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AFFORDANCES AND SIGNIFIERS IN VIRTUAL LEARNING ENVIRONMENT DESIGN

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ABSTRACT

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Virtual learning environments (VLEs) represent a relatively new mode of teaching. In the design of these environments, along with acknowledging the demands already set for education, it is essential to understand how individuals perceive and understand the technology used. Perceived usability is a concept that describes product or service design in terms of how people understand its usefulness and ease of use. These understandings are derived from the properties and functions of objects, i.e. affordances, offered by different clues, i.e. signifiers, alluding to how the objects may be used. This thesis is implemented as a literature review. It aims to define the concept of VLEs and inspect the perceived usability within them. The thesis also aims to inspect the role of affordances and signifiers in perceived usability, as well as map the ways to utilize affordances and signifiers as a part of the VLE design. Based on the literature, VLEs, or e-learning environments, are characterised by technology-based learning maintaining flexibility regarding time, space and geographical location. Additionally, these environments are also adaptable and authentic spaces inhabited by their users. Furthermore, crucial for e-learning continuance are satisfaction and performance level influenced by perceived usability. Detected affordances and signifiers influence this perceived usability, as they both enhance the conveyance of information about the product's qualities and the assessment of its functionality and appropriateness for usage. In VLE design, the role of affordances has been researched more than the role of signifiers. Affordances have been studied both as a part of VLEs and in the study of learning effects of VLEs.

Keywords: Virtual Learning Environment, E-learning, Virtual Reality, Affordance, Signifier, Semiotics, Perceived Usability

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Virtuaalioppimisympäristöt edustavat suhteellisen uutta opetusmuotoa. Näiden ympäristöjen suunnittelussa on opetukselle asetettujen vaatimusten huomioimisen lisäksi oleellista ymmärtää yksilön tavat kokea ja ymmärtää käytössä oleva teknologia. Koettu käytettävyys on käsite, joka kuvaa tuote- tai palvelusuunnittelua siltä osin, kuinka ihmiset ymmärtävät käytettävyyttä ja käytön helppoutta. Nämä ymmärrykset on johdettu kohteiden ominaisuuksista ja toiminnoista eli affordansseista, jotka ovat erilaisten vihjeiden eli merkitsijöiden tarjoamia viittauksia siitä, miten kohdetta voidaan käyttää. Tämä tutkielma on toteutettu kirjallisuuskatsauksena. Sen tarkoituksena on määritellä käsitteenä virtuaalioppimisympäristöt sekä tarkastella koetun käytettävyyden ilmenemistä niiden kohdalla. Tutkielman tarkoituksena on myös tarkastella affordanssien ja merkitsijöiden roolia koetussa käytettävyydessä sekä kartoittaa tapoja hyödyntää affordansseja ja merkitsijöitä osana virtuaalioppimisympäristöjen suunnittelua. Kirjallisuuden pohjalta virtuaali- tai e-oppimisympäristöjä luonnehditaan teknologia-pohjaisiksi ympäristöiksi, joissa oppiminen on joustavaa suhteessa aikaan, paikkaan ja maantieteelliseen sijaintiin. Tällaiset ympäristöt ovat myös mukautuvia ja todentuntuisia, käyttäjiensä asuttamia tiloja. Lisäksi e-oppimisen jatkuvuudelle on ratkaisevaa tyytyväisyys ja suoritustaso, joihin koettu käytettävyys vaikuttaa. Koetut affordanssit ja merkitsijät vaikuttavat tähän koettuun käytettävyyteen edistämällä sekä tiedon vastaanottoa tuotteen ominaisuuksista että tuotteen arviointia sen toimivuuden ja käytön tarkoituksenmukaisuuden osalta. Virtuaalioppimisympäristöjen suunnittelussa affordanssien roolia on tutkittu enemmän kuin merkitsijöiden roolia. Affordansseja on tutkittu sekä osana virtuaalioppimisympäristöjä että virtuaalioppimisympäristöjen opetuksellisten vaikutusten kohdalla.

Asiasanat: virtuaalioppimisympäristö, e-oppiminen, virtuaalitodellisuus, affordanssi, merkitsijä, semiotiikka, koettu käytettävyys

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1 INTRODUCTION

Use of virtual learning environments (VLEs) as a new mode of teaching has a growing role in education. This places certain expectations on virtual learning environments in terms of their design. On the one hand, virtual learning environments are expected to have a certain level of comfort regarding their use: in addition to its easy usability, a virtual learning environment should succeed in keeping the learner's degree of interest, which is shown through meaningful learning. On the other hand, VLEs like any other educational models need to meet the requirements set out in general education. One of these requirements is that the appropriate kind of technology is used, so that sharing learning material is effortless. (Piccoli, Ahmad & Ives, 2001.)

However, successful delivery of virtual learning environments design does not only require awareness of criteria established for learning environments, rather it is also important to understand individual ways of perceiving and experiencing the technology used. In general, humans have an innate need to understand the properties and intended use of a product or service, as this understanding supports the right kind of use (Norman, 2013). This right kind of use, or use in general, is influenced by how useful the product is or how easy it is to use (e.g. Davis, 1989). Thus, perceived usability, a part of the user experience, can be seen to have a significant role in the design of virtual learning environments: it is particularly important to be aware of those expected requirements of a finished product or service already in the design phase, as they are also expected by users. Such requirements are, for example, the intended use of the product or service, as well as the easily observed, intended use of it. (Norman, 2013.)

As potential benefits derived from the product assist in the formation of user experience (Law, Roto, Hassenzahl, Vermeeren & Kort, 2009), successfully derived intention of use may facilitate particularly positive experience. Thus, any sign or clue, which can provide information about the use of a product or its functions is important. This user-needed provision of the use or features and functions of the product or service seems to be the role of a signifier. (Norman, 2013.) On the other hand, the kind of experience a user forms through observ-

ing a service or product is important information in human-technology - interaction (HTI) research as perceiving affordances may guide the user's actions by formulating the basis for understanding the meaning of an object (Lu & Cheng, 2013). Thus, the fulfilment of requirements depends largely on those opportunities of possible functions, that a user perceives, i.e. affordances. Perception of affordances is not self-evident, and declaration of their existence is also an important role of a signifier. (Norman, 2013.)

As stated above, educational standards are required to extend into virtual ways of learning, similarly as they are included in traditional learning. Yet, the technology dimension of VLEs is something that is needed to be taken into even more consideration, especially in a way learners perceive and understand the technical features built into virtual environments. Thus, the need for the research of affordances and signifiers within the design of virtual modes of learning is justified. This is also the aim of this thesis. The perspective of the review is here limited to whether the affordances and signifiers have been studied in relation to virtual learning environments, and if so, in what ways. Thus, on the basis of objectives for the thesis the research problem here is to find out how affordances and signifiers appear in the design of virtual learning environments. The research problem is approached with three research questions:

1. What are virtual learning environments and how they differ from traditional learning environments?
2. What role do affordances and signifiers play in perceived usability?
3. How have the roles of affordances and signifiers been researched in relation to virtual learning environment design?

The thesis is implemented as a literature review, in which Google Scholar and Scopus were used. Search words utilised in the process were the following main concepts of the thesis: "*Affordance*", "*Signifier*", "*Semiotics*", "*Perceived Usability*", "*Virtual Learning Environment*", and "*E-learning*", as well as different variations of these concepts. Since this thesis approaches the concept of virtual learning environments through traditional learning environments, the search words of "*Traditional Learning*" and "*Learning Environment*" were used as well. Also, the concept of "*User Experience*" was included in the literature search for affordances, signifiers and semiotics, as it represents the root concept of perceived usability. Moreover, the publications referring to perceived usability conducted the sub-concepts of "*Perceived Usefulness*" and "*Perceived Ease of Use*", which were also included in the search. Some of the publications found used a shortening of VLE as referring to virtual learning environments, so this form was also added in the search to retrieve more outcomes of publications. Some of the articles and publications were searched directly based on the information referred to in other searched articles. For example, the lecture publication of Ferdinand de Saussure was found this way. Overall, the found source literature was sifted out by going through keywords and abstract of articles as well as estimating the relevance of publications in relation to the thesis topic. Based on the references chosen for this thesis, the selected literature covers mainly academic researches and

publications. Additionally, also a few books with fundamental information about the main concepts of the thesis are included. Furthermore, several articles published in academic journals as well as one doctoral thesis are included.

