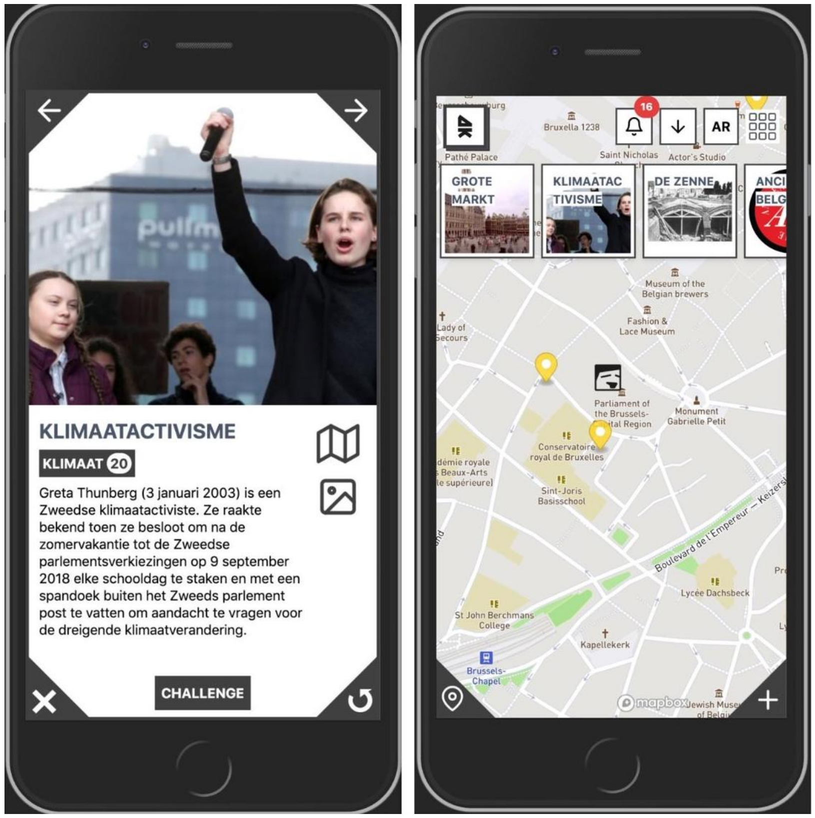


Figure 5.3: Currently supported Mini-Challenges in TICKLE

Moreover, each ChallengeCard is associated with a number of topics and is given a certain amount of points per topic. These so-called *Experience Points* (XP) are earned when the challenge is successfully performed. The XPs are saved in a so-called *Wallet* that can be used to buy (internal or external) rewards. Internal rewards can unlock more content for TICKLE. For instance, with a certain amount of XPs new sets of cards can be made available, or when the user reaches a threshold of XPs a badge is issued to denote that the user is experienced in a certain topic. External rewards, on the other hand, can be freely chosen by the supervisor of the learner(s). For instance, they can range from cinema tickets to coupons for reduction of products. Figure 5.4 (left) shows the front side of an example ChallengeCard. The challenge is revealed when the user clicks on the CHALLENGE button. The back side of a card shows ...

Map and Topic View

The Map View is the main navigational facility of the TICKLE environment. Challenge- mbox
Cards are placed on locations in a map, ready to be discovered by the youngsters. Figure 5.5 (left) shows an example (geographical) map where the user is currently exploring



what about the use of a multifigure environment?

Figure 5.4: Left: front side of a ChallengeCard; Right: Map View of the TICKLE App

the neighborhood; the position of the user is indicated by the avatar symbol. The radius of the user denotes the range within which hidden ChallengeCards can be discovered. The slideshow of cards in the top of the screen shows current cards available in the view. Moreover ChallengeCards can be found via the topics for each card that can be associated to ChallengeCards. In this topic view, the user can access cards more interest oriented (see Figure 5.5 (right)) .

Card Diary

Each collected ChallengeCard is moved to the youngster's Card Diary to track the youngster's progress. It interweaves past TICKLE events in a coherent user story to foster reflection and promote future learning activities. The diary is presented in a visual format to facilitate revisiting collected ChallengeCards and exploring related ChallengeCards, or to perform the challenges not done yet. To create a coherent user story, the diary couples the

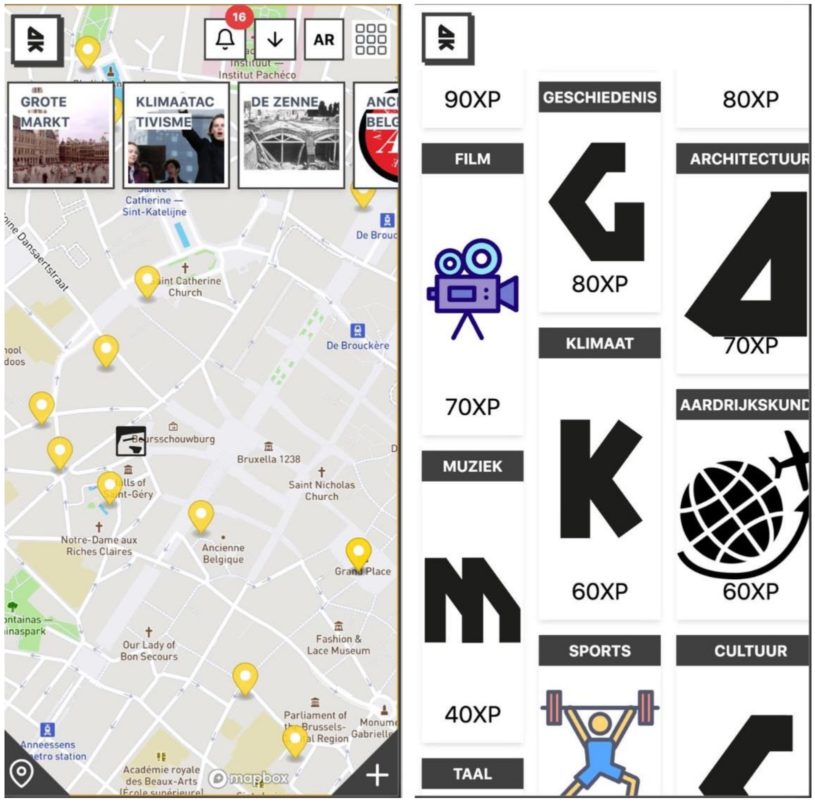


Figure 5.5: The Main View of the TICKLE App to discover cards by location (left) or topic (right)

presentation of the in-app events, such as the performed challenges or important milestones (completion a card set), with personal data. For instance, GPS data is used to determine visited places or participation in social events such as concerts or museum visits. The supervisor of the youngster can make use of this data to notify the youngster about interesting activities or interesting pointers to information.

At certain moments, for instance at the end of the day, users are encouraged to slow down and contemplate on the activity of the past day in terms of acquired ChallengeCards, walked distance, and discovered points of interests. This is done with the precise scheduling of notifications provided by our Rule Engine. However, self-monitoring is not the only function of the visualizations, they are also a means to demonstrate one's accomplishments to others. For instance, a big stack of collected ChallengeCards in a category like art or football can impress others and can strengthen self-esteem. Showing one's personal stack of ChallengeCards to others can help to form a (learning) identity and motivate peers to keep going on. Youngsters may draw inspiration from the actions and behavior of their peers to plan their future activities.

Figure 5.6 shows four important parts of the TICKLE Diary (from left to right):

- Collected XPs are visualized in form of bar charts to give the youngster an overview
  their
  of his/her strengths and weaknesses.
- The next visualization shows nearby ChallengeCards by their distance to the youngster's location in a radial visualization.
- The topics associated with the ChallengeCards are visualized with the help of a visualization technique called Bubble Sets (Collins et al., 2009).
- The Timeline view shows ChallengeCards based on the point in time when they have been collected. By opening a context menu the user can access related ChallengeCards.

Figure 5.6: Screenshots of four important functionalities of the TICKLE Diary

5.5.2 Back End

The back end consists of an Authoring Environment for creating ChallengeCards and challenges and a Supervisor Module for creating and maintaining the profiles of the youngsters, to link ChallengeCards to youngsters, to manage the sending of notifications, and to inspect the progress of the youngsters. The users of the Authoring Environment are (learning) content creators, and the users of Supervisor Module are professionals who want to use TICKLE in their institute or organization. These can be teachers, or professionals supervising youngsters with school burnout, or members of an organization or institute that want to use a TICKLE environment for some purpose, e.g., a teambuilding event, a city game, training. We first describe the Authoring Environment, then the Supervisor Module. Both include sub-modules, namely the *Cards Manager*, *Profile Editor* and the *Learning Analytics*. As shown in the architecture (Figure 5.2), these modules communicate with the ChallengeCard Store, the Learner Profile Store and the Activity Record Store.

all the capitalised words really interrupt the flow of reading ...

Authoring Environment

ChallengeCards are created by means of the Card Editor (part of the Cards Manager). A ChallengeCard consists of a number of fields, such as Image, Title, Description, Links, Videos, Topics, and Time-period. The author can choose which ones to include in the card and then provides the content for those fields. as shown.... See Figure 5.7a for an illustration. Providing ? Giving the location of the ChallengeCard on the (geographical) map is mandatory, as well as the information on when and where the ChallengeCard should be visible. The visibility of a ChallengeCard can be limited to a certain range, i.e., 50, 200, or 500 m, meaning that the ChallengeCard will only become visible when the user is physically within this range of the location associated with the ChallengeCard. The alternative is that a card ~~it~~ is visible wherever the user is located. The duration of the visibility can be limited by providing a starting date and time and and end date and time, for instance when the ChallengeCard is about an event or a temporary exhibition. If such a time period is not given, the ChallengeCard will stay visible (until explicitly removed). It is also possible to indicate that a ChallengeCard should not be visible on the map after it was collected (or the user failed to collect it). Further, To speed up the creation of similar ChallengeCards, templates can be created and used.

