Context Thinking

Anna Wingkvist and Arianit Kurti
School of Mathematics and Systems Engineering, Växjö University
anna.wingkvist@vxu.se, arianit.kurti@vxu.se

Abstract The advancement of technology has had impact on almost all the aspects of human activities. Learning as one representative of these activities is going through changes as a result. For example, the use of mobile technologies and devices in the learning domain has lead to a magnitude of research, resulting in the field of mobile learning. Context plays a crucial role in any learning activity, and it is impossible to separate the participants, the technology, the activities and its focus, from the environment where it takes place. The focal point have been mostly on the technical side but as in all real-world situations, they exist in an inherently complex setting where social as well as personal implications comes to play an important part in order to reach sustainability. We believe that the lack of sustainability is a result of a barely existing holistic view of the educational situation and claim this complexity can be addressed with an extended view of context thinking. To accomplish this, we suggest a combination of hard and soft approaches, as practitioners need to become competent in context thinking from both perspectives.

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Keywords: context, mobile learning, soft system methodology, sustainability

Introduction

The evolution of technology has had impact on almost all aspects of human activities. Mobile literacy is prevalent in most societies and mobile devices are present in every day life. Learning is one example of the human activities and it has been subject to these changes as well. Initially, the use of computer-based training, and later on networked-based learning, especially due to the development of the World Wide Web, led to the introduction of the e-learning concept. Moreover, the advancements in mobile and wireless technologies have

also had an impact on the educational settings, thus generating a new approach for technology-enhanced learning referred to as mobile learning. Current development trends of the mobile technologies combined with access to content almost everywhere and all the time, allows people new experiences regarding learning in a variety of educational settings. Mobile learning has gained wide acceptance by the research community especially due to the popularity of mobile devices (Rogers et al., 2005) (Syvänen et al., 2005). The progression to enter the educational arena has happened but still there is a lack of sustainable mobile learning situations. Applying mobile devices can offer great flexibility in the learning process but the environment, technology, participants and activities need to be better fitted towards each other. Hopefully this in turn will increase sustainability and also in the long run be able to prove that mobile technology has improved and enhanced learning.

This paper proceeds with a problem area description that led our research. This is followed by our considerations concerning learning and mobility. Thereafter we describe our definition of context. After that we move on to systems thinking and the subset of hard and soft approaches. We continue with our idea of tackling the issues of sustainability for mobile learning with the need to address context from a more holistic viewpoint. Then we introduce Soft System Methodology as a suggestion of a "tool" to extract the expanded view of context. We conclude the paper by stating that a combination of hard and soft approaches is needed in order to fully understand mobile learning situations in an attempt to reach sustainability.

Problem area description

Mobile learning is inherently multi-themed and a very intricate endeavor to take on and the research community seem to be taking a keen interest but there is a need to start generating insightful results and show sustainability. There is also a need to have timely feedback on what works and what does not. Measurements need to be built into the approach and there is a need for a greater emphasis on learning rather than technological success. Yet we see that the sustainability is lacking and it is time to acknowledge the "mess". What is before you is complex, and the causal relations are not as simple as they are made to be. The need for approaches is eminent in order to deal with this appropriately. We also need to consider that an approach is closely related to the issues at hand and that one particular approach may not be able to provide all the answers or even come with suggestions. However, it may still provide knowledge concerning those issues that may have impact on the sustainability of mobile learning situation.

Learning, knowledge and mobility

Despite the changes initiated by the evolution of the technology, the aim of the learning has always remained the same; to gain knowledge. The Oxford dictionary defines learning as "the cognitive process of acquiring skill or knowledge". Others define learning as social activity that is primarily based on collaboration (Brown and Duguid, 2000). In this aspect the collaboration could occur between actors and with the help of artifacts (Hoppe et al., 2005). In this sense the recent mobile learning projects have primarily focused on developing new inquiry tools (primarily based on mobile devices) that could enhance the collaboration and knowledge acquisition. Such cases can be found in some of the projects of our group, for example AMULETS (Kurti et al., 2008). The same objectives can also be identified in other research groups' projects (Sharples et al., 2008). Since the inquiry process is an important aspect of learning and knowledge building, we can make an analogy between the mobile learning systems and inquiry systems. This analogy is based on the fact that mobile learning systems show the characteristics of inquiry systems.