The thesis is structurally divided into three content chapters, followed by the conclusions. Chapter two aims to respond to the question of what is meant by virtual learning environments and how it differs from traditional learning environments. The question is approached by first defining the concept of learning environments which is then reflected against the concept of the virtual form of learning environments in a comparative way. Additionally, perceived usability is inspected within VLEs. The third chapter, in turn, deals with affordances and signifiers regarding their definitions as well as to their connections with each other, and the impact of these concepts on perceived usability. At the beginning of this chapter is a sub-chapter about the semiotic context of signifiers which has had its effects on the Norman's (1999; 2013) concept of signifiers, that is also based on the concept of affordances. In the fourth chapter the previous research of affordances and signifiers in human-computer interaction (HCI) and HTI study, especially in product design, is viewed. Then, the focus transfers into affordances' and signifiers' role in former research of educational VR technology. The fifth chapter of conclusions brings together the main results of the previous chapters. The results are considered and of which the conclusions of this study are formed. Finally, the reliability of the conclusions is estimated and advanced research topics of the thesis' area are presented.

2 VIRTUAL LEARNING ENVIRONMENTS AND PERCEIVED USABILITY

One of the most traditional forms of learning can often be seen to refer to classroom teaching where the learning occurs under the lead of the teacher. Contrary to this, one primary way for students to interact in virtual learning environments (VLE) is with other networked participants via widely disseminated information tools (Wilson, 1996). Although the gap between these two learning modes seem substantial, the use of technology has been blended into traditional learning methods for quite some time. This can be referred to as blended learning which combines technological elements such as multimedia, video streaming, email and online text animation with more traditional learning techniques, such as one-to-one coaching (Thorne, 2003). However, there are still many other features yet to be distinguished from VLEs that shape them into an independent mode of teaching, in contrast to classroom teaching.

This chapter discusses the specific features connected to VLEs which are first approached by the inspection of what features are linked to learning environments in general. After this, the distinction of VLEs from the traditional ones is made. Additionally, the issue of perceived usability within VLEs is approached by first defining the concept of perceived usability and its connections to user experience and then inspecting the appearance of perceived usability in VLEs.

2.1 Learning Environments

In approaching the definition of learning environments, Wilson (1996) discusses the word "instruction" and assumptions of time and place, product delivery, and systems and processes related to it. Given the characteristics of instruction, it is defined as happening in a certain place at a certain time, the usual setting being classrooms during 50-minute intervals. The product delivery refers to the instruction as transmitting and processing the information. Systems and pro-

cesses, in turn, refer to steps and stages of instruction as well as inputs and outputs, interlocking mechanisms, and controls of flow. (Wilson, 1996.) These kinds of systems and processes in education can be for example a curriculum and the chosen literature. Additionally, Wilson (1996) reflects the instruction to environment: when instruction is thought of as an environment, the focus is on the place of learning. Thus, a learning environment can be assumed to contain the learner and a setting or space where the learning itself occurs. Based on this, Wilson (1996) states that a learning environment can be defined as "a place where people can draw upon resources to make sense out of things and construct meaningful solutions to problems" and in which "learning is fostered and supported, but not controlled or dictated in any strict fashion". The teacher is also emphasised as his/her role is to ensure that an environment includes proper support and guidance and rich resources and tools. (Wilson, 1996, 3–5).

Based on his inspections stated above, Wilson (1996) divides learning environments into computer microworlds, classroom-based learning environments and open virtual learning environments. Of these three categories, computer microworlds represent self-contained computer-based environments in which students enter to learn. These microworlds can be separate environments or supported by a larger classroom environment. Classroom-based learning environments, in turn, represent the primary learning environments, classrooms, where various technologies may support traditional classroom learning activities. The latter, open virtual environments represent computer-based learning environments which are relatively open to interactions and encounters with other participants, resources and representations. (Wilson, 1996.) Basically, these open virtual environments refer to virtual learning environments which are characterized for example as virtual and social spaces for information storing and sharing (Dillenbourg et al., 2002). Additionally, social media is also included in the inspection of current VLEs: the usage of online social networking, such as Facebook, Twitter and MySpace, and different modes of blogs and weblogs as virtual learning tools are quite examined topic in HCI (see Sim & Hew, 2010; Paul, Baker & Cochran, 2012; Wang, Woo, Quek, Yang & Liu, 2012). The more detailed characters of VLEs will be discussed later in this thesis.

Wilson's (1996) way to distinguish the learning environments into three categories, which are summed up in the table below (Table 1), is quite radical, since there are also some similarities to be identified in their characteristics. Perkins (1992) states that regardless of the type of a learning environment, there are five key aspects to be identified: information banks, symbol pads, phenomenaria, construction kits and task managers (Table 1). Of these five aspects, information banks are any resources that serve explicit information about topics, such as the teacher, dictionaries and encyclopaedias to name a few. Symbol pads, in turn, are surfaces for the construction and manipulation of symbols, which support learners' short term memory. For example, notebooks and worksheets can be such symbol pads. Phenomenaria, instead, refers to areas for presenting, observing, and manipulating phenomena. The main idea of phenomenaria is to pick up aspects of the world and bring them to students for inspec-

tion and exploration. (Perkins, 1992.) For example, video games used in teaching offer these kinds of aspects. The construction kits are packaged collections of content components for assembly and manipulation. Despite their similarity to phenomenaria they are not so tied into the real world. For example, physical construction sets, such as Legos represent these kinds of construction kits. (Wilson, 1996.) Finally, task managers are elements of the environment, such as the teacher, answer lists of texts or even learners themselves, which set tasks for learning, guide and help with the execution of those tasks, and provide feedback (Perkins, 1992).

Table 1 Views of learning environments (LE)

Author(s)	**View**	**Division**	**Characteristics**
Wilson (1996)	Categories of LE	Computer microworlds	Self-contained, computer-based
		Classroom-based environments	Primary environments
		Open virtual environments	Computer-based, open to interactions
Perkins (1992)	Aspects of LE	Information banks	Explicit information resources (e.g. dictionaries)
		Symbol pads	Surfaces for construction and manipulation (e.g. notebooks)
		Phenomenaria	Present, observe and manipulate phenomenaria (e.g. video games)
		Construction kits	Assembly and manipulation tools (e.g. Legos)
		Task managers	Set tasks, provide guide and feedback (e.g. teacher)
Hannafin & Land (1997)	Dimensions of LE	Psychological	Ways to acquire and use knowledge
		Pedagogical	Activities, structures, methods
		Technological	Possibilities of advances in technology
		Cultural	Beliefs, cultural values, roles in society
		Pragmatic	Pedagogical models in practice

These five aspects represented by Perkins (1992) (Table 1) do not always feature in the learning environment at the same time, or at all, as it is possible that some learning environments emphasize some aspects more than others. Based on this, learning environments can be divided into minimalist and rich ones (Perkins, 1992). In minimalist learning environments learning occurs through using information banks for instruction and symbol pads for exploring and problem-solving. As for task management, only a little is left to learners themselves. Rich

environments, in turn, highlight construction kits and phenomenaria, as responsibility for task management is mainly in the learners' own hands. Thus, in these rich environments "students are typically engaged in multiple activities in pursuit of multiple learning goals, with the teacher serving the role of coach and facilitator" (Wilson, 1996, 7). In other words, the rich environments seem to emphasize the learners more as active operators towards their learning goals.

Both Wilson and Perkins focused their inspection on the features of learning environments. As for the inspection done by Hannafin and Land (1997), learning environments are seen through five conservative dimensions: psychological, pedagogical, technological, cultural and pragmatic (Table 1). Of these the psychological dimension focuses the ways that knowledge is acquired and used. These ways are inspected through different design frameworks, activities, and strategies in order to reflect beliefs about how individuals think, learn, understand and act. The pedagogical dimension focuses on the activities, methods, and structures of the learning environment as it emphasizes the ways of how an environment is designed so that its affordances are made available. The pedagogical dimension, in turn, can be seen to include the pedagogical models of the basis for designing the environment, and the technological dimension includes the possibilities of advances in technology meaning the capabilities and limitations of available technologies that can be optimised. (Hannafin & Land, 1997.) This technological dimension seems to be relevant nowadays, as the learning modes are heading towards virtual applications already in elementary schools. The cultural dimension, in turn, focuses on prevailing beliefs about education towards cultural values and the roles of individuals in society. Finally, the pragmatic dimension emphasizes the practical reasons in choosing the appropriate approaches to be used in each learning environment. This dimension also dictates the blend aspects of varied pedagogical models applied in learning environments. (Hannafin & Land, 1997.) When comparing these dimensions to each other, the pragmatic dimension is somewhat similar than the pedagogical dimension, as they both include consciousness about pedagogical approaches towards learning.