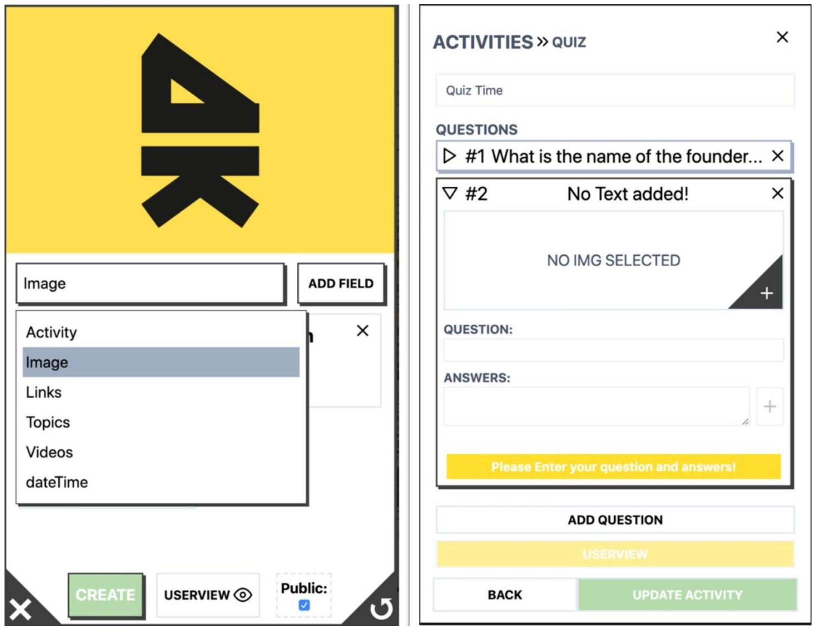


Figure 5.7: (a) Card Editor—Adding an image field; (b) Card Editor—Creating a quiz challenge.

maybe again multi figure environment! (the you have two separate subcaptions)

Currently, TICKLE supports a limited number of challenge types, i.e., a quiz, an open question, and a hangman game. However, external authoring tools, e.g., BookWidgets (), can be used for creating other types of challenges like timeline exercises, riddles, educational games, etc. Figure 5.7b illustrates the creation of a quiz challenge within TICKLE.

avoid etc. at end of sentence

For some types of application it may be useful to help the user to find the ChallengeCards. For this purpose, so-called *waypoints* can be created, which guide the user in the direction of the ChallengeCards. They are especially useful when the ChallengeCards are not visible upfront and need to be discovered by the user. Then, helpful comments can be attached to the waypoints to specify a region of interest for the user. Figure 5.8 shows the creation of these waypoints in the authoring environment.

Cards are grouped in a so-called *Card environments*. A card environment is given a name, a description and an image. It is possible to make the card environment public,

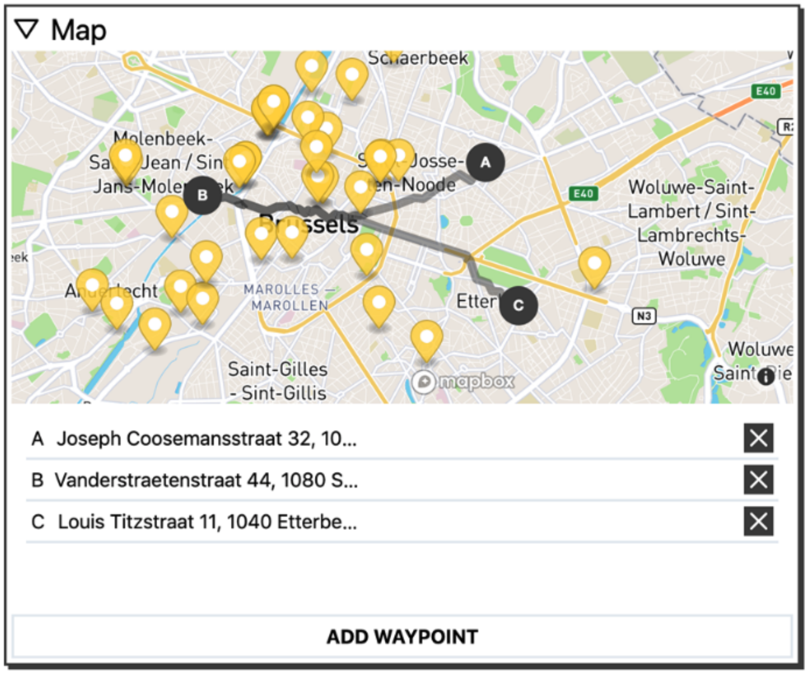


Figure 5.8: Creation of Waypoints in TICKLE

which means that all TICKLE users will be able to use the card environment. Otherwise, the card environment is private and needs to be assigned to a user to allow the user to see the environment. This is done in the Supervisor module. Note that a user can have access to multiple card environments. In Figure 5.9, we see the start screen of a user who has access to multiple card environments.

Supervisor Module

In the supervisor module, accounts for youngsters can be created and youngsters can be given access to card environments. The information about a user (youngster) is maintained in a user profile. The user profile includes personal information (such as the name and email address of the youngster and his/her interests), and also information to steer the sending of notifications (such as the block offtime, i.e., time period(s) in which no notifications should be send to the user), as well as the persuasion profile of the user that contains personality information (e.g., the values for the Big Five) that is used by the system to select the appropriate persuasion techniques for the user. User profiles are created and

Figure 5.9: Start screen for a user who has access to multiple card environments.

maintained by means of the Profile Editor.

The supervisor can also inspect the performance of his/her users, i.e.,the points collected, the cards collected, failed, or started, and their activities in TICKLE by means of the Learner Analytics Module. Note that a supervisor can only manage his own users. In the Cards Manager Module, a supervisor can manage his or her card environments. For a card environment, (s)he can add and remove cards, add and remove users. To ensure that the challenges are adapted to the abilities and the interests of the user, (s)he can add or remove individual cards for a user. (S)he can also inspect who could collect a particular card, and who could not (see Figure 5.7a for an illustration of this last functionality). For the challenges that cannot be assessed automatically (like open questions), the supervisor should inspect the answers given and assess them (see Figure 5.7b). Furthermore, the Cards Manager allows adding rewards to a card environment.

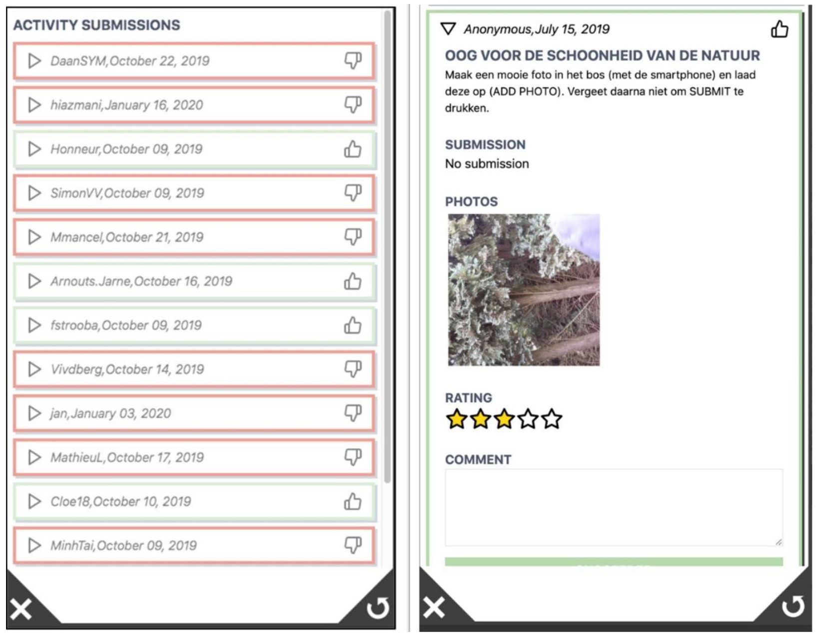


Figure 5.10: (a) Interface in the supervisor module for inspecting who could collect the ChallengeCard and who could not; (b) Interface for rating an open question

Learning Analytics

In TICKLE, the results of the learning activities that are presented to the youngsters need to be registered. Therefore choices will have to be made on how and where to store these results. To keep track of all learning-related activities that happen within TICKLE and to be able to store the relevant ones in a Learning Record Store, events are used. These events are described in the following. The learning analytics system in Tickle is based on events that are occurring when the user performs an activity. Below, in Table 5.2, one finds a selection of the most important events modeled after the xAPI standard. To keep it short, the term ChallengeCard is replaced by card in this table. where?

In the ?? (Card Interface or Card Diary?), each user has an Activity tab when inspected in detail. There, one can see a list of events sorted by time. This is illustrated in Figure 5.11

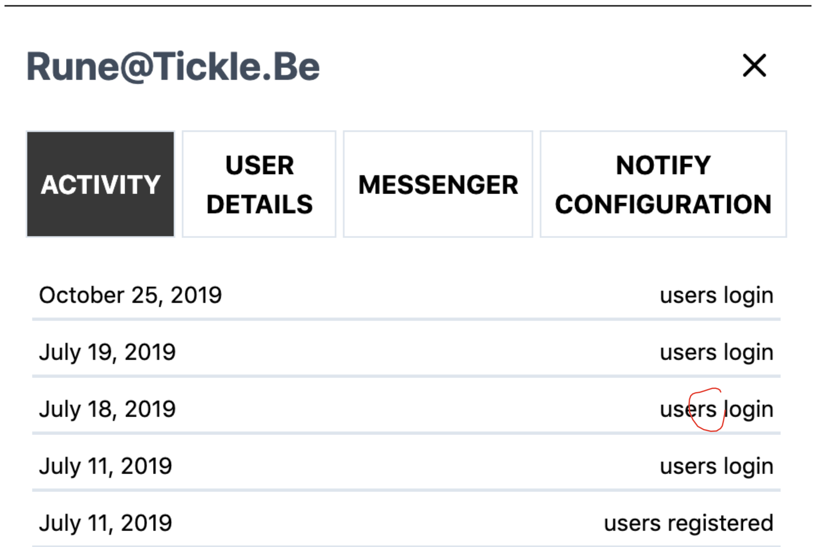


Figure 5.11: Activity Tab of a specific user showing latest events

Notification System

In this section we discuss the design decisions taken for the personalised/persuasive notifications. In general, notifications are used to inform users about an event or to add interactivity to software applications. According to the Hook model (see ~~sub~~section 3.4.3) external triggers are an essential part to build habit-forming products. Notifications are such triggers that can be used to build a habit-forming product. Each trigger should be followed by an action to make it easier for the user to perform the target behavio~~u~~r. We will use this in our notifications to make it easier for the user to go to the TICKLE environment or to the relevant ChallengeCard. For TICKLE, we decided to use two types of notifications: internal and external notifications. Internal notifications are shown ~~inside~~ within the TICKLE environment, ~~this means~~ meaning that the user must be using the application to see these notifications. They are useful to notify the availability of ChallengeCards when the user moves in the surroundings. However, this may not be sufficient to trigger a youngster to use TICKLE. Therefore, we decided to also foresee external notifications that are sent to the user without the need that they are using the TICKLE app. Examples of external notifications are emails and push notifications. Figure 5.12 shows an example of an internal

(*) → next page

notification message given when the youngster failed to perform the challenge correctly. It is a supportive message tailored towards the personality of the youngster and depending of the number of attempts already made.

n a
Figure 5.12: Example Notification in the TICKLE App → see previous page (*) consistency

As discussed before, one of the objectives of TICKLE was to motivate youngsters by using persuasive techniques. These persuasive techniques will be used in our notification system in a personalised way. Therefore, the user profile is extended with a persuasion profile. To build the persuasion profile we opted for the *BigFive* and *HeXad* (explained in section 5.3). Figure 5.13 shows a part of the persuasion profile as seen by the supervisor. In this example the values for the Big Five still need to be entered. One can see that learning deficits, interests, sensitive content and personality traits can be specified for a particular user.