According to Churchman (1971), one of the pioneers of the inquiry system field, the inquiry is defined as "*an activity, which produces knowledge*". Therefore learning and inquiry have the same goal; gaining knowledge. Knowledge is a keyword for both of the activities, learning and inquiry. There are many interpretations of what knowledge is in literature. According to Churchman (1971) "*knowledge can be considered as a collection of information, or as an activity, or as potential*". Nyíri (2002) gives another definition of knowledge and reveals concisely the fundamental role of context, with "*knowledge is information in context*". The Nyíri definition clearly states the intimate connection between information and knowledge. It describes this connection as something more than just simple collection; it describes the need of context as a catalyst for knowledge creation. Mobile learning can be described in terms of a data-information-knowledge-wisdom chain as illustrated by Figure 1.

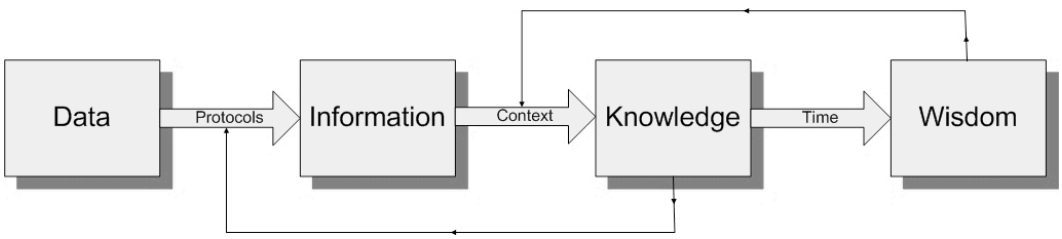

Figure 1. Data – Information – Knowledge – Wisdom chain.

The chain starts with data that usually resides on the system side. To transform the data into information there is a need for rules or protocols that should be defined by knowledge. This set of rules or protocols can for example be an alphabet or any communication protocol such as TCP/IP etc. This transformation usually happens on the system side. To transform information into knowledge there is a need of putting the information into context. The challenging part here is to define the context. In cases when context is defined from the system side we deal with some kind of system awareness, while if a user defines the context then it becomes more of a design input. The knowledge over time becomes wisdom or experience, which represents the last stage of the chain. From this perspective, the main challenge is to identify the methods for defining the context in mobile learning. Context became increasingly important in the mobile learning era and Frohberg (2006) classifies the context of mobile learning into five different categories: free, formal, digital, physical, and informal context. However, he does not address the issue of modeling the context. We believe that mobile learning research needs to acknowledge the complexity of context in order to reach sustainability. In the following sections we will describe our perspective on context and how to deal with it in respect to mobile learning.

Defining context

Research increasingly indicates that the inability of students to apply concepts learned in formal contexts is in many cases due to the abstraction and de-contextualization of the learning (Brown et al., 1989). But it is not the abstraction of knowledge as such that distracts learners, but rather that the abstractions are not illuminated with examples to put them into context. Understanding and learning is a product of the context and activity. Context provides a frame that guides and supports the learner. Situated cognition argues that learning is simplified by embedding concepts in the context in which they will be used (Brown and Duguid, 2000). There have been numerous attempts to define context. For example, Hull et al. (1997) defined context as *"aspects of current situation"*, which is a very broad definition. Another definition from a computer perspective is given by Brown (1996) where he defines context as *"elements of the user's environment which the computer knows about"*. Dey and Abowd (1999) gives a human centric definition when they define context as *"any information that can be used to characterize the situation of entities (i.e. whether person, place or object)"*. In Figure 2, Tarasewich (2003) illustrates context as a combination of environment, activities and participants. These continuously change internally as well as in relation to each other which is indicated by the arrows. The timeline is there to stress that context is a sequence of snapshots.