Although the information presented in the table of differing views of learning environments is stated over twenty years ago (Wilson, 1996; Perkins, 1992; Hannafin & Land, 1997), there can be found studies that support this information also today. Wilson (1996) emphasised the role of the teacher, or the instructor, in terms of fostered and supported learning with guidance and rich teaching tools. Additionally, Perkins (1992) mentions the teacher's role both as an information bank and a task manager. Additionally, the teacher's role is also present in the pedagogical and pragmatic dimensions by Hannafin and Land (1997). The emphasis of the instruction and guidance is also present in the study by Lizzio, Wilson and Simons (2002), which states that the elements of the learning environment provided by a teacher are related to students' learning outcomes. Since these properties of the classroom environment are related to learning outcomes, they indicate that the effort used for improving the class-

room environment is also very likely to improve the student outcomes in studying (Fraser, 2015).

Although the role of the teacher is considered quite essential in the education, it seems that even more emphasis has been moved towards students' role in learning. Results of many studies seem to emphasize learners' ideas and ways of making sense of the world as the key factors in developing teaching strategies and learning materials as well as curriculums (Eylon & Hofstein, 2015). This, on the other hand, can be directly linked to the psychological dimension of how students acquire and use knowledge in the provided setting (Hannafin & Land, 1997), since these changes in settings influence students' motivation and learning (Eylon & Hofstein, 2015). As for the changes in settings, they can vary within instructional approaches as well as physical setting all the way from small group cooperative learning in school to use of games outdoors (Eylon & Hofstein, 2015). Basically, this expands the three-division of learning environments by Wilson (1996) even further. In sum, it is possible to influence on learners' motivation and learning outcomes via providing different opportunities in learning settings with which the learning itself can be extended further. Still, some part of the learning remains in the hands of the learner, such as the control of time and place used for the learning outside the classroom (Piccoli et al., 2001).

2.2 Virtual Learning Environments

Before continuing the discussion towards defining VLEs, it is necessary to first define the concept of e-learning, as some of the articles refer to VLEs as e-learning environments. Sun, Tsai, Finger, Chen and Yeh (2008, 1183–1184) refer e-learning as both "the use of telecommunication technology to deliver information for education and training" and "a web-based system that makes information or knowledge available to users or learners and disregards time restrictions or geographic proximity." Zhang, Zhao, Zhou and Nunamaker Jr (2004) view e-learning also as technology-based learning in which the material delivering and learning happens via a computer network. Thus, this can also be assumed to be done without any limitations of time and place.

The concept of virtual learning environment is first approached by Dillenbourg et al. (2002), who examines it through three different spaces: a designed information space, a social space and a virtual space. VLE as a designed information space refers to the architecture of the information included in the environment that results from analysing numerous requirements like multi-authoring and information sharing and using in educational interactions. Multi-authoring means the mechanisms that share objects of VLE when needed. Additionally, information using and sharing in educational interactions includes also the ways to produce dynamic responses in learning activities. (Dillenbourg et al., 2002.) These dynamic responses are the interactions that remain as an active and developing element among all participants in the virtual environment. VLE

as a social space refers to the educational interactions occurring in the environment; the social aspect steps forward as students see who else is interested by which information (Dillenbourg et al., 2002). This social space can therefore be seen to consist of student profiles by which the experience of communality can be gained, as participants can see the information viewed from others. VLE as a virtual space refers to the representation of which information and social aspects a virtual environment offers. This representation impacts the learning process beyond motivational aspects as it signals to students what is needed to be done with it. For example, the representation should both support navigation by informing users about the moves and position of others in the workspace, and facilitate collaborative tasks among users. (Dillenbourg et al., 2002.) Because of the emphasis of collaborative tasks, information search and responsive action in a virtual educational setting, the main idea of Dillenbourg et al.'s (2002) division seems to be that students are the actors who co-construct the virtual space by contributing social and information space.

The view by Dillenbourg et al. (2002) emphasised the characteristics of virtual learning environments through spaces. Instead, Kalay et al. (2004) discuss about inhabitation of VLEs: based on their inspection virtual environments create senses of places as they are "inhabited" by their users. This inhabitation involves social and cognitive engagement with objects and/or people who populate the environment, and therefore, they require presence (Kalay et al., 2004). Presence, in turn, along with the location promote a sense of authenticity: users know they participate in a "real" event, rather than view a previously recorded one. Presence and location also promote adaptability, since the place can be appropriated for the specific needs of the learner by placing, re-arranging and adding objects or symbols, making the place personal. This also emphasizes the authenticity of the place. (Kalay et al., 2004.) In sum, the social and cognitive engagement in VLEs along with the authenticity are emphasised as the enhancing contributors of supported learning. This indicates that a certain level of engagement by learners is needed for learning to be efficient in gaining the wanted results. Moreover, this learners' engagement can be even instructed towards the suitable settings of learning to be occurred by locating VLEs in a more appropriate context or time frame that reflects the qualities associated with the learned content (Kalay et al., 2004).

The concept of VLEs can also be approached by comparing their features to traditional learning environments. Zhang et al. (2004) represent the main advantages of e-learning to be unlimited access to knowledge, cost-efficiency, and capability to store knowledge for reuse and sharing. These advantages also include the flexibility towards time, location and learning space presented earlier by Sun et al. (2008). Another advantage feature about VLEs is that they support both distance and presential learning which makes them more robust. VLEs can also overlap many physical environments together, such as non-computerised learning resources (instruments and books), not computer-mediated interaction (e.g. face-to-face and group discussions) and not computer-based activities (e.g. field trips and role playing). (Dillenbourg et al., 2002.) Uzunboylu, Bicen and

Cavus (2011) have also attained this kind of results about VLEs as they conducted the research about the effects of Windows Live Spaces integrated with different Web 2.0 tools to learning. Results of their study showed that WLS environment integrated with Web 2.0 tools supported students understanding of lessons and thus made their learning more efficient. Based on this, it is indicated that VLEs bring a new dimension to distance learning, as they enable students to perform various tasks within the same learning environment. (Uzunboylu et al., 2011.)

As continuing the positive features of VLEs, Kalay et al. (2004) inspected the characteristics of learning as a phenomenon by discussing the occurrence of learning in different settings. Although traditional learning can be characterised by communication (Zhang et al., 2004), Kalay et al. (2004) state that it is missing the characteristics of inhabitation and presence of virtual learning:

> Learning, as an activity, takes on a very different meaning in the absence of complementary environmental cues: it operates more on the level of communication than on the level of inhabitation and presence. Communication is a process that looks at information from the outside: even though the observer can interact with the information, s/he is not part of it. The computer screen, much like the printed page of a book, stands for a separation from the information, rather than a connection with it. (Kalay et al., 2004, 199.)

By this quote Kalay et al. (2004) emphasize the difference between the traditional way of learning and learning via virtual space in terms of using the technology, such as a computer. Based on the quote, if a user reads information through a computer screen, s/he only receives the information, rather than interacts directly with it. In the virtual space, on the other hand, the user is also present in the learning as an actor, since s/he experiences the learning by acting as s/he receives information and shares it forward.

Even if many positive aspects can be pointed out from VLEs, compared to traditional classroom modes, e-learning is not suitable for every aspect of learning. For example, before integrating this kind of environment into educational applications, it is important to consider different expectations and individual differences along with the right educational method (Uzunboylu et al., 2011). In some cases, it is also possible for VLEs to cause more frustration, anxiety and confusion to a user (Zhang et al., 2004), even though the perceptions of students would be positive in general towards virtual way of learning (Uzunboylu et al., 2011). Additionally, Dillenbourg et al. (2002) state that technology cannot entirely replace presence-learning: even a small amount of co-presence may solve some of the problems that can't be solved at distance. A few examples of these modes of learning that need to involve co-presence, are launching a new project, complex technical assistance and negotiation that are important especially for vocational training, university courses and lifelong learning. (Dillenbourg et al., 2002.) Additionally, unlike VLEs, traditional classroom learning enables immediate feedback, since the instructor is present at the same time (Zhang et al., 2004). Hence, the advantages and disadvantages seem to go in both directions in case of juxtaposition of completely virtual or traditional learning modes.