The notification system will respond to events that occurred in the system. However, when an event occurred, the system must take action only when specific conditions are met. Therefore, a simple rule engine is used. Rules are used to specify when specific actions should be taken. The system will check the input event against the conditions formulated in the rule(s) and when these are satisfied the corresponding action is taken as output. To enable personalization when using the notification system, the youngsters (i.e. user) have the ability to choose the preferred medium for the external notifications, e.g. email. We also decided to allow the user to indicate some time span where (s)he does not want to

maybe some more details what rule engine? simple example of a rule?

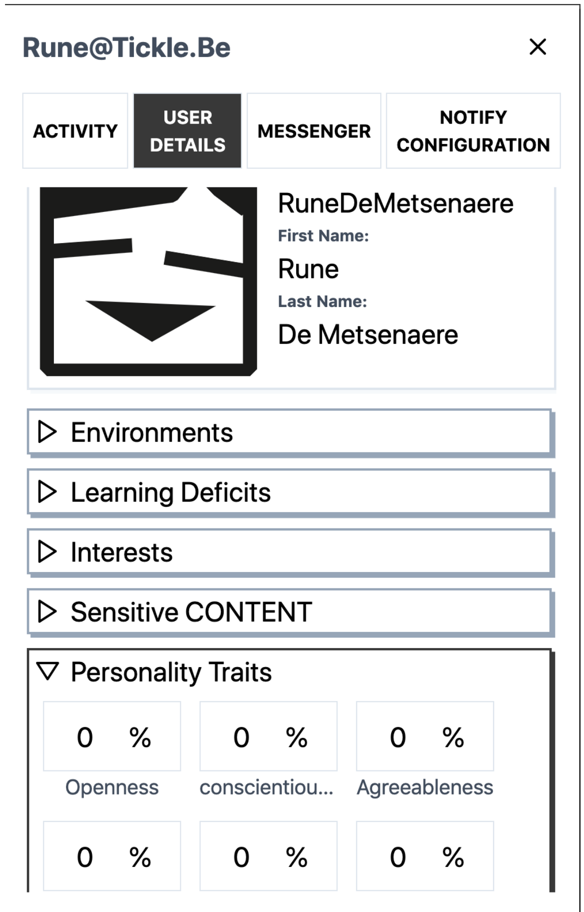


Figure 5.13: Persuasion profile of a particular user

receive notifications to avoid disturbing the end user too much. This principle is based on the "quiet times" introduced in Pushover. ref ?

5.5.3 Summary

In this section we have explained the design of TICKLE, an a MLPE application. Next to the principles formulated for a MPLE, the guiding principle in the design of the TICKLE environment was the Hook Model (Eyal, 2014) and the PSD Model (Oinas-Kukkonen, 2013). Both models were used to connect the different facets of the MPLE into a coherent application. The Hook model is a methodology to bind users to a product or service and provides the general structure of the user interaction process whereas the PSD model was used for strategies to perform the required actions in each phase of the Hook Model. Starting with the trigger phase, TICKLE takes the hand of the youngster by providing guided tours and notifications that are customized and personalized based on their characteristics using the PSD Model. For instance, when the youngster opens the app, all suitable ChallengeCards in proximity of the youngster's location are presented and possible rewards are teased with suitable visualization in the Card Diary. To make it easy to access learning activities, TICKLE also allows to provide exact routing how to find the physical location of ChallengeCards. By collecting ChallengeCards and exploring areas of interest the youngster makes progress in the app. As a result, TICKLE becomes more open-ended and the youngster is notified about new ChallengeCards in the domain of interest. The notifications use persuasive messages tailored towards the personality of the youngster. For the moment, the Big Five trait taxonomy (Jia et al., 2016) and HeXad (Tondello, Orji, et al., n.d.) are used for this purpose. In a second stage, when the youngster has collected a fair amount of ChallengeCards, (s)he also gains access to the card authoring system. From then on, the youngster is not a bare consumer of information anymore, (s)he is also encouraged (using persuasive techniques) to become a producer of ChallengeCards.

An important strategy for a MPLE is the ability to self-monitor progress and receive feedback. Therefore, we included an extensive Diary component into TICKLE that is not only used to recapitulate learning content based on time and topic, but it is also used to allow the youngsters to discover new related learning content based on their interest. For instance, when the youngster has performed a couple of learning activities based on sports, then TICKLE can use this to recommend further sports activities. With the help of the Leaderboard, youngster can compare their performance to others, which is also important for the self-monitoring of ~~the~~ their progress.

5.6 Implementation

In this section, we discuss important artifacts of the implementation, i.e. the client and server architecture and data model including our Learning Record Store implementation.

Overall, the implementation of TICKLE follows the Progressive Web App (PWA) paradigm which mimics the user experience of native mobile applications on the Web platform ("Progressive Web Apps", 2020). A PWA is required to be reliable, i.e load instantly, provide limited offline functionality, and also to be fast and engaging.

5.6.1 Client-Side Architecture

the

To separate business logic from implementation internals we chose to follow the Redux architecture as a model ("Redux - A Predictable State Container for JS Apps", 2020). It centralizes the state of the application in one place and provides a unidirectional data flow which makes it easy to test complex user interaction procedures. Whenever the user interacts with the UI to read from the database for instance, an action is triggered which updates the state of the application and the view again. Figure 5.14 depicts in a graphical way the process flows in the application. For the view, we chose React.js ("React JS - A JavaScript library for building user interfaces", 2020) as framework which provides a declarative way to author HTML components in Javascript. Moreover, it has its own notion of state which helps further to separate business logic and ~~pure~~ user interaction.

where in the figure?

implementation of the

React.js

maybe just footnotes?

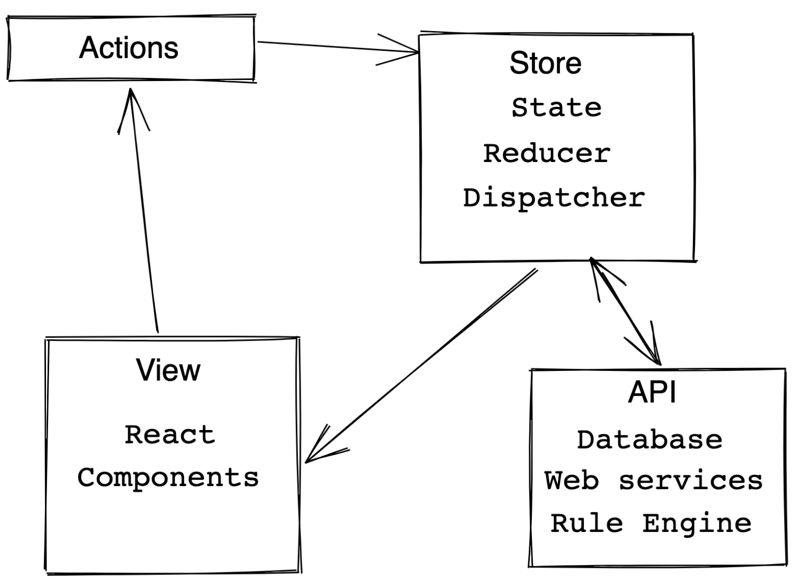


Figure 5.14: The process flow in the TICKLE App

5.6.2 Server Side Architecture

The API or server layer is provided by Firebase ("Firebase", 2020), including a schema-less in Firebase? document database i.e. Firestore and Firebase's Cloud functions. The rule engine is used to process user events (login, challenge submitted, location change) and schedule (when, what, how) user notifications based on their persuasion profile. Every time a new event is stored in the database, ~~this~~ the newly created event is passed ~~in~~ to the rule engine (this is achieved by using a Cloud Firestore *onCreate* \texttt{} function trigger). The rule engine will then evaluate all the rules based on the data from the newly created event. It will take the appropriate action if all conditions of a particular rule evaluate to true. Then, the Firebase Cloud messaging service is used to send the resulting notifications to the clients. Figure 5.15 ~~presents~~ provides an overview of the overall data flow embedded in the TICKLE app. It is presented by means of a simplified UML class diagram, i.e. it is not the complete data model of Tickle because it contains only high level the entities.

I don't see the data flow just the UML classes: but where is the data flow?

An event instance represents a particular event that occurred in the system e.g. a user that logged in, or a new card that became available, ~~etc~~. An event is used as input for the rule engine. The rule engine will make a decision about what action to take based on the event. Each event belongs to other entities e.g. users and cards and has a type e.g login. The events are linked to users, cards and environments. An user instance represents a particular user who is using the system. The following information about a user is captured: Basic contact information about the user i.e. first name, last name, email, username is listed. This type of information will be used in the message body of the notifications to target the user and their characteristics directly. The preferred time span is stored in which notifications may be sent. A unique token from the Firebase Cloud Messaging service is stored. The notification system will make use of this service to send push notifications. This can only be used if the user has a device that is able to receive push notifications. The characteristics based on the BigFive methodology is stored also for a user. This information is used to determine the persuasive message that needs to be ~~send~~ t to the user.