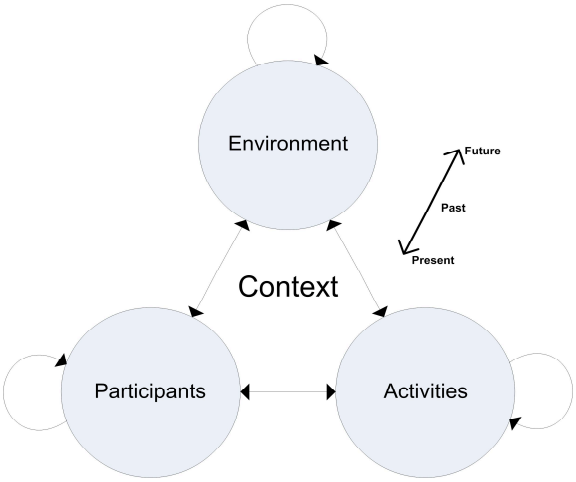

Figure 2. Tarasewich´s context model

Context is defined by Sharples et al. (2005) as *"context should be seen not as a shell that surrounds the learner at a given time and location, but as a dynamic entity, constructed by the interactions between learners and their environment"*. Our view of context differs slightly from these definitions, and is based on the idea to define context from the activity perspective and scale it down to attributes. Thus, we define context as *"information and content in use to support a specific activity (being individual or collaborative) in a particular physical environment at a specific time"*. This definition of context relies upon a three-pole structure consisting of the following attributes; location/environment attributes, activity/task attributes and personal/interpersonal attributes. These attributes depend on time, and are placed on a time line. The attributes of this structure are interdependent, meaning that information about who the user is, where the user is, what the user is doing and the interplay between these activities needs to become valuable inputs to the design process. Winters and Price (2005) claim that the context in which an activity is taking place is crucial. In Figure 3 we make an attempt to model a context applicable to mobile learning. A central component of this model is the Learning Activity System, best described as a computational system and content repository that provides the technological infrastructure for integrating educational content into the context where the learning activity is taking place. The participants interact with the Learning Activity System and with each other, thus promoting different modes of collaboration.

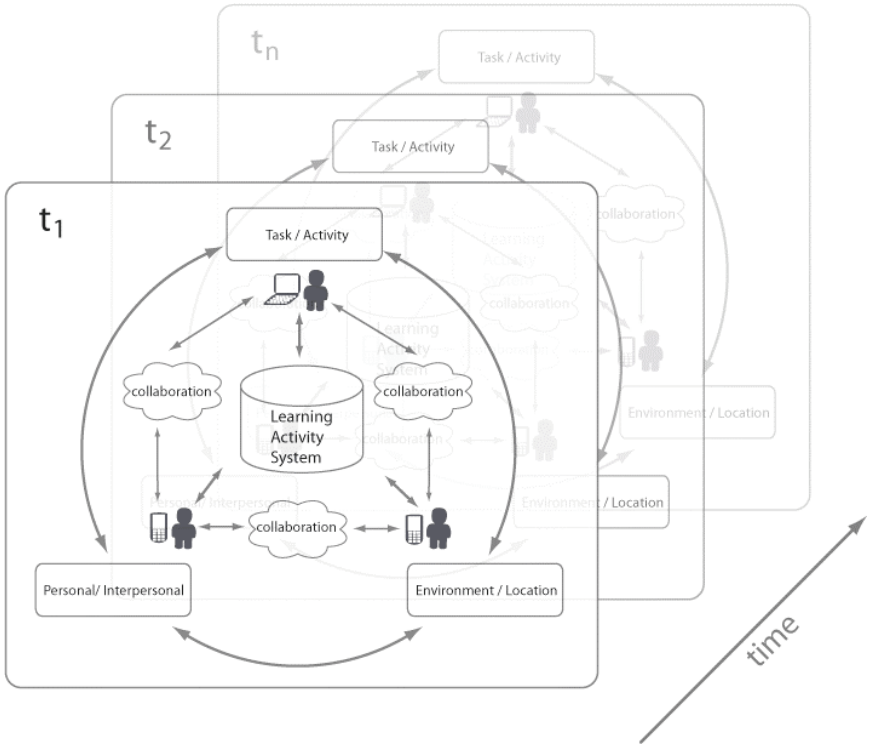

Figure 3. A Conceptual context model for designing learning activities

The square of the conceptual model in Figure 3, basically defines one frame of context where the activities are taking place. The frame is defined by a snapshot in time. The Learning Activity System is the central component and provides the technological support for the collaboration between learners in the context that these learning activities are taking place. From a technical perspective, the implementation of the Learning Activity System relies upon the use of different software components and mobile technologies, as well as sensors in order to contextually support indoor and outdoor activities and collaboration.