2.3 Perceived Usability and Its Link to Virtual Learning Environments

The concept of perceived usability is quite extensive in the literature. For example, Hassenzahl and Monk (2010) refer to perceived usability as pragmatic quality by which they mean a judgement of a product's potential to support its given "do-goals". These do-goals mean functional tasks, such as making a telephone call (Hassenzahl & Monk, 2010). Pragmatic quality also includes the assessment of the appropriateness of the functionality provided in addition to the ease of access to this functionality (Hassenzahl & Monk, 2010). In sum, a product should be practical, easy to use and function appropriately towards the situation. Davis (1989), in turn, approaches perceived usability with the definitions of perceived usefulness and perceived ease of use: People tend to use an application in relation to whether the application is seen to help performing the job better. Thus, perceived usefulness is "the degree to which a person believes that using the system would enhance his or her job performance" (Davis, 1989, 320). Yet, although a potential user would believe the usefulness of a given application, the system might be also experienced too hard to use. Thus, the effort of using the application becomes more relevant than the performance benefits of usage. Therefore, perceived ease of use is "the degree to which a person believes that using a particular system would be free of effort." (Davis, 1989, 320.) Especially the perceived usefulness is a strong correlate for user acceptance, because users are firstly driven to adopt an application by the functions it performs for them. This is followed by how easy or hard it is to get the system to perform those functions, which leaves the perceived ease of use as secondary aspect. (Davis, 1989.) This can be also somewhat contextual of whether a person overcomes the fact of having a system that is not that easy to take in usage.

Perceived usability can be linked to the extend concept of user experience, since user experience is something dynamic, context-dependent and subjective that results from various potential benefits that users may derive from a product (Law et al., 2009). Furthermore, user experience is related to usage as it can be broadened to products, systems, services and objects with which a person interacts through a user interface (Law et al., 2009). This view is also supported by Pucillo and Cascini (2014) who state that user experience is a consequence of user's prior experiences, attitudes, skills, habits and personality. Rousi (2013), in turn, approaches user experience through semiotics, as she states that user experience concerns two types of explicit representations: explicit representation of the design and of the information delivered by the user in response to representation. Based on this, an object is perceived in relation to already existing information contents in the mind, which means that the perceived object in reaction to the interpretation is individual (Rousi, 2013). Here, the subjectivity of perceived usability is facilitated as well.

Perceived usability in relation to virtual learning environments is a well examined topic. For example, Sun et al. (2008) inspected the critical factors af-

fecting learners' satisfaction in e-learning. In their article the learner's perceived usefulness is defined as the perception of degrees of improvement in learning effects, and perceived ease of use as learners' perception of the ease of adopting an e-learning system (Sun et al., 2008). Basically, with perceived usefulness is referred to system's usefulness towards learning, and with perceived ease of use to the understanding of systems adoption. Based on the results, the higher the perceived usefulness of an e-learning system is the more satisfaction it engenders. This higher learning satisfaction should also be gained through ease of use of an e-learning system, as it enables individuals to dedicate their attention to learning the course materials instead of spending additional effort learning the instrument. (Sun et al., 2008.) Based on this, it seems to be most effective for learning, if both perceived usefulness and perceived ease of use are supported.

Based on the research by Johnson, Hornik and Salas (2008) perceived usefulness can be related to course instrumentality, course performance and course satisfaction. This means, that individual who perceives the technology to be more useful will have higher perceptions of course instrumentality, perform better and be more satisfied than individuals who perceive the technology to be less useful. Here, the instrumentality refers to quality and quantity of information, such as additional course content, audio or video files and peer-to-peer information sharing. (Johnson et al., 2008.) Further, the background contributor for the perception of satisfaction is user's belief in usefulness (Roca et al., 2006). Basically, user's continuance intention towards e-learning results from satisfaction determined by perceived usefulness, perceived ease of use and cognitive absorption along with the perceived quality factors. The cognitive absorption indicates here the state of deep involvement and enjoyment with software (Agarwal & Karahanna, 2000), as well as the dimensions of temporal dissociation and focused immersion (Roca et al., 2006). Chiu, Hsu, Sun, Lin and Sun (2005) also discovered the significant effects of perceived usability, along with the perceived quality and perceived value, on satisfaction and to e-learning continuance intentions by a user.

The results gained by Roca et al. (2006) and Chiu et al. (2005) emphasize the individual's role in satisfaction formation. Same kind of outcome gained Sun, Li, Zhu and Hsiao (2015) with their study of the effects of different virtual reality learning systems in usability outcome. Here usability was approached through effectiveness, efficiency, and satisfaction. Based on the results, promotion focus, i.e. positive attitude and expectations towards using a system, influences positively usability all in all. Basically, positive and beneficial ways linked to the system enhanced learning, since learning was indicated more effective, more efficient and more satisfied. (Sun et al., 2015.) Based on this, along with the other study results presented, perceived usability is quite tightly connected to using virtual learning environments, since it influences the way user experiences the environment and how satisfied s/he is to its appropriateness and functions.

3 AFFORDANCES AND SIGNIFIERS IN RELATION TO PERCEIVED USABILITY

An affordance, the concept originally developed by visual perception theoretician James J. Gibson, represents what the environment can afford to people in general: what they can do or how they can act. Gibson's point of view towards affordances is ecological, and he discusses in detail the relationship between an animal or a human and the environment in *The Theory of Affordances*. Gibson's theory of affordances is based on for much of his analysis on a previous discovery in *The Ecological Approach to Visual Perception of the Pictures*. Signifier, on the other hand, is the concept developed by Donald A. Norman and by which the creation is largely influenced by the concept of Gibson's affordance. Norman himself also covers affordances closely among other things in his book *The Design of Everyday Things*. While the definitions of affordances by Gibson have been quite perceptual psychological, has Norman instead sought to define the very same concept within the frame of HCI, and differentiate the real affordances from perceived affordances, i.e. signifiers.

In the following chapters the concepts of affordances and signifiers will be explained through. Both definitions by Gibson and Norman are used as well as other aspects found in literature are pointed out. In addition, signifiers' link to affordances will be reviewed. Finally, affordances and signifiers in relation to perceived usability will be discussed. Though, the inspection of affordances and signifiers is first approached by defining the semiotic frame of especially the term of a signifier.

3.1 Semiotics

Before defining the concept of signifiers, or even affordances, it is relevant to introduce the area of semiotics as the roots for the term. Rousi (2013) states in her thesis that semiotics might be challenging to describe, since there is multiple views and understandings of it. In general, semiotics can be seen to concern

"with everything that can be *taken* as a sign" and this sign can be anything that "can be taken as something standing for something else." (Eco, 1976, 7, 16.) In other words, a sign can be any written word with a meaning, or any object through which substance is defined. Although semiotics mainly focuses on the science of signs and signifying systems (Eco, 1976), it can also appear as a field of science that studies the theories and perspectives on semiotics themselves (Rousi, 2013). With semiotics, it is also possible to gain more understanding of the representations of mental contents that arise in response to symbolic meanings triggered by the designs, and of how these thoughts of representations are expressed via language and associated symbolism (Rousi, 2013).

As for the concept of signifiers and its semiotic roots, de Saussure (1959) has made familiar with the pair-concept of a signifier and signified for a sign: Of these two concepts the signifier is the concept and the signified is the sound-image of the concept. The concept "tree" can be used as an illustrative example of this: as the written word "tree" expresses the signifier of whose sign plays an arboreal plant of what we combine to that specific word. Thus, the signifier and the signified always form a pair: A concept, or a signifier, becomes linguistic entity only when associated with sound-image, or with signified. Thus, "a concept is a quality of its phonic substances just as a particular slice or sound is a quality of the concept." (de Saussure, 1959.) Signifiers always represent an object. Again, the represented object always represents some combination of letters, which signifies the object. Thus, there cannot be a signifier without a signified, and vice versa. de Saussure (1959) has stated that the relationship between the signifier and the signified is arbitrary, because the signifier has tied into the linguistic community it uses; therefore, the signifier selected by a certain language cannot be replaced by another.

Andersen (2001) applies the relation between a signifier and signified to interaction between a human and technology in terms of algorithms and data structures: Each algorithm and data structure represents a certain function or feature, which makes them signifiers. The signified half of these algorithms and data structures are, in turn, the respective interpretations found for these representations of functions and features. de Souza, Leitão, Prates and da Silva (2006), in turn, approach signifiers from the field of semiotic engineering that examines signs to which users are exposed as they interact with computing artefacts. These signs of computer interfaces that sent messages from designers to users are in forms of widgets, images, words, colours, dialog structures and graphic layouts (de Souza et al., 2006). Based on this, three sign classes for computer artefacts are differentiated: static signs, dynamic signs and metalinguistic signs. Static signs, found in screen shots of the systems' interface, express the system state, and dynamic signs, found as a user interacts with the system, express the system behaviour. (de Souza et al., 2006.) Metalinguistic signs, in turn, represent other static, dynamic and metalinguistic signs. These representations depend on the separation between two representational levels of where the action is performed and where information, instructions, descriptions or explanations about the action are provided. (de Souza, Leitão, Prates, Bim & da Silva, 2010.)

In sum, all these sign classes deliver the messages by designers to users. Additionally, as these signs are representations of familiar functions and features to users, they function as signifiers, like Andersen (2001) sees in the case of algorithms and data structures.