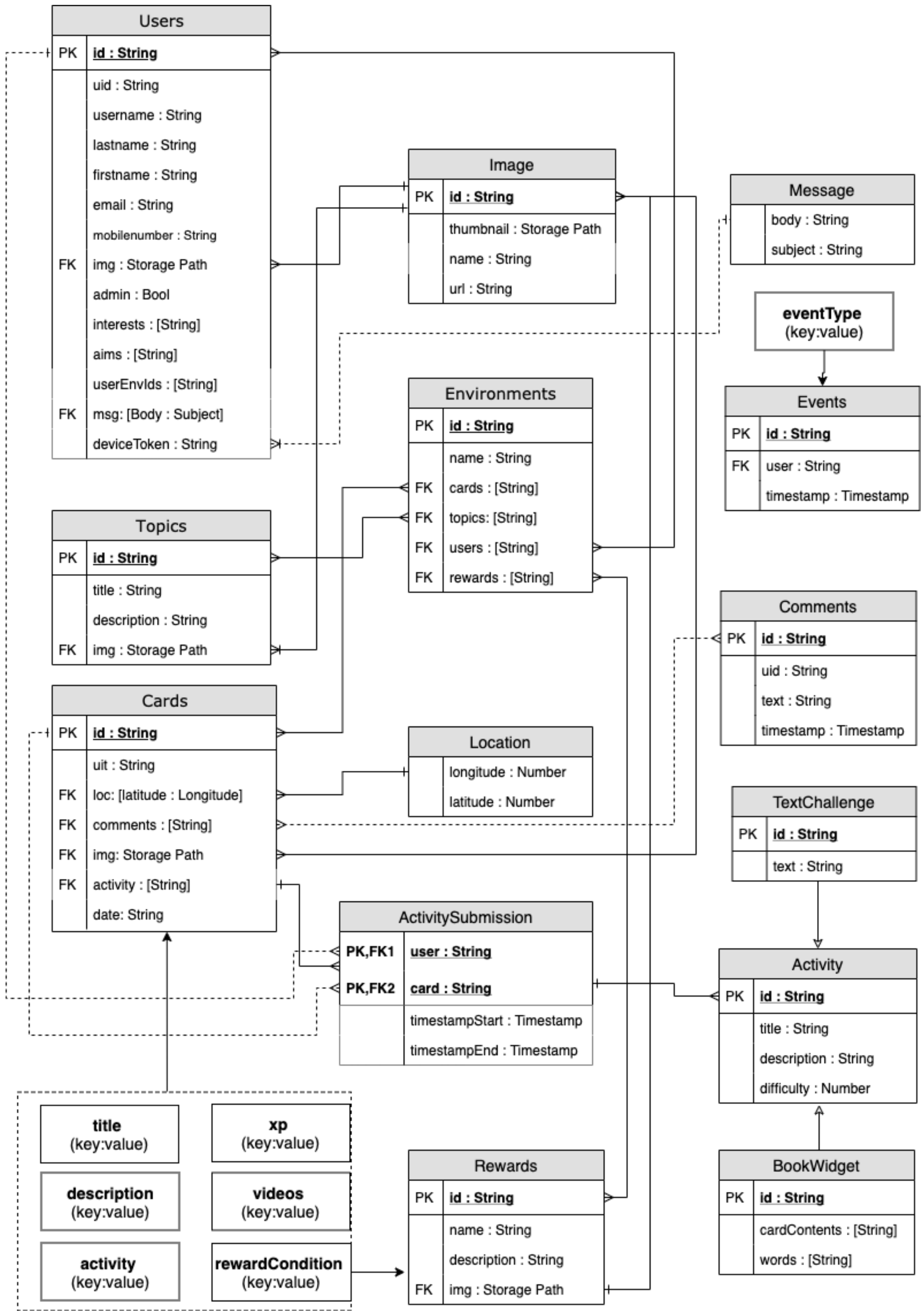


Figure 5.15: The data flow in the TICKLE App

A card instance represents a particular card of a particular environment. Basic information about the card i.e. title, description image is saved as key-value pairs. Besides this, a card can contain complex fields such as media and learning activities which are also stored with key-value pairs. In this way, a card is a generic container which can hold a wide range of different data that can be easily extended by creating a new unique key-value pair. Moreover, it contains an Activity which is a generic and abstract instance of several learning activities. To this date, we implemented a simple PhotoChallenge, a Hangman game and a Quiz which all follow the data structure specified by the class Activity. A card also holds instances of ActivitySubmission which link the user with a card and the response the user has given to certain activity. Instances of the Reward class are saved in the Environment class as well as optional rewardCondition which unlocks certain rewards on collection of a specific Card. A environment instance represents a particular card environment in Tickle. Some basic information about the environment i.e. name, and image is stored as atomic values. As the name suggests, an environment is used to store a number of users and cards and rewards into a group to organize different types of users and cards including learning activities. Therefore, we store corresponding foreign keys of users and cards.

use \texttt{}? for classes and methods

The remaining fields such as Topics, Location, Image are helper classes to facilitate to use the same data structure in different contexts. For instance, the Image class is used in the user, reward as well as card class.

5.6.3 Learning Analytics Implementation

? existing standard? → footnote

The Learning Analytics module is implemented with the means of a Learning Record Store based on the Experience API standard. The basic underlying idea of xAPI is quite simple: people learn by interacting with text, video, e-content, other people. The aim of the new standard is to provide a means of recording such learning interactions and store them in a so-called Learning Record Store (LRS) **??**. Every interaction is stored by sending a secure statement to the LRS in the form of "Noun, verb, object" ("I did this"). An example of such a statement could be: "Pascal finished exercise 5". All of these data can be accessed, within

a

or outside an LMS. Figure 5.16 shows this procedure based on an example. LRSs can also

```
{
  "actor": {
    "name": "Sally Glider",
    "mbox": "mailto:sally@example.com"
  },
  "verb": {
    "id": "http://adlnet.gov/expapi/verbs/experienced",
    "display": { "en-US": "experienced" }
  },
  "object": {
    "id": "http://example.com/activities/solo-hang-gliding",
    "definition": {
      "name": { "en-US": "Solo Hang Gliding" }
    }
  }
}
```

Figure 5.16: Example statement in the grammar of the Learning Record Store. Taken from ("xAPI Statements", 2021)

which one?

share their data with each other. This standard uses a whole new philosophy about learning. Learning is no longer limited to working your way through a pre-made learning object, but literally 'everything' can be recorded as a 'learning activity': watching a video, attending a conference, following a step-by-step tutorial on the Web, reading a book~~,~~ or writing a paper. A learner is no longer bound to the limits of a browser and an LMS to register ~~his~~ their learning activities. No Internet connection needs to be established to record an interaction, it can be done afterwards. All data are recorded in the form of short sentences. The xAPI protocol is used to send statements to the LRS to store them. Afterwards they can be retrieved to perform some analytics. xAPI defines how statements should look like to be accepted by the LRS. In ~~the~~ its simplest form, an xAPI statement is of the form 'Actor Verb Object', e.g. 'Pascal has read "The catcher in the rye"'. All statements of this kind should be sent to the LRS in JSON-format **??**, i.e. a number of properties expressed as key/value pairs.

is that not what you already explained on the previous page?

5.7 Evaluations and Demonstrators

During the research and development process, we performed several evaluations and provided different demonstrators. The evaluations were formative evaluations with the aim to improve the application as its development progresses. For that purpose, qualitative research methods are more useful than solely quantitative ones (Kaplan & Maxwell, 2005). According to Kaplan and Maxwell (Kaplan & Maxwell, 2005) qualitative methods can be used throughout the entire development process, as they can help to identify potential problems as they are forming, thereby providing opportunities to improve the system as it develops. A phased approach was used for this formative evaluation. After each evaluation phase, the app was improved based on the feedback received. The main questions for this formative evaluation were: *Is the TICKLE environment, as an adaptive mobile tool with persuasive strategies: (1) usable for youngsters, (2) able to engage youngsters, and (3) able to increase the intrinsic motivation and learning capacity of youngsters?*

In this section, we discuss the different evaluation phases performs and the demonstrators developed. We also provide a ~~discussing~~ discussion on the findings and the limitations of the evaluations.

5.7.1 Evaluation Phase 1

In the first phase, which was situated in the early design phase, we wanted to receive suggestions and recommendations from supervisors and organizations concerned with school burnout and dropout to ensure that our environment would be usable for this purpose. Individual sessions were held with 11 organizations, all ~~organizations~~ of them working with youngsters. In the sessions, we used open interviews to gather feedback and/or input on specific topics concerning the TICKLE environment (i.e., on attractiveness, usability, and the feasibility of the approach). After a short introduction, the researchers explained the aim, design, and features of the TICKLE environment, after which the current prototype was presented. Next, the TICKLE environment was discussed using some questions as a guide for the interview conversations. The interviews were audio-recorded, transcribed ad verbatim, and read through repeatedly. The interviews were coded and analyzed in the MAXQDA software package through an iterative process that combined elements of both content and thematic analyses (Bowen et al., 2009) by a colleague researcher from the domain of Pedagogy. Findings and actions taken were:

- Potential value of TICKLE for exploring the youngster's environment: The organizations we consulted pointed out that a lot of youngsters, among whom those that (eventually may) dropout, hold on strongly to the boundaries of their own quarters, ? in this way missing opportunities to broaden ~~broader~~ their interests. Trough its location-based service and on-the-go approach, the organizations did see merit in TICKLE in allowing young people to go out and step outside their own direct neighborhoods, enabling them to explore new parts of their neighborhood and the city in general. By offering youngsters different challenges and activities, the application could bring them to locations and places they have not been before and stimulate them to explore activities they did not participate in before.

- Potential value of TICKLE for engaging youngsters: The coaches and supervisors from the consulted organizations recommended that the offer in terms of cards, activities, and challenges should be very diverse, so that all youngsters could find something of their interest. Themes mentioned were sports (e.g., dance and boxing) and music, but also media. Next to our intention to start from the youngsters' own interest, the gamification element within TICKLE was considered a positive and appealing way to motivate youngsters to explore more. Based on this feedback, and in order to allow the youngsters to broaden their interests, we decided to provide links to "related" cards on (the back side of) a card.

- Potential value of TICKLE for informal learning: Within the environment, the youngster is able to track the cards already opened and collected, the themes discovered, and his/her own growth. It was indicated that this could offer a means of self-reflection. Furthermore, it also provides ownership over one's own learning process. Another idea that was dropped, and added to the system, was to include soft skills next to topics of interest, and allow the labeling of cards with soft skill labels too, e.g., responsibility, team spirit. In this way, the youngsters can (possibly unconsciously) practice these soft skills and also collect points for them. Furthermore, it was indicated that it would be valuable to guide the youngsters around within the educational, social (-cultural) support and service landscape. This has been taken up by providing a specific card environment dedicated to this. In this card environment, each relevant organization is described by a card, which is positioned on the map by means of a dedicated icon (see also ~~sub~~section 5.7.4).

- Other suggestions: It was suggested that the app could support geocaching ("Geocaching", 2020). Although TICKLE is not explicitly tailored towards geocaching, it is possible to support it by means of the open challenges. In the future, we will investigate how it can be supported in a more explicit way. Another aspect that was mentioned was the importance of allowing youngsters to connect with each other with and within the TICKLE environment. The organizations gave several reasons why this would be good to have: to communicate and connect, to inspire and trigger each other, to collaborate and meet in real life, to help and learn from each other. This valuable suggestion would be implemented later. It was also suggested that the app should provide a help button that the youngster could use when ~~(s)he~~ would be stuck on a challenge. There are different possibilities to implement such a help-functionality. It will be considered in future work. Another suggestion was to introduce leaderboards. This was consider ed later as part of the the persuasive strategy.