Mathematical representation of the context

Our view of context is built upon a space-time paradigm. Space is defined by three-pole structures. The time dimension becomes important especially when it comes to historical dependencies that could affect user profiles (i.e. personal/interpersonal attributes), activities and location/environment. The space part of our context model is built upon the three-pole structure, which in turn is represented as three coordinate axes (Figure 4). Each axis represents one of the attributes of our context model. It should be noted that this represents just one snapshoot at a certain point in time (t_1).

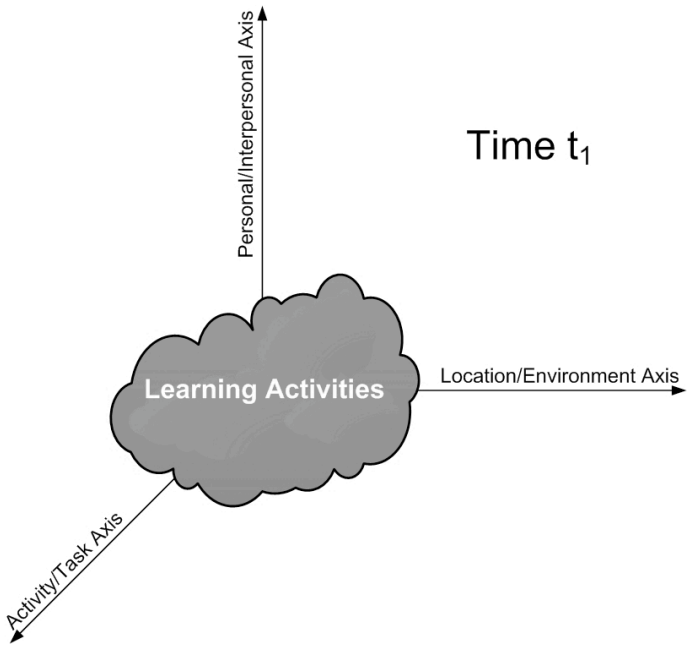

Figure 4. Context model as space-time paradigm

If we perceive the learning activity as a spatial function and use the three pole attributes of the context, then the mathematical representation of a context definition will be a function:

$$f\,(X_{LE}, Y_{PI}, Z_{AT})$$

This basically means that context is a function of location/environment attributes (X_{LE}), Personal/Interpersonal attributes (Y_{PI}) and Activity/Task attributes (Z_{AT}) and time. The time factor is important especially when it comes to historical dependencies and their impact on context. Each of the X_{LE}, Y_{PI} and Z_{AT} variables are functions of sub variables as well. These dependencies are presented in Table I.

Context $f(X_{LE}, Y_{PI}, Z_{AT})$		
Location/Environment $f(X_{LE})$	**Personal/interpersonal** $f(Y_{PI})$	**Activity/Task** $f(Z_{AT})$
X_{LE} = longitude latitude building humidity temperature light intensity etc.	Y_{PI} = person group age membership collaboration with etc.	Z_{AT} = type rules subjects involved outcome division of labour etc.

Table I. Spatial context representation

As Table I shows, the context is basically comprised of infinite dimensions that can be grouped into three major (location/environment, activity/task and personal/interpersonal) groups. McCarthy (1993) claims that contextual dimensions are infinite. Using this mathematical representation it is possible to build an infinite number of three-pole structures, which could be of use when representing context.