3.2 Affordances

According to Gibson (1979), affordances are directly perceived opportunities of an action that do not involve any substantial interpretation. The emergence of affordances is not tied into the environment, as they are observed from both natural and artificial environments. Therefore, natural and cultural environments should not be separated from each other, since the surrounding world itself remains the same regardless of the changes that is been made in it. (Gibson, 1979.) Additionally, it is thorough to learn to recognize the differences between a real object and virtual object as it will also clarify the affordances perceived (Gibson, 1978). The comparison between the real and the virtual object can be clarified by using the photograph of a tree as an example. The actual tree from which the photograph is taken is the real object and the picture of it is the virtual one. As recognizing the actual tree from the picture, the information perceived is somewhat dual, as the duality of the information: we perceive the information about the tree from the picture, but the physical form of it that we are known of, differs from the actual tree from the nature. But, as we have perceived the real surfaces of that tree from the environment, we can connect the pictured tree to the real one. (Gibson, 1978.) Affordances are characterised by proportionality as they appear in the interaction between the operator and the environment, and the same environment can provide a variety of affordances to different recipients (Gibson, 1979). For example, a hat can be used as accessory or, alternatively, it may be used as a place to maintain keys and other small articles. In this case, it presents itself in different affordances to each user. On the other hand, affordances can also be independent of a recipient's incidental needs (Gibson, 1979). Thus, this same hat might be useless to warm one's hands.

Norman (1999) has continued the work by Gibson (1978, 1979) by bringing the concept of affordances closer to HCI design. Since the use of the concept has been partly misunderstood by designers, Norman (1999) has clarified the concept by separating perceived affordances from real affordances: The real affordances reflect the possible relationships between actors and objects as they are already existing features. The perceived affordances, in turn, provide visual messages from real affordances. Norman (1999) uses screen-based interfaces as an example of this: Because of the physical form of the computer system, they come with built-in physical affordances that are real, such as touching. But, within reaching distance afford touching, all screens do not detect the touch and respond to it. Therefore, it is the role of designers to indicate with perceived affordances, whether the screen is touchable or not. (Norman, 1999.) Norman (1999) has also stated that affordances should not be mixed with con-

ventions that can be arbitrary, artificial and learned, such as writing style or conventions for courtesy. In other words, a certain way of writing or using symbols in a design is not an affordance itself, but rather it can help in creating a certain association for users. Moreover, planning affordances is influenced by largely well-established social practices (Norman, 1999), which can make the separating these affordances from conventions difficult. In addition to this, the existing practices can be difficult to change if they have deep roots in the community (Norman, 1999). For example, signifiers for the signified objects, as discussed in sub-chapter of semiology, might be difficult to change, as they are adopted tight in the everyday communication.

Since affordances refer directly to the properties of both an operator and object, Gaver (1991) states that they are directly applicable to the interaction between technology and a user. For example, a keyboard arouses the affordance of pressing buttons and writing, which are peculiar also to a user as functions (Gaver, 1991). Gaver (1991) also discusses about successive affordances, which refer to the situation where a detection of a specific affordance leads to knowledge of a new affordance. For example, a scroll bar of a web page may at best be designed such that it provides successive affordances (see Gaver, 1991). Lu and Cheng (2013), in turn, see affordances as relationships between users and situations they are in, which emphasizes the situational aspect of affordances: "an affordance in different situations will lead to different perceptual probabilities of that affordance. Sudden changes in situations will raise or lower affordance threshold as perceptual information." In addition, "situations affect affordances directly rather than through human cognitive process." (Lu & Cheng, 1991, 147.) In other words, the way humans think, remember and process information is in-built and it is remodelled as experienced different situations. Yet, since affordances are a part of the environment (Gibson, 1979; Norman, 1999), it seems that the situation type affects the way affordances emerge and how they are perceived in the environment.

Hartson (2003) expands this review as he divides affordances based on their properties into cognitive, physical, sensory and functional affordances. Cognitive affordances, equivalent to Norman's (1999) perceived affordances, enable and support a thought or knowledge of something. For example, the clear label for the button in a web page helps a user to understand the function followed by the pressing of that specific button. Physical affordances, equivalent to Norman's real affordances, enable the adoption of some physical action. For example, the appropriate size of a button facilitates a user to focus on the press of the button accurately. (Hartson, 2003.) Sensory affordances help, improve, support, facilitate and enable user's perception, such as seeing, hearing or feeling. These affordances include design features like sight, hearing, taste and other sensations related to devices. For example, the size of a font substantially affects to legibility. (Hartson, 2003.) Functional affordances enable and improve the user-imported functions and bound usage with utility. For example, the general functioning of an information system is a functional affordance. (Hartson, 2003.)

3.3 Signifiers

Based on Norman's (2013) definition a signifier means a sign or sound that targets the message to a user. This certain sign is also easily detectable. Thus, the signifier is linked essentially to the concept of an affordance, since its role is to assist in the detection of affordances (Norman, 2013). A signifier may also be either deliberate and intended or inconsiderate and unintended (Norman, 2013). For example, a bookmark can be both at the same time: It is deliberate and intended, when it tells to a reader, where the reading has left of last time. On the other hand, on behalf of the physical structure of the book the bookmark also reveals to the reader, how much reading the book outstands. In this case, the signifier is inconsiderate and unintended. This example indicates that signifiers have a lot of influence in the interaction between the object and the actor. Lu and Cheng (2013, 146) have discovered the same as they stated that signifiers "are perceptual cues and symbols created by designers that point directly to products' functional meanings." This view of signifiers emphasizes the role of designers and it is rather product design centred. Hence, the idea behind it is logical, as signifiers' main role is to maintain the interaction between the user and the object in a way that the affordance is perceived.

The aim to define the concept of signifiers within the HCI research has been to Norman (2013) first and foremost to seek to clarify the difference the distinction between real and perceived affordances. Firstly, Norman (2013) has sorted out the meaning of an affordance by defining it not as a feature but a ratio of which existence depends on the properties of both an object and operator. Thus, both an object and operator along with their characters, such as operator's attention and the needed closeness of an object, are essential. In other words, an affordance is not perceived until the operator has detected it from the object. But, to detect an affordance, a certain way to send a signal from its existence is required. In this matter, the signifier comes along: the existence of affordances is often linked to the role of signifiers to produce a certain sign or a sound from product's or service's characteristics. (Norman, 2013.) Hence, the signifier attaches the wanted affordances to a product to catch user's interest and inform the necessary information about the product. Based on this, perceived affordances can be also assigned as signifiers for the affordances, since their intentions are similar.

Norman's (2013) view of signifiers focuses mainly on the connection between the signifiers and affordances. Andersen (2001), instead, merges signifiers into the computing as he states that computer systems add a new sign-feature into the interaction: features like moving the mouse and clicking mean something special in the program used, which makes them such signifiers of copying, pasting, sorting and saving. Additionally, this kind of interaction exploits the ability of one interface object to influence another and it creates meaning based on the user's hand movement. (Andersen, 2001). In sum, signifiers

emerge and reforms between the interaction of users' commands and computer systems' interpretations and inner commands.

As returning to the features linked to the signifier, not every view supports the way de Saussure (1959) defines signifiers as a counterpart of the signified. Rather, this definition is questioned, and thus, the concepts of floating and flickering signifiers are presented in the literature. Lacan (1975, according to Hayles 1993, 77) has stated the following about the relation of signifiers and signified: Signified do not exist in themselves, since they are produced by signifiers, which is why they are floating beneath a network of signifiers constituted through continual slippages and displacements itself. Pluth (2012) opens this statement a bit more by stating that a signifier can be independent of any specific signified, but also signify something else or nothing. For example, letter combinations can exist that do not, at least yet, signify anything. Thus, signifiers can be referred to as floating, or even empty, signifiers. Hayles (2008), instead, determines signifiers as flickering: The signifier can be no longer referred to as a single marker in informatics, but rather as a flexible chain of markers bound together by the arbitrary relations that are specified with the relevant codes. These codes exist in between the user and the computer which intervene between of what the user sees and what the computer reads from the commands made. Therefore, a signifier on one level may become a signified on the next level, and as the interaction between the signifier and the signified is arbitrary, it can be changed with a single global command. (Hayles, 2008.)

3.4 The Role of Affordances and Signifiers in Perceived Usability

Like discussed in the previous chapter about perceived usability within virtual learning environments, perceived usability is somewhat pragmatic quality of a product, that arises from of the assessment of both product's potential supportive do-goals and a product's appropriateness, functionality and easy accessibility (Hassenzahl & Monk, 2010). In other words, a product is expected to be practical, easy to use and function appropriately towards the situation. Perceived usability can also be divided into aspects of perceived usefulness, as in how applicable the system is to a user, and perceived ease of use, as in how useful the system seems compared to the effort of taking it into usage (Davis, 1989). Furthermore, perceived usability is a part of a user experience that is a dynamic, context-dependent and subjective interpretation of the benefits derived from the product by a user (Law et al., 2009). This interpretation is partly affected by user's prior experiences, attitudes, skills, habits and personality (Pucillo & Cascini, 2014), which emphasizes also the individuality of perceived usability.