5.7.2 Evaluation Phase 2

Within phase two, the developed tool was piloted and evaluated in real-life settings. The main aim of phase two was to receive feedback and suggestions from the target group, ~~i.e., youngsters~~, in order to adapt or redesign the environment according to their feedback and suggestions. More specifically, we wanted to know (1) if the app was attractive and usable, (2) if its use was motivating, and (3) the youngsters' willingness to use the app on a longer term basis. On purpose, we did not focus on youngsters with school burnout but on youngsters in general. This decision was taken in order to ensure that the app would be usable by youngsters in general and would be usable for a broader goal than school burnout. In this phase, two evaluations took place, both with the youth organization the "Vlaamse Dienst Speelpleinwerking" (VDS) ("VDS", 2020), translated as the Flemish Service for Playground Work. VDS organizes so-called playgrounds (i.e., play days) for children during school holidays. They also organize courses for youngsters who want to become animators for the playgrounds. In both evaluations, the participants were animators of the organization. We informed them that they were participating in an evaluation, and they were informed about their rights and agreed to participate.

think you mentioned the translation earlier

Evaluation 1 of Phase 2

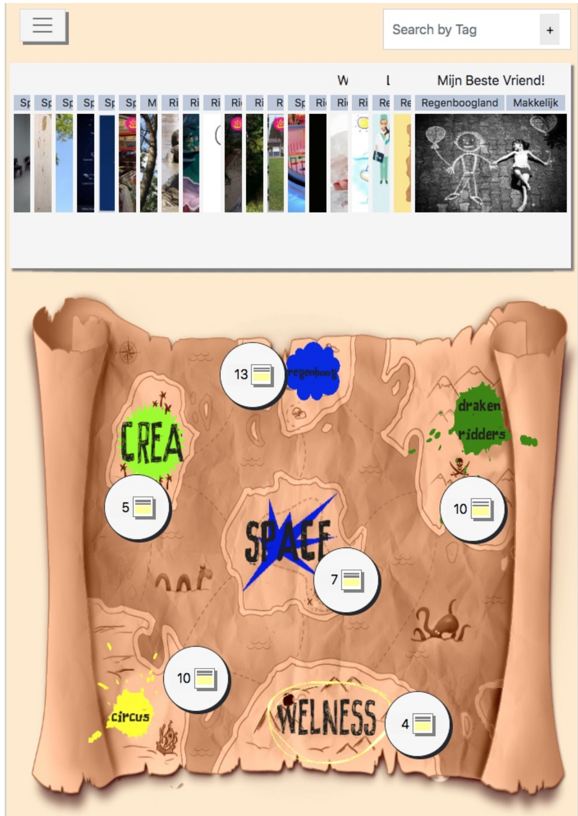
VDS was looking for a game to improve the cooperation between the animators of the playgrounds and to stimulate their creativity. In order to do so, we proposed them to try out the TICKLE environment. For this evaluation, cards were created with challenges related to the operation of a playground. An example challenge was, for instance, to build a spaceship.

how is this related?

The cards and challenges were created by experienced instructors from the organization. Challenges could be carried out individually, or collaboratively with other animators. The goal for the participants was to carry out the challenge/activity to the best possible standard and to collect as many cards as possible. For this evaluation, the cards were not placed on a physical map but on a fantasy map, ~~i.e.,~~ a treasure map ~~(see~~ as shown in Figure 5.17~~)~~, as all challenges were located at the playground's location. All cards were visible and labeled with a topic, as well as with a difficulty degree (level?): easy, medium, or difficult. In both evaluations, the participants were animators of the organization. We informed them that they were participating in an evaluation, and they were informed about their rights and agreed to participate.

redundant!

The evaluation was ~~done~~ took place at two different playground locations. In principle, all ani-



→ slightly larger

Figure 5.17: TICKLE's treasure map interface for the first evaluation with VDS.

mators of those playground locations could participate. The animators were introduced to the TICKLE environment in small groups by means of an oral presentation and a hands-on demo. They also received a short manual on paper. Afterwards, They could use the environment for three weeks. The animators youngsters had to use their own smartphones. At that time, only recent Android smartphones were well supported. Youngsters that did not have such a device could use the application on a laptop or desktop computer through a w Web browser. Afterwards, feedback was collected ~~invited~~ through an online questionnaire. Next to some questions related to the participant (age, background), this questionnaire contained questions from the short version of the User Experience Questionnaire (UEQ) (Rauschenberger et al., 2013), as well as questions for testing whether the participants understood specific features of TICKLE, questions about the look and feel of the cards, the challenges, and about the original goal (i.e., stimulating the cooperation and creativity of the animators). ~~These~~ based on

different groups!

a X-point

~~questions used~~ a Likert scale. The participants could also leave comments and suggestions for improvement.

Show a ~~representation~~ graphical representation of these scores (with mean and intervals) → add figure

Results: In total, 20 animators filled out the questionnaire: nine participants were 16 years old; the others were between 17 and 25 years old. Nine participants had no or only one year of experience as animator. Concerning the questions ~~from~~ UEQ, the hedonic quality (stimulation and novelty) scored higher (1,5) than the pragmatic quality (attractiveness, efficiency, perspicuity, dependability) (1,00). According to the UEQ handbook, these scores represent a positive evaluation. The results on the questions to test the understanding of specific features, as well as about the look and feel, were mixed, indicating that some improvement would be needed on these aspects: eight of the 18 participants (40%) gave a score higher than 4 for attractiveness (where 1 was attractive and 7 not attractive); five participants (25%) gave a score of 4, while the scores of the other seven participants were between 1 and 3. In general, we received positive results about the challenges. For the fun aspect, all scores were between 1 and 4 (where 1 was fun and 7 boring), with 20% (four participants) for score 1 and 40% (eight participants) for score 2. All scores for being doable (where 1 was not doable and 7 good doable) were 4 or higher, with 45% (nine participants) for score 5 and 6. The results on the questions related to the original goal were positive: 85% (17 participants) indicated that the challenges were inspiring, the other 15% (three participants) replied "maybe"; 70% (14 participants) indicated that this app could contribute to a better collaboration, the other 30% (six participants) answered "maybe"; everybody agreed that the challenges could contribute to a higher quality of the playground activities. Suggestions and comments were provided. Comments about the challenges provided useful feedback about the type of challenges youngsters are interested in. The other comments and suggestions were about improving the interface, the ~~info~~ information presented on the cards, and some aspects of the functionalities. Additionally, usability issues with specific smartphones and browsers were mentioned.

Evaluation 2 of Phase 2

For the second evaluation, the app was used for a kind of city game restricted to ~~one~~ a single long street, in the context of a "start of the year" event of the VDS. On the TICKLE map, cards with challenges were spread along the street (see Figure 5.18 for an illustration). Participants had to find the cards, which only became visible on the map when the participant (i.e., the smartphone) ~~physically~~ came in the physical vicinity of the location of a card. Each challenge that was well executed yielded points. The aim was to collect as many points as possible.

this is nothing new!? right?

The cards and challenges were created by the organizers of the event. For this evaluation the youngsters had to use their own smartphones. Just as for the previous evaluation, only recent Android smartphones were well supported. However, as the street game was done in small groups and only one smartphone was needed per group, enough suitable smartphones were available. Afterwards, feedback from the animators was invited through an online questionnaire. This questionnaire included the same UEQ questions as the first evaluation, as well as specific questions about the way the street game was set up in TICKLE, about the look and feel of the cards, and about the challenges. These questions also used a Likert scale (1 to 7). The participants could again leave comments and suggestions for improvement.

So here often brands supported at all and did you allow them → otherwise remove the 'well' and also explain in the discussion what the issue was

different than the ones in phase 1? maybe good to mention

Results: In total, 18 animators filled out the questionnaire. In this evaluation, the participants were young adults: 18 years old or older; one person was older than 26. Concerning the questions from UEQ, the results were in line with the previous evaluation: the hedonic quality (stimulation and novelty) scored higher (1.34) than the pragmatic quality (attractiveness, efficiency, perspicuity, dependability) (1.04). The results on the questions about the set up of the game confirmed our setup: 88% (16 participants) agreed that keeping the cards hidden until close to the location made the game exciting, but in addition, 39% (seven participants) would have preferred an alternative to see all the cards right from the start, but keep the challenges hidden, or only provide the functionality to submit them when near the location. In this evaluation, the results about the look and feel were mixed (11 of the

again show some graphics

18 participants (61.1%) gave a score higher than 4 — where 1 was attractive and 7 not attractive). The ease of entering the answers was also evaluated mixed (nine of the 18 participants (50%) gave a score higher than 4 — where 1 was easy and 7 cumbersome). We received positive results about the challenges. For the fun aspect, all scores were between 1 and 4, with 38.9% for score 2 (where 1 was fun and 7 boring). All scores for being doable (where 1 was not doable and 7 very doable) were 3 or higher, with 50% for score 5. Comments were about the available time for the game (which they found to be too short), the data consumption and the battery consumption (which were both considered too high), and small usability problems and bugs.

Could also be shown again in the graphics (with the corresponding labels)

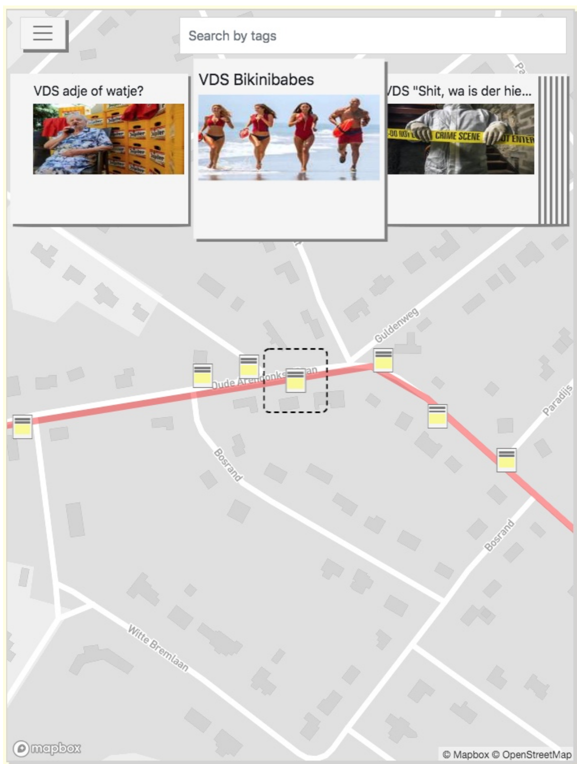


Figure 5.18: TICKLE's Map Interface for the second evaluation

5.7.3 Evaluation Phase 3

In this phase, also evaluations in real-life settings were done, but this time the focus was on youngsters in some way related to the issue of school burnout and school dropout.

maybe footnotes ?

Two evaluations took place, both with an organization dealing with youngsters who are in a problematic situation, i.e., Try-out ("Alba", 2020) and CAD Limburg ("CADLimburg. Centra Voor Alcohol-en Andere Drugproblemen Limburg", 2020). Try-out offers activities that allow youngsters with school issues to detect their talents and interests, and in this way ~~try~~ tries to reconnect them with regular school or work, and CAD Limburg offered a Reboot Camp ("Reboot Kamp", 2020) for young gamers at risk, who often are also at risk for school dropout. In both evaluations, the participants were informed that they were participating in an evaluation, they were informed about their rights, and agreed to participate. Due to the problems experienced with the broad range of smartphones used by youngsters in the evaluation phase two, we decided to provide them with a smartphone to avoid usability problems due to incompatibility issues. The smartphones were Android devices. Sufficient mobile data was provided, as this was reported as an issue in the previous evaluation phase. We realize that those issues should be resolved ~~in~~ at a later stage, but we wanted to avoid that issues with smartphones influenced the results of the evaluations.

mbox

what does that mean?