Context as a data model

Using the three-pole attribute of our context definition we build a data structure based on XML. This data structure is extensible and relies on four child nodes. Three nodes represent the three-pole structure while the fourth node of the XML file represents the snapshot attribute. The Snapshot attribute consists of time and date elements. The data structure is designed according to the XML schema illustrated in Figure 5. The XML file that complies to this schema structure represents one snapshoot of the context or one context frame as illustrated by Figure 3. Each of the nodes of the XML document represents one variable of the context spatial equation. Elements of these nodes represent different sub variables as presented in the Table I. The context data model can be used as metadata model that accompanies content (such as pictures, audio files, video files, document etc) that can be shared and distributed in the activities. Using metadata to capture context is advocated by Lehikoinen et al. (2007), where they argue that context-based metadata could improve and enhance movement and transmission of the content. Therefore we consider that having a structural organization of the context based on the three-pole structure, as metadata for different types of content can support and enhance collaboration between participants in mobile settings.

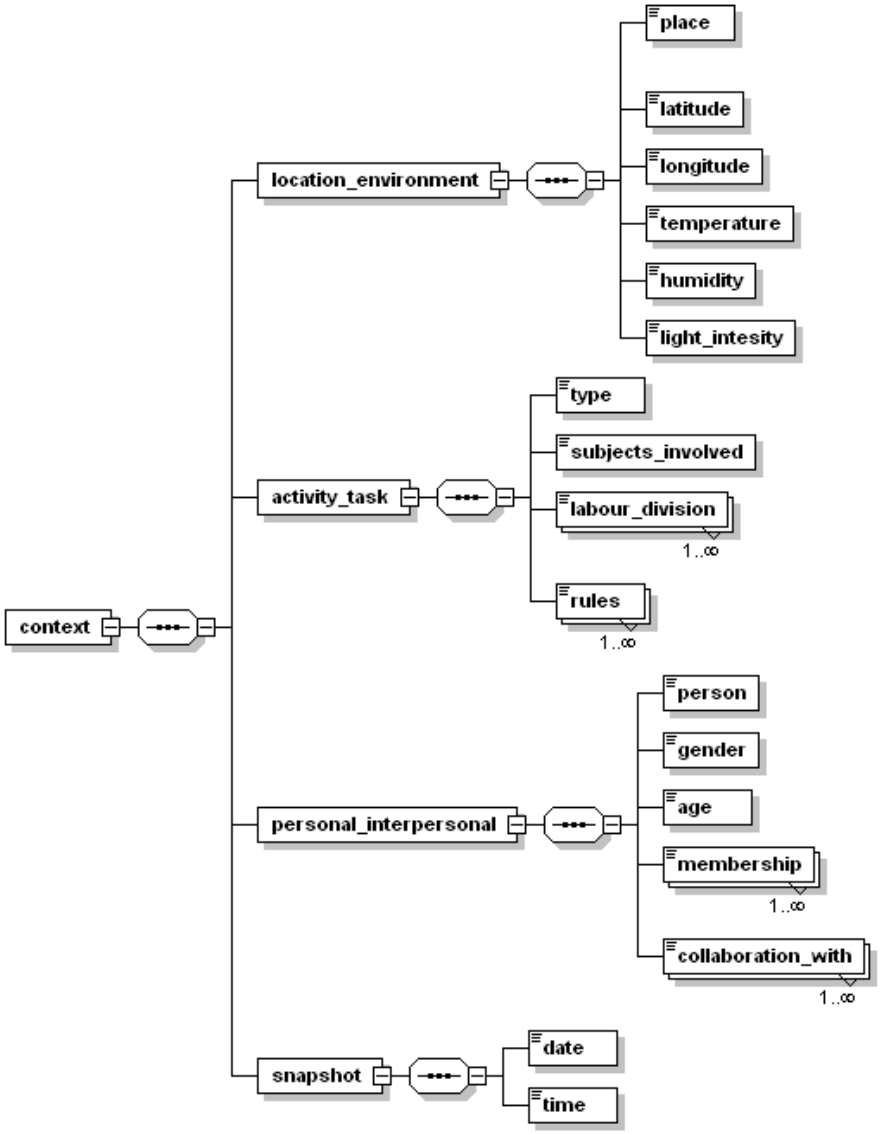

Figure 5. Context as a data model

Thinking in terms of systems

The context thinking in regard to mobile learning seem, up to this point, to be rather limited in view and the key as we see it is to look at mobile learning from a more holistic standpoint. This in turn will hopefully lead to practitioners gaining insights at all levels of mobile learning and be able to prove the potential improvement and enhancement. It is important to realize that a thorough grip on context is the key to sustainability for mobile learning. In other words, we have to