Affordances and signifiers have their own links to perceived usability since their detection affects the way perceived usability is formed to a user. Gaver (1991) states that what is perceived is what is acted upon. In other words, user's way to act is based on the information received from the product. Yet, even before the act itself arises, the acceptance of products usability is formed.

This user acceptance is strongly impacted by perceived usefulness, since the first step towards the adoption of the application, or a product, is driven by the functions the application performs to a user (Davis, 1989). This goes back to the affordances and signifiers perceived, since these performed functions, also opportunities of an action, are the representations of affordances (Gibson, 1979) that a user detects from the product with the help of signifiers (Norman, 2013).

Gaver (1991) has also stated that in some situations perceived attributes must be related to those relevant for action by a mediating representation. This means that perceiving the appropriate information from the product requires first receiving the right mental representations from the situation. Gaver (1991, 81) illustrates these two situations via following examples: "Perceiving that a door handle affords pulling does not require a mediating concept because the attributes relevant to pulling are available for perception." Instead, "knowing that a key should be turned inside a lock does require mediation because the relevant attributes are not available." In other words, observing the environment and its potentials occurs via direct perception (Gibson, 1979), but also with the basis of user's inner models such as the knowledge of prior experiences (Pucillo & Cascini, 2014). Basically, detecting similar affordances and signifiers from other contexts also facilitates their detection in new situations. This, in turn, facilitates the assessment of product's features, such as functionality and easy accessibility (Hassenzahl & Monk, 2010).

Lu and Cheng (2013) connect affordances into user's observation and perception with the concepts of perceptual probability of affordance and perceptual threshold of affordance. Perceptual threshold of affordance means the threshold at which an affordance can be perceived. This threshold is individual, since different people have different thresholds for detecting the same affordance of an object. (Lu & Cheng, 2013.) The perceptual probability of affordance, in turn, means the probability for people to perceive a certain affordance, and it has three aspects of natural probability, situational probability and attribute of the perceiving populations. Natural probability means, that an object typically has multiple affordances, and typical function always has the greatest probability to be perceived. Situational probability, in turn, means the ways in which an affordance is perceived in certain situations. The attributes of the perceiving population mean that perceptible affordances of the same object vary depending on the diversity of capabilities, experiences, cultures and psychological states. For example, the greatest probability of affordance of a pen is "write-able". However, the same pen could be used as a "weapon" in an emergency. This "write-able" as an affordance of a pen may also be more logical to adults, since for babies a pen is just a "grasp-able" object. (Lu & Cheng, 2013.) In sum, these two concepts by Lu and Cheng (2013) combine affordances into perceived usability within the frames of being something individual and situational as well as dependent on aspects connected to a single user (e.g. capability to observe and perceive).

4 AFFORDANCES AND SIGNIFIERS IN HCI VIRTUAL LEARNING ENVIRONMENT DESIGN

As viewed in the chapter about affordances and signifiers in perceived usability, affordances were first defined as a part of interaction of a human and an object in a natural setting (Gibson, 1979; Norman, 1999). Broadening this view closer to artefacts, the concept was adopted in industrial design (Lu & Cheng, 2013), especially in HCI research. Nowadays, affordances in HCI seem to be more like interactions of mental and bodily processes of the user that assign values to objects; and as for detecting these affordances, the interaction occurs whenever affordances activation is supported (Xenakis & Arnellos, 2013). This supported activation refers to situations in which users perceive these affordances. Product-Affordance-User model by Galvao and Sato (2013, according to Lu & Cheng 2013, 144) supports the interaction aspect of affordances; based on the model affordances exist within the product without perception, or some attributes of them being perceptible, yet they are realised only via interaction between the user and the product. The model emphasizes the interaction between the user and the product, and can be used as the basis for the product design (Lu & Cheng, 2013). Additionally, the perception of affordances is a matter of perceived affordances that help in detecting the real affordances (Norman, 1999). Although, in the field of emotional design perceived affordances have also been utilised in a misleading way to arouse specific emotions among users (see Norman, 2005). As for the signifiers in HCI, their main object is to clarify the use of affordances among designers (see Norman, 2013).

This chapter discusses the role of affordances and signifiers in HCI virtual learning environment research. The inspection is approached by viewing affordances and signifiers in HCI research, especially in product design, in general. Then the discussion moves forward to inspect how these two concepts have been utilised especially in the field of VLE design.

4.1 Previous Studies of Affordances and Signifiers in HCI Research

The role of affordances and signifiers in HCI research is emphasised particularly in the product design, where they have been examined by many researchers from different aspects. Norman (2013) has stated that the visibility of affordances is critical to designers, as affordances provide strong clues of the functions of objects. For example, the shape of the door handle has a strong impact on the formation of affordance of how the door is opened. Hartson (2003) sees also that a closer inspection of affordances can improve the design and analysis of human-technology interaction, as understanding the differing roles of affordances in interaction design can help to diagnose the usability problems perceived in the usability assessment process. This, in turn, might possibly guarantee that all design features are easier to cover. In this way, product and service design can be also developed in the future, when areas that need to be developed are identified. Gaver (1991) has also foreseen the consideration of affordances in the design essential: Affordances can guide us to design such products and services, which highlight the desired affordances. This, in turn, helps designers to focus on the fundamental interaction between technologies and users, apart from these two sides alone.

The perspective of affordances viewed by Xenakis and Arnellos (2013) is somewhat interactional as they state that the detection of affordances is a consequence of an interaction. This interaction, in turn, is particularly a mental or bodily process that sets values to an object, whenever the existing conditions support the activation of these affordances. Since interaction can vary both internally, as in bodily and behavioural conditions of the user, and externally, as in environmental conditions, in relation to design-participant, these conditions of an interaction are dynamic. (Xenakis & Arnellos, 2013.) As examples of these internal and external changes can be user's current mood influencing the behaviour and the situation where the interaction takes place.

Xenakis and Arnellos (2013) continue their theory about interaction affordances by approaching it from the aesthetic dimension: In this context, aesthetics is seen both as experiences or impressions (e.g. visually or by touch) that we usually have as we interact with products and as a discipline of visual perception, that focuses mainly on the visual or physical properties of an object. Further, the dynamic and interaction characters of an aesthetic experience are emphasised, which is why aesthetics is here referred to as interaction aesthetics. (Xenakis & Arnellos, 2013). Xenakis and Arnellos (2013) state that aesthetic-oriented emotions, that are part of aesthetic experience, provide us the ability to give values to those dynamic presuppositions of an interaction, and this enhances the detection of interactive affordances. These interaction affordances are interactive potentialities for a further action, that can be afforded based on the presuppositions present at the interaction. Moreover, they emerge when all the internal and external conditions indicating the appropriate potential actions

exist. Basically, detection of interactive affordances depends on other dynamic processes which form our experience with the environment. (Xenakis & Arnellos, 2013.) In sum, aesthetic-oriented emotions of a user influence design-representations by assigning values for their content, and this way, supporting the process of selecting the best action (Xenakis & Arnellos, 2013). Basically, this best action refers to the best interaction affordance emerged from this aesthetic experience of a product's artefact. Yet, although it appears as an important part of the affordance detection, aesthetics alone does not guarantee the successful design (Xenakis & Arnellos, 2013). Moreover, as Norman (2013) has stated, the focus on aesthetics alone can be fatal, if the designer is blind to the lack of usability: at the end, the understandability and usability of the product are those aspects that overcome the aesthetics, if the user does not manage to benefit from the product or its functions.

Lu and Cheng (2013) explored also the interaction between affordances and users, and based on their inspections, they represent the Affordance-Meaning-Generation model (AMGM), which illustrates the process by which people go from affordance to meaning (Figure 1). The model is developed for the designers to extend technology affordance theory and help with better control of interactions (Lu & Cheng, 2013). In the figure (Figure 1), solid-line boxes indicate innate structures of the model and fine-line dashes indicate the additional structures for the meaning generation. All the structures are outlined with dot-line dashes which emphasizes the whole of many structures, and arrows represent the direction of the process. (Lu & Cheng, 2013.)