Evaluation 1 of Phase 3

This evaluation was done in the context of a day activity organized by the organization Try-out. For this evaluation, a city game was created with TICKLE. The location was the center of Brussels, and the cards and associated challenges had the aim of letting participates explore interesting places in the city and find out more about these places. See Figure 5.19 for a screenshot of the card interface. Variable amounts of points could be collected with the cards. The goal was to collect as many points as possible. There was no predefined route; the participants had to develop their own strategy to collect as many points as possible in the given time ~~(2 h)~~ of two hours. They played the game in groups of two to three. Each group was accompanied by a supervisor from the organization. Each participant received a smartphone with mobile data and a short manual on paper (three pages). We had six participants in total.

mbox

do you mean mobile internet access? → I wouldn't call that mobile data since that's not clear

Figure 5.19: TICKLE's Card interface for the city game in Brussels

Afterwards, the youngsters were asked to fill out an online questionnaire. The questionnaire included questions about their age and interests, as well as questions related to the user experience. This time we did not follow UEQ completely, because the way the questions in this questionnaire were formulated is not suitable for the youngsters who would participate in the evaluation (see also ~~sub~~section 5.7.5 - ~~Discussion~~). Furthermore, questions about the challenges, the look and feel and the information on the cards were asked. In this evaluation, we also measured whether the app was able to engage the youngsters, and if it was able to increase the motivation for learning more about Brussels. All these questions used a Likert scale. In this evaluation, the questions were formulated as statements, and a scale from 1 to 5 was used to indicate the level of agreement with a statement: 1 being "strongly disagree" and 5 being "strongly agree". The participants could again leave comments and suggestions for improvement.

would "not be possible" with 6 users only anyway

show graphics

Results: all participants (six) filled out the questionnaire. They were 14 and 15 years old. Given the small number of participants, we did not use statistics to process the results. The results on the user experience were rather neutral. In this evaluation, the participants found the look and feel more attractive (note that after the previous evaluation phase the interface was improved considerable): two participants (33.3%) agreed with the statement that the cards were attractive with a score of 3, three participants (50%) with a score 4, and one participant (16.7%) with a score of 5; two participants (33.3%) respectively agreed with the statement that the cards look nice with a score of 4 and 5. They liked the challenges (four participants (66.7%) confirmed this with a score of 4 and two (33.3%) with a score of 5), found them not difficult to understand (three participants (50%) strongly disagreed (score 1) with the statement that the challenges were difficult to understand, while the other three participants provided a score of 2, 3, and 4 respectively), very doable (three participants agreed with this statement, with a score of 4 (two participants) and 5 (one participant) respectively; two participants were neutral (score 3), and one gave a score of 2), and varied (two participants (33.3%) agreed, with a score of 4, and four (66.7%) gave a score of 5). They appreciated that the challenges addressed a range of areas of interest (50% agreed, with a score of 4, and 50% gave a score of 5). They all found the city-game with TICKLE a nice way to get to know Brussels (four participants (66.7%) agreed with a score of 5, the two other participants gave a score of 3 and 5 respectively); four of the six participants recognized that they learned new things; and 50% indicated that they would use the app again (with a score of 4), the other 50% gave a score of 3 on this statement. However, the results were mixed concerning the questions to measure a change in their motivation for learning more about Brussels or other domains. Regarding the statement of whether they would like to learn more about Brussels, the distribution of the scores were as follows: one participant gave 1, two participants gave 2, two participants gave 3, and one participant gave 4. On the statement whether they would like to learn more about other domains, two participants gave a score of 4, and one participant gave a score of 1, 2, 3 and 5 respectively. Few comments were given and were mainly on small usability issues.

too much info in text → graphics and maybe details in appendix (then you can for example only mention the average in the text)

Evaluation 2 of Phase 3

This evaluation was done in the context of the Reboot Camp organized by the organization CAD Limburg. The camp lasted one week (5 days). For this evaluation, cards were created for the different activities offered during the camp. In this way, the youngsters could use TICKLE as a kind of agenda. Each day they could see, by means of cards, the activities of the day. The cards only became visible on the day of the activity. The cards contained information about the activity. To collect a card, they had to do a small challenge related to the activity. The challenges were ranging from doing a quiz to writing a small reflection about an activity. In this way, points could be collected. There were also cards with general information, such as a card with a short manual, a card with the rules of the camp, a card about the camp's location, and a card with a link to the questionnaire. See Figure 5.20 for a screenshot of the card interface used for this evaluation. The seven youngsters that participated in the camp received an introduction with a hands-on demo. They each received a smartphone with mobile data. On the request of the organization, we restricted the use of the smartphone to TICKLE, to consult the Web, and to take pictures. Unfortunately, the supervisors of the camp decided that the youngsters could only use the smartphone at certain moments during the day. At the last day of the camp, the participants were supposed to fill out an online questionnaire, an activity that was also offered through a card. The questionnaire for the participants was similar to the questionnaire for the city game. The questions were formulated as statement and a scale from 1 to 5, used to indicate the level of agreement with the statement: 1 being "strongly disagree" and 5 being "strongly agree". In this evaluation, we also asked questions about the notifications provided in TICKLE. The

integrate it with another sentence

participants could again leave comments and suggestions for improvement.

Results: Although we explicitly asked the organization to stimulate the youngsters to fill out the online questionnaire at the last day of the camp, only three (of the seven) youngsters filled out the questionnaire. They were respectively 14, 15 and 18 years old. These participants were positive about the app (measured by means of different questions), found it easy to use (two participants agreed with a score of 4, one with a score of 5), and a nice way to detect new things (one score of 3, one score of 4, and one score of 5). They were positive about the use of notifications for letting them know which activities would take place (two scores of 4 and one of 3), but they were divided about the usefulness for informing them about the points collected (one score of 1, one score of 3 and one of 4). The information on the cards and their look and feel was evaluated positively (agreement with a score of 3 (one participant) and 4 (two participants) for the information, and with a score of 4 (three participants) for the look and feel). Also, these participants liked the challenges (one score 4, and two score 5), found them good doable (three scores of 4) and varied (one score of 3, and two scores of 4), but found them in average difficult to understand (one score of 2, one score of 3, and one score of 4). They found TICKLE a nice way to get to know the activities (one score of 3, one score of 4, and one score of 5); recognized that they learned new things (two scores of 4 and one score of 5), and indicated that they would use it again (with different degree of certainty: one score of 3, one score of 4, and one score of 5). For the questions used to measure a change in their motivation for learning more about new areas of interest or activities, the results were mixed: two showed a clear increased motivation (score 5), while one did not (score 2). No comments or suggestions for improvement were given.

really difficult to read text like that → graphics

5.7.4 Demonstrations

why demonstrations?

In the context of the evaluations, different card environments were created that demonstrate the possibilities of the application. We used TICKLE to create a street game and a

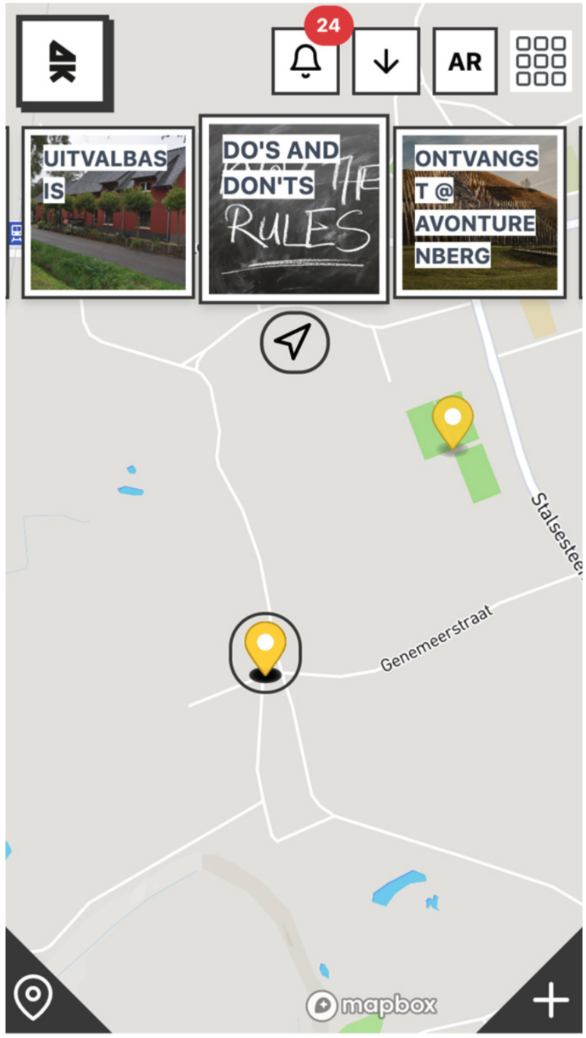


Figure 5.20: TICKLE's Card interface for the Reboot Camp

city game; for creating a playful environment to stimulate collaboration and creativity of animators; to inform and support reflection during a camp for youngsters at risk of game addiction. These use cases cover informal and non-formal learning. Next, we used TICKLE in the context of formal learning, i.e., to stimulate the processing of the course material during the semester for one of our university courses. Cards were created about topics in the course, and the associated challenges had the aim of letting students test their knowledge about the topic. By collecting cards, the student could collect points. The cards became available during the course of the semester. The students were notified by email when new cards became available. This demonstration was used to test the personalized notification system. We asked the students (on voluntary basis) to fill out an existing online questionnaire in order to determine their personality in terms of the Big Five taxonomy (Tondello et al., 2016), and send us the results. Based on this information, the students received notification messages tailored to their personality. Next to these card environments, we also created an environment that provides an inventory of all organizations related to school burnout or ESL located in Brussels. This card environment contains 41 cards. There is a card for each location of an organization (some organizations have more than one office in Brussels), and the cards are positioned on the map of Brussels. The card of an organization contains the following information: the name of the organization, a short description, address, a link to the website and Facebook page of the organization, and contact information. These cards could be collected without the need to perform a challenge.

5.7.5 Discussion

In general, in the context of the formative evaluations, we obtained positive results and received useful feedback to improve and extend the application. Based on the results, we can conclude that in the context of these formal evaluations, the app is usable for youngsters and able to engage them, and we see indications that it may be able to increase the intrinsic motivation and learning capacity of youngsters. However, the evaluations were limited in the number of participants and the context in which they were performed, and they had a limited goal, i.e., checking the usability of the app for youngsters and the ability to engage them. To confirm the results and to verify whether the app can increase the intrinsic motivation and learning capacity of youngsters, summative and longitudinal evaluations are needed. Such evaluations were under preparation but could not be performed yet due to the COVID-19 restrictions. For these evaluations, questionnaires other than UEQ would be considered. While UEQ aims to measure the user experience in general, GAMEX is a new instrument (~~i.e.,~~ questionnaire) for measuring gameful experience, i.e., the user experience of engaging with gamified applications (Eppmann et al., 2018). Although developed in the context of customer behavior, it may also be usable for education. PLEXQ (Boberg et al., 2015) is another questionnaire focusing on measuring playfulness. This questionnaire targets a wide range of products, including mobile apps. To measure the effect on motivation for learning, we would collaborate with our research partners from the educational domain.