deal with things contextually. In other words, we should not handle the parts of a situation in isolation but rather deal with them as a compound. We have to regard all the attributes of a situation and see how they interact with one another. We cannot change or expect to change one of those attributes without impacting on or having to change some of the others. A sustainable mobile learning initiative would indicate that our mental paradigm (the model of the system in our minds) reflects the situation (real system) well. When little and no sustainability for mobile learning exist this indicates that our mental paradigm does not reflect the situation well. If we want a different outcome from a situation, in this case sustainability for mobile learning we have to come to terms with the system that underpins the situation in such a way that it delivers this output. In order to fully understand the underlying system, you must have a philosophical commitment on how to perceive the world and deal with issues you want to address. It is a way of looking at a situation from a holistic point of view, always searching for all the attributes it is made up of and looking for the outer boundary.

Churchman (1971) defined that a system has a goal, a purpose to fulfill and is made up of elements somehow related to each other. The elements themselves have a purpose as well but combining the elements has a greater effect than if they operate separately. The system is thus more than the sum of its elements. In order to investigate a particular issue an understanding of the connections and interactions between the elements that comprise the entirety of the system need to be reached. This kind of thinking may be used to study any kind of system be it natural, scientific, engineered, or human. But to think in terms of systems require an eye for seeing events, patterns, systemic structures and mental models. These models are a way of representing situations in the real world and can be expressed in different forms, e.g. conceptual, physical, data, and mathematical. To reach these models either a hard or a soft approach need to be adopted and the difference is summarized in Table II, which has its origin from Pidd (1996).

	Hard approaches	Soft approaches
Model definition	A representation of the real world	A way of generating debate and insight about the real world
Problem definition	Clear and single dimensional (single objective)	Ambiguous and multidimensional (multiple objectives)
People and organization	Not taken into account	Are integral elements of the model
Data	Quantitative	Qualitative
Goal	Solution and optimization	Insight and learning
Outcome	Product or recommendation	Progress through learning

Table II. Difference between Hard and Soft Approaches

Senge (1990) states that all human endeavors are systems and bound by interrelated actions. A system, either natural or mechanical, that is not influenced in any way by a self-conscious being, i.e. humans is best suited for hard approaches. In this research, we are discussing a system that is designed, built, and maintained by humans, and therefore we cannot solely use a hard approach, even though an element is technological. A hard approach enables us to see the elements and take them apart. It is usually the first step in tackling issues, focusing on one attribute at a time and trying to understand everything within that scope. A hard approach is more about understanding how things work in isolation, and more focused on finding differences rather than similarities. In our case, this is too limiting since when we break things down into smaller and smaller attributes, we tend to lose sight of the interactions between them. We need to understand how the attributes behave together in order to suggest improvements. Another problem with a hard approach is that it is a bottom-up approach, so it needs to be complemented with a top-down approach. For a soft approach, the opposite apply.

Mixing things up

A combination of both a hard and a soft approach would enable us to see the attributes and take them apart, while still not losing track of the interactions. The soft approach would be working from outside of the scope while the hard approach is working from within. We therefore feel that hard and soft approaches should be seen as complementary and mutually reinforcing each other. The idea is

to think both from a hard respectively a soft approach to maximize the understanding of situations and the issues at hand. The attempt is as much about troubleshooting our own mental paradigms as it is about troubleshooting the situations and issues we face. It enables perspective of both hard and soft approaches and thus provides more realistic, pluralistic and holistic models to be presented. A fundamental assumption is that everything is contextual and everything interacts with, affects, and is affected by the attributes around it. The key to this approach is that systems are made up of repeating patterns. We see patterns in things, situations etc. This enhanced context thinking enables us to identify the pattern (draw the box) so that we can think outside of it. Context is difficult to deal with as it is dynamic in texture and its elements change all the time and affect each other differently every time they do so. The important thing to realize is that we can train ourselves to think about context in a deliberate way. In other words, it helps when you can define your frame of reference (the box) clearly. Unless you are able to draw the box, you can certainly not think outside of it. Once you have drawn the box, you can escape it and this is invaluable when it comes to our expanded view of context.