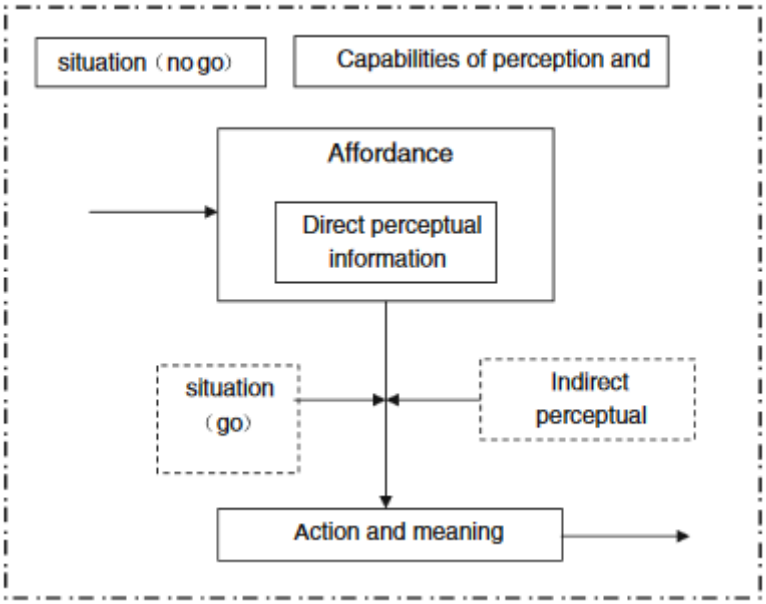

Figure 1 Affordance-Meaning-Generation -model (Lu & Cheng 2013, 148)

Based on this model, the affordance describes the functional meaning between objects and humans in which the meaning of the object is attained by perceiving

and interacting with affordances. Thus, perceptual information can change affordance's threshold: Direct perceptual information makes affordance available for directly perceived perception. Indirect perceptual information, in turn, highlights an existing affordance and thus, relates to cognitive process. Unlike direct information, the indirect one is an additive factor in human cognitive process; it needs to be interpreted and processed. (Lu & Cheng, 2013.) Capabilities of perception and action refers to different ways of people to perceive and act, and as Lu and Cheng (2013, 149) state: "the consideration of the capabilities of human should be a part of product design and should affect every stage of the model in a diffuse way as a background factor." This emphasizes the perceived usability aspect of affordance detection. Additionally, situation effect in the model is described in two ways: No go -situation refers to the background situation that influences every stage in the process, and when the situation remains the same, the whole system remains stable. Go-situation, in turn, refers to changes in situations, which raise or lower thresholds of affordances and lead to the system change. (Lu & Cheng, 2013.)

Based on the above, the role of affordances is emphasised in HCI research, particularly in product design. Yet, they are also arguably dependent on the signifiers: A successful communication regarding the purpose, structure and operation of the designed product is also an essential part of the good design. In this communication, the signifiers have a critical role as they provide these clues of possibilities of an action, i.e. affordances. (Norman, 2013.) The signifier, therefore, needs to be specific enough to arouse the right kind of perception from the intention of a finished product or service in a user. Thus, easy interpretability of products and services may be regarded as one of the most important design objectives. Andersen (2001), who studied the semantic meaning of user interfaces, states that the ease of interpretation itself is not enough, since user interfaces need to be also verbally presented: As information systems are sign systems themselves, the signs will also need to be easily connected to the surrounding communication. The planning of signifiers has therefore an important role for the affordances arising from products and services in a way that these affordances are clear, and do not contain ambiguities or cross-reaching uses.

Hence the importance of signifiers in detecting affordances, they seem not to be examined in HCI research. Motives for this may be relating to the role of the signifier being rather the link between a user and properties of a product or service. Therefore, its importance is well established as a sign of an affordance (Norman, 2013), and there is no need to examine its properties further. Second, as the literature above indicates, the characteristics of affordances can vary widely as moving towards different fields of HCI research. That makes the role of affordances meaningful, since they indicate the properties of the designed item (Norman, 1999; Gaver, 1991). After the properties of an affordance are detected, only then the focus transfers into signifiers in regards to what kind of signifiers are attached to the certain affordances.

4.2 The Role of Affordances and Signifiers in Virtual Learning Environment Research

In the earlier chapter, which discussed the concept of virtual learning environments, the differences of VLEs from traditional learning environments were articulated through emphasizing VLEs as new models for education. Bayne (2008) refers to this as the "digital turn" in higher education and wider culture. Moreover, as this digital turn seems to be crucially influencing the way we think and practise learning, it is important to answer the questions regarding which social and pedagogical practices the VLE interfaces reflect and inform, and what meanings are produced (Bayne, 2008). These questions can be approached with the help of affordances and signifiers.

The research by Limperos, Buckner, Kaufmann and Frisby (2015) studied the impact of modality and clarity manipulations to experiences of instructor's trustworthiness, goodwill and competence, as well as to perceived and actual learning in a simulated online class. The research included two modes of text only and text with audio, and clarity measurement of low/high clarity (Limperos et al., 2015). Based on the results lectures containing both audio and text facilitate actual learning more than those that contained only text, as in these the perceived learning was experienced to be better. Furthermore, results indicate that instructor is perceived as more competent, trustworthy and to have more goodwill in lectures delivered via two modes of information (text and audio) than lectures with only one information mode (text). Yet, the clarity of information did not seem to influence either learning or perceptions of instructor credibility. (Limperos et al., 2015.) The results implicate, that the number of affordances (information modes) provided seem to influence on the learning performance.

The research by Limperos et al. (2015) was based on many theoretical perspectives dividing technological affordances and human actions to clarify connections between student experiences and technology and learning outcomes. However, pointing out the main results gained (Limperos et al., 2015), it is relevant to highlight the MAIN model of affordances (Sundar, 2007; 2008) used in this study: the model represents four affordances of modality, agency, interactivity and navigability that occur with separate impacts in every interaction in digital communication technology. Modality refers to different methods for presenting instructional content. By agency is meant the sources of information, such as discussion forums and user generated content. Interactivity refers to mechanisms that allow users to dynamically impact or change content of the digital environment. Final, navigability refers to the ability to find and use information in a meaningful way. (Limperos et al., 2015.) Especially the role of modality affordance is emphasised in this study, as to alternative methods for presenting lecture material were studied. Also, affordances of agency and navigability were present, since the information was possible to gain from audio as well as text form.

Knutsson, Blåsjö, Hållsten and Karlström (2012) in turn, conducted a case study about digital literacy within three communicating parties of VLEs: VLE designers, teachers and students. Digital literacy, that here includes any conceivable skill or activity, is defined as an access to three registers of everyday knowledge, specialised knowledge and reflexive, or critical knowledge. These registers form the scale of potentials for linguistic expression to an individual user and which are measured in terms of what the interaction is about (Field), the relationship between the interactors (Tenor) and the type of the communication (Mode). (Knutsson et al., 2012.) Knutsson et al. (2012) viewed their study from the social semiotic perspective as they stress the relation between social context and meaning, rather than the arbitrary relation between sign and meaning (e.g. de Saussure, 1959).

The study revealed the expected differences between the three parties, which points out the difficulties of maintaining a shared register in VLEs. (Knutsson et al., 2012.) According to Knutsson et al. (2012) the results can be explained with the divergent levels of knowledge registers between different participants: people do not always understand each other because the levels of knowledge can vary significantly. This, in turn, can complicate the communication within the shared virtual space. The issue implicates the importance of acknowledging all participants', but especially students', everyday knowing about digital literacy, including the knowledge of Field, Tenor and Mode (Knutsson et al., 2012). In sum, designing VLEs that meet the level of all participants' digital literacy registers is crucial, but difficult to implement, since these knowledge levels can vary in different participant groups and within the same group. However, with detailing where the registers of participants are shared, or where the differences occur in digital literacy may enhance the design of these VLEs (Knutsson et al., 2012). Additionally, with understanding the social semiotic context within the VLE users, such as the sense of signs and meanings behind them, these differences discovered can be further inspected.