Next to the positive results obtained from the formative evaluations performed, we encountered different issues that are worthwhile to mention:

- Performing formative evaluations in real life settings is challenging. First of all, we found that our target audience, ~~i.e., youngsters~~, is very demanding, especially concerning look, feel, and usability. Although we always explained very well that the app under evaluation was research work and still required improvements, most of the critique was on the look and feel, and about minor ~~small~~ usability issues. Also being able to quickly start and resume the app was very important for them. Next, there exist a broad range of smartphones with different screen sizes and browser versions. It turned out to be impossible in the context of a research project to ensure that the application was running smoothly and without issues on all possible devices used by youngsters. For that reason, we decided to provide smartphones to perform the evaluations in the third phase. However, for the longitudinal evaluation this may cause some bias. When the youngsters have to use an additional device next to their own smartphone, they may find this annoying, and it will counteract efforts to make the app *a seamless part of daily life*. Lastly, when performing evaluations in real-life settings, it is not always possible to have full control over the setup. Even after careful preparation, unexpected issues may show up during the evaluation. For instance, this happened during the Reboot Camp evaluation: although we limited the use of the mobile phone to the TICKLE app (so the youngsters could not use it to make phone calls, download or play games, or for other apps), and discussed this with the organizers in advance, it turned out that the strict policy for using mobile devices was also applied to the mobile phones given to the youngsters for the evaluation. ?

don't get it

Probably, during the camp, it must have been easier to ban the use of any mobile phone during the day, and because we were not allowed to be present during the camp week, we could not intervene.

- Questionnaires for youngsters. Most available questionnaires on usability and user experience are designed for adults with good literacy. For the evaluations in phase two, we used UEQ in the native language of the participants, but simplified the language somewhat, because a pilot with youngsters of the same age indicated that some terms were still too difficult to understand. When the youngsters were filling out the questionnaire, we also noticed that they had problems in using the Likert scale, especially when the lowest score represented a good result and the highest a bad result. For instance, they had no problem in scoring a statement like "the system was (1) easy to learn...(7) difficult to learn", but a statement like "the system was (1) motivating...(7) demotivating" caused misunderstanding. Apparently, in their education, they were used to associating a high score with a good result. The participants in phase three were even younger, and it was known that their literacy could be an issue, so we simplified the language in the questionnaire even more and used statements that all could be answered with the same scale: "strongly disagree" to "strongly agree". As much as possible, we tried to avoid negatively formulated statements. In the first evaluation of phase three, the youngsters could ask for an explanation while filling out the questionnaire, but in general they did not use this opportunity. For summative longitudinal evaluations, even more attention should be paid to the questionnaire, it should be pilot several times, and if possible, an existing validated questionnaire tailored towards children/youngsters and suitable for the purpose should be used.

contradicts good example (both low ones are 'good' results)

how? do you not introduce a bias?

5.8 Summary

In this chapter we presented TICKLE, a playful learning environment for youngsters. The environment is a mobile location-based smartphone application that offers youngsters an interactive environment with which they can explore their surroundings based on their interests or needs and is based on the MPLE model. The environment offers cards that the youngsters can collect by performing small challenges. In the regular case, the cards are associated with physical locations, and the challenges are related to those locations. In this way, TICKLE promotes the playful exploration and discovery of information in a physical environment. However, the environment is also usable with a fictive environment, like a treasure map.

We explained how the requirements where derived, justified the decisions made, and presented an overview of the system and its functionalities. The system consists of a front end that is the actual playful environment, and a back end that offers an authoring environment for creating the content, and a supervisor module for managing and monitoring the performance of the users and the card environments. We also discussed important aspects of the implementation. Next, we discussed the evaluations performed. We opted for an elaborated set of formative evaluations to ensure good usability, before performing summative and longitudinal evaluations. Such evaluations, which should also measure the learning impact, could not be undertaken due to the COVID-19 restriction imposed in 2020.

Notwithstanding that the results of the different formative evaluations were positive, the feedback received was used to considerably improve the system, and other suggestions were noted for future work. Still to be considered, and planned for future work is:

- Allowing youngsters to connect with each other with and within the TICKLE environment and to collaborate on the collection of cards.

- To provide a help functionality that a youngster could use when (s)he would be stuck on a challenge.

- To provide the possibility to use leaderboards as a persuasive technique when this is appropriate.

- To allow youngsters to create cards themselves. This will contribute to the investments made by the youngsters, but also to the fact that youngsters like to share their own material online. This functionality is already available, but a procedure needs to be added to prevent youngsters from creating cards that are not acceptable.

- Adding an intelligent matching algorithm to suggest cards to youngsters in an automatic way. Currently, this needs to be done manually by the supervisor of a youngster.

Although the environment was developed for dealing with school burnout, the environment is also usable in other contexts and for different purposes. We have demonstrated that TICKLE can be used for a large range of use cases: for team building activities, for information providing, and for non-formal learning activities, as well as in the context of regular education (for formal learning). Although we did not yet test it, we see more possible application domains, e.g., for tourism, for museums, for shopping opportunities in a city, for event announcements, for social engagement, etc.

To what extent does this still serve as an evaluation for your MPLE model? Maybe good to elaborate on that....

Event	**Description**	**Insights**
Card created	Triggered when there is a new card created.	Card is created in an particular Environment
User invited	Triggered when the user is invited by the admin.	Possibility that a new user will use the system
User registered	Triggered when the user is registered after being invited by the admin.	A new user that wants to try/use the system, Interests of this new user
User deleted	Triggered when the user is deleted.	An existing user that no longer wants to use the system, Feedback of the user who stops to use the system
User became inactive	Triggered when the user is inactive for a certain period, e.g. 7 days not logged in.	An existing user who loses the interest in the system; Feedback, why the user loses the interest in the system
User started the challenge of the card	Triggered when the user started the challenge of a particular card	Which user started, which card in which environment
User asked for help on the challenge of a card	Triggered when the user asks for help to perform the challenge of a particular card.	Which user asked for help on which card in which environment
User wanted to help another user	Triggered when a user wants to help another user with a particular challenge of a particular card.	Which user responded to help with which challenge for which user
User submitted the challenge of the card	Triggered when the user submitted the challenge of a particular card.	Which user, Which card, Which environment; Points earned by submitting the challenge on the card; Time elapsed to submit the challenge; Challenge succeed or failed; BookWidget result; Whether the user got help or not; Which user helped the user with the particular challenge
User collected a card	Triggered when the user collect the card by performing the associated challenge of the card	Number of collected cards of the user

Table 5.2: Event types of TICKLE and their corresponding insights

should come much earlier
I assume

CHAPTER 6

Discussion

CONCLUSIONS, LIMITATIONS AND FUTURE WORK

do we really need that again? that should be clear by now -> focus on discussion limitations/ main contributions

The traditional way of learning usually takes place in a classroom environment. In such an environment, the teacher can explicitly observe interaction and participation of the learners. The advantage is that the teacher can provide the appropriate interventions immediately. However, classic classroom teaching frequently faces difficulties. A specific challenge is that it might be difficult to gain or keep the attention from everyone in a large class due to the "one-size fits everybody" approach usually applied. On the other hand, modern communication technologies provide~~s~~ a situation of no boundaries to knowledge and thus could facilitate independent learning, as well as informal learning characterized as learning integrated into daily routines as ongoing, voluntary, and self-motivated pursuit of knowledge. While independent learning is an admirable aspiration, in practice for most people this will not be feasible. Most people are often overwhelmed by the sheer amount of information faced in the digital world. Therefore, many learners will continue to require guidance in their learning process. Leaving them entirely alone in learning activities can lead to dropout and loss of motivation. Especially the so-called digital native learners (Thompson, 2013), born after the 1980s and grown up with digital technology, have an ambivalent relationship with the overabundance of information online. On the one hand, they are used to a wide range of information technologies in their daily life, including search engines and social networks, instead of printing press (Helsper & Eynon, 2010), but on the other hand information is received fast, which makes them they switch fast and frequently between activities. However, fast switching between activities often results in a superficial view rather than an in-depth understanding of information because little time is taken to reflect or evaluate the information, neither for relevance, accuracy or authority. Therefore, we argue that even for informal learning, a learning environment could provide added value. Such a learning environment should provide ways but also guidance to explore interests freely and use them for future opportunities from a personal, professional or educational perspective. In this thesis, we introduced the Mobile Playful Learning Environment (MPLE) model that aims to provide a reference model for such type of learning environment. As proof of concept for the MPLE model, we developed TICKLE, a mobile playful learning environment for youngsters at risk for school dropout, and evaluated this environment in different settings.

what does the proof of concept verify/evaluate?

6.1 ~~Summary~~ Findings

In order to deal with the issues related to informal and lifelong learning introduced in the Introduction, including the limitations digital native learners, we started by formulating our main research objective and the related research questions. We now provide a summary of the findings ~~work~~ that has been described in this thesis, by providing the answers to the research questions and reflecting on the achievement of our research objective. We start by recalling our objective. Next, for each formulated research question we discuss the approach taken and our findings.

Research Objective: to create a conceptual framework for creating digital environments that offer opportunities for lifelong learning and can support informal as well as formal learning activities, and which are suitable for digital natives.

Research Questions:

- RQ1: How to empower the learner to realize that learning is not only a way to succeed in a formal school context but also a way to improve other areas of personal and social lives from a lifelong learning perspective?

In order to answer this research question, we started by looking into different forms of learning with or without support of technology and relevant for lifelong learning. To gain an overview of different learning strategies, we used informal, non-formal, and formal

is that not the same?

learning as categories to organize different types of learning and investigated their relationship with these types of learning. The purpose was not to only list different strategies and ~~to~~ inspect how they impact the learner in terms of knowledge construction, but also to analyze the components, ~~i.e. which~~ with respect to the steps ~~are~~ needed to make learning a successful activity in terms of efficiency, efficacy and ease. We considered Mobile Learning and Ubiquitous Learning because they focus on the learner seamlessly moving between different contexts and scanning the environment for learning opportunities. Playful Learning was considered because it imposes a fixed set of learning activities within a clear defined space by setting up a technology-enhanced playground where learners have to obey rules to succeed in a play-like fashion.

To recapitulate, the aim was firstly to obtain an overview of how learning is currently supported in a real-world context, but secondly to derive informal learning strategies that can inform the design of our ideal learning environment, ~~i.e.~~ We wanted to investigate which strategies that can empower the learner to realize the importance of learning for personal and social lives.

In this regard, Mobile and Playful Learning were deemed of special importance because they can blend aspects of informal and formal learning in a way that blurs the boundaries between these concepts. For instance, mobile technologies can be used in the classroom as additional tool to access teaching materials but they can be also used to access environmental information to enrich the interaction with learning material. Within our ideal learning environment learning strategies that combine aspects from formal and informal learning are important to provide openness and guidance at the same time, i.e. the learner can freely move within the learning space and discover learning opportunities but is also restricted in the sense that boundaries to the learner are shown to provide guidance and goal orientation.