Mingers (2000) argue that three purely analytical dimensions or aspects need to be considered in all real-world situations: the material, the social and the personal. The material world refers to aspects of the situation that concern physical space-time, entities and objects. The social world can be seen as the norms, language and practices. Finally, the personal world take into account the intricate power of personal experiences with feelings, beliefs and choices. It is our opinion that practitioners in the field of mobile learning need to develop ways to understand these important dimensions. The main argument we want to bring forward is that all real-world situations, no matter how technical they appear, exist in complex organizational environments, which has social as well as personal implications. As a suggestion to deal with this the benefit of soft approaches are evident and Soft System Methodology can be seen as its flagship bringing a strong structure to the table.

Introducing Soft System Methodology

Checkland developed Soft Systems Methodology in the 1970s as a systemic approach in order to perceive, predict, compare and ponder on changes for a real–world situation. It should not be regarded as a technique or a method but a methodology as the name it self points out. Checkland (1981) stresses that the outcome of research is not a method but a set of principles. The starting point for Soft Systems Methodology is that the real world is seen as a complexity of relationships and these should be explored via models of purposeful activities based on explicit world-views. It is critical to formulate the root definition and collect the minimum amount of necessary activities in order to structure these

activities into basic conceptual models. The next step is to compare these to the reality. Inquiry is structured by questioning the perceived situation using the models as a source of questions in turn. Action to improve is based on finding accommodations (versions of the situation which conflicting interests can live with). This inquiry is in principle never-ending.

Soft Systems Methodology is a means to learn and communicate about a system where humans are an attribute. The special nature of these means that systems studies concerned with them is always multi-facetted, with many relevant and often conflicting values to be explored. The outcome is never a solution to a problem; it should rather be viewed initiative to start a learning process with no end, to form the basis for action. Soft System Methodology addresses the broader system in a profound, self-perpetuating and reinforcing way. It enables us to deal with the attributes of a situation in combination rather than in isolation. Its power lies in its body of knowledge and techniques. It offers the potential to find the context in respect to any situation. Soft System Methodology is useful when rigor and deep insights are needed under these circumstances: multiple goals, different views and perspectives, different assumptions, different logics, different stakeholders i.e. a very complicated situation.

For the case of mobile learning we clearly see that the above applies and we want to address this complexity with Soft System Methodology, as it provides a "tool-set" to be able to grasp the context from an extended view. This can be the key to fitting the environment, technology, participants and activities appropriately and in the long run reach sustainability.

Conclusion

Mobile learning is exposed to an inherently complex situation, which results in issues with sustainability. In order to understand the situations and the issues that may impact that sustainability of mobile learning and suggest improvements we need to create an overall picture. Mobile learning must be studied within the context it is deployed in. This concern mutually the material, social and personal world, although their relative importance will vary depending on the situation at hand. It is our belief that in order to promote and achieve sustainability in mobile learning, an extensive view on context needs to be used. Model building in itself should not be seen as a way to provide the "answer" to anything; it is merely a way of creating a platform for reflection and a communication tool. Knowledge of the world is incomplete and subjective, so the process of creating models is iterative and evolving. A model is used to represent something, and the representation might be true to real life or may be conceptual in its attempt to emulate real-life. Instead of focusing on sustainability in isolation for mobile learning, using hard and soft approaches enables us to better understand the attributes and the context. The hard approach enables us to focus on the attributes

on a more technological level. The soft approach is a top down approach aiming for a holistic view and the underpinning philosophy is interpretive and its systematic nature makes it suitable for dealing with complex situations. We therefore feel that hard and soft approaches should be seen as complementary and mutually reinforcing each other. We therefore suggest combining the hard and the soft approach. These efforts would maximize our understanding of the situation and the issues at hand. Both the strength and weakness of this suggestion is that it needs to be done by people truly involved and able to see the attributes at play. Drawing up the box and having a grip of the whole context is a very demanding chore.

Nonetheless, the expanded view of context might provide the palette to reach sustainability for mobile learning. The intention is to elucidate the most important attributes in the context of mobile learning but still having a holistic viewpoint in mind.

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