Both researches by Limperos et al. (2015) and Knutsson et al. (2012) utilised rather earlier gained information about affordances and signifiers. Yet, especially the inspection of affordances has extended also in the research of affordances emerging from VLEs. For example, Dalgarno and Lee (2010) explored the potential learning benefits of 3D VLEs by identifying learning affordances within them. 3-D VLEs are here distinguished from 2-D ones by three-dimensionality, smooth temporal changes and interactivity, as well as the facilitation of tasks with the promising outcomes, such as enhanced spatial knowledge representation, increased motivation and engagement, and more effective collaborative learning (Dalgarno & Lee, 2010). Based on their investigations, Dalgarno and Lee (2010) represent five learning affordances of 3-D VLEs: spatial knowledge representation affordance, experimental learning affordance, engagement affordance, contextual learning affordance and collaborative learning affordance. Spatial knowledge representation affordance facilitates learning tasks in VLE, such as viewing it from any position and manipulating objects within it, which develops further enhanced spatial knowledge represen-

tation of the explored domain. Experimental learning affordance, in turn, facilitates experiential learning tasks impractical or impossible, by their cost or safety, to undertake in the real world. (Dalgarno & Lee, 2010). For example, constructing different cultural settings can be implemented in VLEs with these affordances. Engagement affordance facilitates learning tasks that lead to increased innate motivation and engagement, which at its best is likely to increase the feeling of flow via psychological immersion within the environment (Dalgarno & Lee, 2010). In other words, users are inhabited in the environment. Contextual learning affordance, referring the conceptual understanding of the learning domain, facilitates learning tasks that improve knowledge and skills in real situations through contextualisation of learning. Finally, collaborative learning affordance facilitates tasks that lead to more effective collaborative learning. Moreover, this affordance is applied to support positive interdependence within a learning group by allowing learners to engage simultaneously in shared tasks and produce joint artefacts. (Dalgarno & Lee, 2010). All these five affordances co-exist in the VLEs, and are used to engage users to learning within these environments.

Like Dalgarno and Lee (2010), also Warburton (2009) inspected affordances of 3-D VLEs as a part of his study about potentials and barriers of Second Life (SL), a 3-D multi-user virtual world platform used in education. Warburton (2009) represents three major components of the type and quality of experiences, i.e. affordances that SL offers for educational activities: technical infrastructure, immersion and socialisation. Technical infrastructure includes the tools and processes available in SL for creating artefacts, interaction and immersion. Immersion, in turn, refers to the visual and physical realism that SL adds to the virtual space to produce a profoundly immersive experience. This immersion conveys a feeling of being there and a strong sense of co-presence. (Warburton, 2009.) In a way, this immersion resembles the authenticity represented by Kalay et al. (2004) earlier in the thesis. Finally, with socialisation is meant those social acts and socialisation that drive the use of SL and which are supported by multiple communication channels, viewable avatar profiles and built architecture and objects (Warburton, 2009). With these SL affordances, the innovations in pedagogy can be facilitated for example through community presence, content production and extended/rich interactions between individuals and communities, objects as well as artefacts (Warburton & Perez-Garcia 2009, according to Warburton 2009, 421). As for utilising this information about SL affordances into education, Warburton (2009) states that these affordances must be constructively approached to make decisions that encourage the positive and rewarding use of virtual worlds for learning and teaching. Additionally, this requires not just improvement of our digital and cultural literacy, but also understanding both the links between immersion, empathy and learning, and the developing design skills to utilise virtual spaces (Warburton, 2009). Basically, this all goes back to the way learners perceive and process information, in order to designers to develop VLEs.

5 CONCLUSION

This thesis, implemented as a literature review, examined affordances and signifiers in virtual learning environment design. Since virtual learning environments as a new mode of teaching are growing in education, the requirements for their design are emphasised. Yet, meeting only the educational standards is not enough, since the technological aspect of these environments form a new dimension of learning: In general, meaningful learning results from both learners' degree of interest and perceived usability gained from the learning equipment used. This perceived usability is linked to affordances and signifiers, since any sign or clue, i.e. signifier that provides information about the use of product or its functions, i.e. affordances, is important. In the case of VLEs, the technology perceived and experienced seem to be the key to understand perceived usability of learners, and this information can be used to enhance features of VLEs. Based on this it is justified to research, how the roles of these affordances and signifiers appear in the design of virtual learning environments. This research problem was approached via three research questions: (1) what are virtual learning environments and how they differ from traditional learning environments, (2) what role do affordances and signifiers play in perceived usability, and (3) how have the roles of affordances and signifiers been researched in relation to virtual learning environment design? These research questions were approached by various academic journals and publications, along with the few non-academic articles, books and one doctoral thesis.

Based on the literature, the concept of virtual learning environments is approached either from the aspect of their included features or by their emphasis of users' roles within them. In other words, VLEs, which are also referred to as e-learning environments, are stated as technology-based environments, that utilise telecommunication for learning and educational material delivering. In these environments, students are referred to as actors who co-construct the virtual space by both searching, adding, receiving and sharing information, and contributing collaboration and communality through responsive interaction. Due to this, VLEs are expressed to be inhabited by their users through social and cognitive engagement: the VLEs are appropriated for the learners' specific

needs, and this adaptability creates the senses of presence and authenticity. Basically, VLE setting can be customised for the individual learners, but they can also be constructed after the implementation by learners' involvement in creating meanings of the virtual space.

As compared to traditional learning environments, VLEs are stated to have unlimited access to knowledge and capability to store it for reuse and sharing, and have no restrictions within time, place or geographic location. Additionally, they are characterised by the ability to overlap physical environments. Based on these statements, VLEs are cost-efficient and supporting elements to both distance and presential learning. Yet, despite all these positive aspects of VLEs, there are also some negative aspects presented in the literature: Due to their functions, VLEs do not enable immediate feedback, or solve all the problems that rather need co-presence. These aspects have been seen to emphasise the fact, that VLEs are not necessarily suitable for all users due to differentiating expectations as well as individual differences. Although, this issue can be faced within the traditional learning environment as well, since their modes for teaching are constructed to concern the whole class as an entity, rather as concerning a group of individual learners.

In the use of virtual learning environments, perceived usability is been seen to have a significant role to learner's satisfaction and continuance of e-learning among other things. This, in fact, results the second research question of affordances and signifiers behind the formation of perceived usability, as it links virtual learning environments together with affordances and signifiers. Perceived usability is affected by detection of affordances and signifiers in terms of how people observe and perceive information. Perceived usability, also referred in the literature as a pragmatic quality of the product, is stated to arise from the assessment of product's expected practicality, easy usage and functionality towards the situation it is used. This, at its best, results as user acceptance, which is influenced by the perceived functions that a product performs to a user. These perceived functions have stated to be opportunities of an action, which makes them the representations of affordances. Moreover, the detection of these affordances has been stated to be influenced by the certain threshold or perceptual probability of an individual to perceive an affordance in the first place. Yet, especially the perceived threshold of an affordance can be lowered by signifiers, as they are said to bring the opportunities of an action into user's attention. On the other hand, user's inner models and prior experiences have also been discovered to influence the detection of affordances and signifiers. Thus, the detection of affordances and signifiers within the certain product can also be seen to call for the knowledge of this product's possibilities for affordances and signifiers in general. For example, the door is known to offer affordances of opening and closing, so this information can be utilised, when identifying the signifiers of how the door is opened or closed.

As for the answer to the third research question, it appears that the roles of mainly affordances in the VLE design have been approached by two differentiating ways in the literature. First, the information about affordances gained

from the previous research within the field of HCI was utilised as a background theory for the current research. For example, Limperos et al. (2015) utilised the MAIN model of affordances, when they studied the impact of lecture material's modality and clarity manipulations on learning outcomes. This approach method was also used within the inspection of signifiers: Knutsson et al. (2002) utilised semiotics from the social perspective as studying the relation between social context and meaning in digital literacy within VLE designers, teachers and students. Second, some researches focused their inspection of affordances in gaining the information about actual learning affordances found within VLEs. This kind of research was implemented by Dalgarno and Lee (2010) with the result of five potential learning benefits of 3-D VLEs, as well as Warburton (2009) with the result of three learning affordances identified from the virtual platform of Second Life.

This thesis included some limitations that can be culminated into two aspects. First, compared to the literature found from affordances, there was not as much literature found about signifiers either in the VLE design or even when they were viewed in the HCI research in general. This narrowed the inspection of signifiers within this thesis, although it also clarified the obvious importance of affordances. The second limitation for this thesis is related to the restricted sampling offered by some researches. For example, when studying the perceived usability within the VLEs, most of the researches were implemented either as case studies or with the sampling narrowed by age or educational level. This aspect should be considered in future research by mapping the perceptions from learners within different age groups and backgrounds. Instead, as viewing the researches about affordances and signifiers in the VLE design (sub-chapter 4.2), this method for inspecting the learning affordances within a specific VLE, as implemented in the research by Warburton (2009), is justified due to VLEs' character of offering personalised teaching to its users. Thus, in the future it might be essential to inspect every virtual learning environment also as its own unity with its personalising characters. In addition to these research recommendations, the perceptions of individuals might be useful to concern further: since these VLEs are emphasising the role of an individual learner, it is rather important to gain more information about both sides of the users, as in what are the reasons for a learner to perceive a VLE positively versus negatively. In other words, what elements of the VLEs are causing the feelings of frustration and anxiety compared to positive feelings, such as felicity and satisfaction?

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