Next, we reviewed learning paradigms relevant for Lifelong Learning. In particular the Experiential Learning of Kolb, which is described as a constructivist learning paradigm, was considered important for achieving our goals. Kolb observed that reflection is the key step in experiential learning to show the value of information for personal aims and the applicability of knowledge in wider contexts. When reflection succeeds, a so-called learning identity can be formed which is an attitude to embrace the world and its settings as resources for learning. A person with a great learner identity actively seeks for opportunities to learn and gain more knowledge about the world. Therefore, we also discussed the concept of Learner Identity.

- RQ2: How can we guide the learner in the learning process and persuade ~~him~~ them to be active while maintaining the openness and non-committal character of informal learning?

The insight that we gained by studying the work of Kolb and the importance of reflection served as the starting point for dealing with RQ2, namely to investigate how we can guide the learner in the learning process and support the phase of reflection while maintaining the sense of openness and non-commitment ~~from~~ of informal learning and playful learning. For answering this question, we looked at the field of persuasive technology. Persuasive technology has already been applied in contexts such as marketing but rarely found its way ~~in~~ to education, where ~~It~~ it could be used to guide and persuade the learner to be active. Next, persuasive technology also takes behavioral models into account.

Based on the decision to use persuasive and reflective technology to guide the learner, we first continued ~~with~~ by answering research questions resulting from this approach taken for answering RQ2:

so these question were not defined in the beginning then but only after chosen reflective technology?

- RQ3: What is the role of reflection in the persuasion process and what techniques are available to facilitate reflection?

- RQ4: Which aspects of existing persuasive and reflective technology can be applied?

To answer RQ3, we further studied models for supporting reflection in HCI. Already in early 2000, Fogg mentioned self-monitoring as a starting point to convince the user to start to reflect on behavior and change it for the better. By taking inspiration from ~~Mr~~

that you also referred to it as Hooked model earlier? → check

Eyal's Hook model, we propose to embed the reflection process as self-monitoring in a so-called learning pipeline, and to utilize different human-computer interaction techniques to scaffold this process. Fore this we decided to look at visualization not only to persuade the user for continuous usage but also provide~~s~~ ways to scaffold the self-reflection process. Regarding RQ4, we studied existing persuasive technologies in the context of HCI. As overall process model, we mainly based ourselves on the hook model of ~~Nir~~ Eyal. This process model provides a number of sequences the user has to go through to be hooked to a product, meaning the user is ready to use the product over a longer period of time and come back to it when a need arises that product solves immediately. In each step of the model's cycle different techniques from psychology are applied. For instance, in the rewarding phase the integration of game-based concepts familiar to youngsters, such as collecting points and obtaining rewards, could be a way to motivate learners to use the environment. In software development, this is known as gamification. Game mechanics, such as points, badges, leaderboards, avatars or stories, can be integrated into the environment to scaffold playfulness. Furthermore, the Six Principles of Persuasion, Fogg's Behavioral Model, and the Persuasive System Design (PSD) model were selected for use in our solution. The choice of using visualization techniques to provide ways to scaffold the self-monitoring (to support self-reflection) resulted in the research question RQ5 and RQ6:

- RQ5: Which visualization techniques are suitable for for self-monitoring in the context of informal learning?
- RQ6: What kind of data can be accumulated in the learning process and how can this data be transformed into a meaningful visualization?

These two research questions focused on ways to make self-monitoring more efficient by means of visualization techniques. We started by studying existing Information Visualization for reflection and decision making to select suitable techniques for integrating meaningful visualization into our solution.

One obvious candidate was the so-called timeline to highlight the events with a value of learning. Therefore, a classification of events that might have a learning value or can be used to recommend learning activities is needed. In our proof of concept application, called TICKLE, we designed and implemented such a visualization solution and evaluated it with youngsters. The result was that users liked the fast access to past learning activities to reflect on them with additional information. But they struggled to gain additional knowledge from the visualization itself and its presentation of screen space as time. The aesthetic presentation was deemed useful but the encoding of data was of secondary value.

did you really describe those (apart from showing them in a figure)

Besides this, we also investigated visualizations to show different categories of learning content. The technique used in the TICKLE prototype is called Bubble Sets and described in. It was chosen because aesthetically it integrates well in a playful context due to use of manifold colors and soft shapes that can be often found in video games. ~~It~~ Bubble sets facilitate~~s~~ the comprehension between sets of information and the relations between them in form of subsets. This type of visualization makes sense if sufficient learning content is present, ~~Then, this visualization~~ providing ~~can be~~ a fast way to access learning content target-oriented and to discover related activities.

The last research question RQ6 focused on the type and format of the data necessary to be visualized. In the beginning of the design of the TICKLE application, we were certain that time and geolocation data are candidates for meaningful visualization but also learning categories were deemed useful if a certain overlap between categories exist. Therefore, we developed an event framework that tracks every behavior in the platform in a with the help of a rudimentary grammar consisting of an actor, also called subject, an action (predicate) and an object. This basic grammar is is heavily inspired by the xAPI (ref?) specification which defines statements or that keep track of learning experiences happening in e-learning software. Therefore, they define the structure of a learning record store that keeps track of all different learning activities and makes them accessible to the developer for later usage which ~~is~~ in the form visualization in our case. Our event system does not only provide ~~a~~ the scaffolding for the current visualization used in TICKLE but also for future visualizations because not all types of events have been exploited in the current version of TICKLE. The core idea is the same as in the xAPI with the difference that we do not use the learning record store as additional abstraction layer. Our solution is represented directly in the database which mitigates the risk of performance overheads and the usage of powerful real-time ~~realtime~~ update functionalities of modern databases.

not sure whether I got it.

After having answers to all our research questions, we returned to our research objective: to create a conceptual framework for creating digital environments that offer opportunities for lifelong learning and can support informal as well as formal learning activities, and which are suitable for digital natives. To understand the needs and characteristics of digital natives, we studied the literature in this context. The results are reported in section 2.3. Next we also studied different Technology-Enhanced Learning Environments (section 2.4) to position our solution, and studied related work (Chapter 4). Based on all the findings, we defined the Mobile Playful Learning Environment (MPLE) Model. We motivated the main features of such an environment and its learning pipeline and indicate how the different components in this pipeline interact with each other to achieve their goal. In this way, we reached our research objective: to create a conceptual framework for creating digital environments that offer opportunities for lifelong learning and can support informal as well as formal learning activities, and which are suitable for digital natives. In **??**, we have positioned ? MPLE in the overview figure given in chapter 2 (i.e. Figure 2.1). As a proof of concept, we developed and evaluated TICKLE, a mobile playful learning environment for youngsters at risk for school dropout. As already indicated while answering some of the research questions, the development of this proof-of-concept provided answers to some of the research questions for the specific case. Those questions seem to be hard to answer in general, and the context for answering them seems to be important. ?

you should definitely explicitly summarize the main contributions of your work!! i.e. what's your contribution to knowledge

6.2 Limitations & Future Work

In the previous section we summarised how our research trajectory led to our MPLE conceptual framework and the proof-of-concept prototype called TICKLE which supports informal (non-formal) learning practices and provides a link to formal learning activities to some extent. In this section we discuss the limitations of these research artefacts which are of conceptual and technical nature.

- The scope of informal learning could not be fully captured in the MPLE framework. and th Validation of informal learning ~~has not been~~ is not covered by the MPLE framework.
- The implementation of MPLE is limited compared to the scope of the MPLE framework. Some features of the MPLE could not be represented in the TICKLE application. which ones? why?
- Many features to streamline the usability and user experience of the TICKLE prototype could not be realized.

if you capitalise Chapter, then I would also do it for Section (which I would prefer)

First of all, Informal learning is a broad topic and discipline including many different activities and mental processes. In this dissertation, we focused specifically on reflective practices (based on Kolb and others described in Chapter 2) to improve informal learning. But there are many more activities that occur away from a structured, formal classroom environment which happen to be informal learning. It comes in many shapes, including viewing videos, self-study, reading articles, participating in forums and chat rooms, games and so on. It's impossible to consider all these different activities within one conceptual framework and one proof of concept application. One has to make decision which features to include and which not in a research project that is limited in terms of time and money. Right now, the MPLE framework is a closed system focusing on learning activities such as mini-games, quizzes and photo-challenges supported in the framework itself. But in the future, we want to examine how to extend the framework to activities happening outside the system. As already ~~said~~ mentioned, informal learning has many shapes and forms. One has to come up with a flexible communication service to other platforms of informal learning to capture better the scope of informal learning. We showcased such a principle with a prototype implementation to communicate with the Canvas LMS to represent learning units. But in the future this mechanism needs to be cleanly represented in conceptual framework itself, which is not yet the case.

Explained earlier?

Moreover, only limited research has been done in the validation of informal learning practices, i.e.ways to showcase achievements performed in informal learning to peers and instructors. This is especially difficult because by definition informal learning does not lead to any certification. However, The European Council's Recommendation in December 2012 urged member states to proceed with the validation of non-formal and informal learning, to enhance employability and mobility of the youth on the job market. In lifelong and life-wide learning, 'validation' is a crucial element to ensure visibility and to indicate the appropriate value of the learning that took place anywhere and at any time in the life of the individual (Colardyn & Bjornavold, 2004). Validation has the potential to bring wide benefits to young people who are in danger of dropout. Finding opportunities in informal learning practices that happen outside of school can lead to a huge confidence-boost which is the first step towards a return to formal learning or finding a pathway to employment.

In the context of the TICKLE app, the authoring of learning activities has been identified as a bottleneck to create fast and effective informal learning experiences. It takes a major effort to create meaningful learning activities because the author has to consider a wide range of different learning variables, i.e. the description, aims, location, classification and content of a learning activity. During the development, we identified a range of web services as possible ways to scaffold the authoring by prefilling certain variables. For instance, Google Maps offers a service to identify points of interests which could serve as as possible locations for learning activities. Or certain A.I.-powered web services can auto-classify content to free the instructor from this task.

(of course AI solves everything :-)
(not AI but machine learning anyway)

validate?

To conclude, the TICKLE app is only prototypical implementation of the MPLE framework. It was created to represent main features of the corresponding framework but not to be a production-ready application. This was also reflected in the evaluation where students faced problems in some of the learning activities and visualization tasks. Especially, the navigation was a problem. Some users struggled to exit menus and did not know that they could interact with some features of the visualizations.

6.3 Conclusions

Appendices

APPENDIX A

EXPERIMENTAL EQUIPMENT

A telescope and a spectrometer were used to analyze the sun. Many other instruments were used.

APPENDIX B

DATA PROCESSING

Data was processed before being added to this document.

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VITA

Clark Kent was born on April 18, 1938, and adopted by parents Jonathan and Martha Kent in Kansas. He currently resides in the city of Metropolis, where his reporting for the Daily Planet has earned him critical acclaim both at home and abroad. He frequently collaborates with such fellow journalists as his Pulitzer-winning wife Lois Lane, close friend James “Jimmy” Olsen, and longtime editor Perry White.

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