Challenges for a Microlearning-Driven Process of Knowledge Creation

Modes of Knowing and Creating Knowledge in Microlearning Environments

(On Microlearning)

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Abstract: Any kind of learning always is rooted in different modes of knowing. This paper aims at developing a vision in which microlearning is not only embedded in a knowledge ontology, but also in a whole process/cycle of knowledge creation: i.e., by starting from observations, via constructing relationships, rules, etc. and meaning, to developing the potential of realities and creating new realities, as well as reflecting the whole process a whole cycle of knowledge creation will be developed. It will turn out that microlearning strategies are particularly interesting and beneficial for almost every stage in that process – microlearning as a process of knowledge creation. The epistemological challenges for such a framework will be outlined in detail in this paper.

1. Introduction

Whenever we are dealing with educational processes we are confronted with various forms of knowledge. In most cases these types of knowledge remain implicit and unquestioned. They just appear as one chunk of knowledge (e.g., definitions, questions, arguments, explanations, instructions for acting, image, etc.) in the course of a teaching/learning unit. In most cases the meta-data about this knowledge is not considered very important.

However, if we take seriously that educational processes are intrinsically knowledge-driven, it is necessary that these questions concerning different types of knowledge receive new attention. Recently various approaches, which can be summarized by the notion of "knowledge didactics", have been developed (e.g., Auinger and Stary–2005, Swertz 2004, standardization processes in the educational field, etc.). Most of these approaches take into account didactical, pedagogical, or web/technology-specific issues

as well as refer to specific traditions in the field of education.
Apart from these issues, it is also necessary to consider epistemological as well as cognitive issues (cf. Peschl 2003, 2005). This is of special relevance in the context of *microlearning*, because this type of learning often is applied in more "existential fields" or in context sensitive fields (e.g., "learning pulses" in specific situations). That is why it is necessary to consider the question of knowledge-typologies or "knowledge-ontologies" from a new perspective taking into account the role of reality, which kinds of (cognitive) interaction are applied to reality, which types of interaction lead to which types of knowledge, which "domains" of reality are covered by which types knowledge/interaction, what can be done with that knowledge, etc. and how these types of knowledge creation can be embedded in microlearning settings. It is important to take these questions into consideration especially in the context of microlearning, as – in many cases – microlearning is embedded and realized in scenarios where direct interaction with reality(i.e. the phenomenon of interest) and situatedness (of the learning process) in reality are primary sources for the process of learning and of knowledge creation/construction.

2. Modes of Knowing and Knowledge Creation – a Microlearning Perspective

Hence, if we take seriously that knowledge is the main resource, source, as well as the main product of learning processes, we have to develop a "knowledge-based" approach taking into account the special features and possibilities which are offered by the microlearning-paradigm. The process of (micro-)teaching/learning will be re-interpreted in the light of an individual and collective process or *cycle of knowledge construction and knowledge creation.*
In order to understand and improve learning/teaching processes according to the microlearning-concepts, we have to take a closer look at the modes of knowing and levels of knowledge that are involved in these processes first. Table 1 gives an overview over these modes. This table identifies three domains describing (i) the level of knowledge (in the sense of which realm of reality/the phenomenon this level refers to), (ii) the cognitive activities which are necessary to construct and explore this realm, and (iii) the characterization of the knowledge which is the result of these construction processes. In the section to come these forms of knowing, knowledge, and knowledge creation will be brought into the context of microlearning.

Table 1: Levels of knowledge, modes of knowing, and the (cognitive) activities necessary for developing these modes.

	Level	*Cognitive activity*	*Resulting knowledge*
1	**Behavioral level**	• Observing • Detecting & registering • Describing	• Description of the observed object, its behavior(-al dynamics), its external and superficial properties (e.g., material, etc.) • List of observed properties ("data", "facts", etc.)
2	**Level of (emerging) patterns of behaviors and relationships**	• Searching for, constructing, and "discovering" regularities and patterns • Projecting patterns • Quantitative induction • Constructing patterns • Single-loop learning	• „Explanation" of the observed behavior by making use of internal mechanisms (which are postulated and "projected" into the observed behaviors) • These mechanisms are said to be responsible for generating the constructed (behavioral) patterns (i.e., these mechanisms are the „pattern generators") • "Know how" • "Recipe knowledge" & algorithmic knowledge
3	**Level of causes and the "source"**	• Searching for, constructing, and discovering causes, meaning, finality, etc. • Activity of "radical questioning" • Discovering/constructing the intangible dimensions of reality • Discovering & constructing the "deeper source", the "substance"	• Understanding the observed phenomenon • Understanding its meaning and the "source"/causes which are behind the mechanisms • Knowledge about the intangible dimension of the observed reality • "Deep knowing/knowledge", knowledge about the core of the reality • Knowing "from within" • "Metaphysical knowledge" (in the sense of knowing the "substance")
4	**Level of potentiality, change, and design**	• Exploring, discovering, and developing the potentials of a reality • Making use of and bringing "deep knowledge" and the mechanisms to the domain of application • "Facere" and design • Changing reality according to knowledge	• Artifacts, technology • Social, scientific, and cultural realities • Organizations • Visions + their realizations
5	**Level of reflection (of the causes, source, patterns, processes of knowledge construction, etc.)**	• Reflecting • Reframing • Radical Questioning (your mental models, premises, etc.) • Reflecting the learning and construction process itself • Reflecting the design-process itself • Double-loop learning	Knowledge about the following questions: • What are the assumptions/premises behind these causes/source? • What are the mental models behind the observed behaviors, patterns, and the source? • How can these premises and mental models be changed and which effects would these changes have on the understanding of the whole phenomenon/reality?

As can be seen in Table 1 each domain of reality is "covered" by a specific form of knowledge and by a specific "cognitive activity" – this is not surprising: from a constructivist (e.g., Foerster 1973; Glasersfeld 1984, 1989, 1995) as well as cognitive perspective (Peschl 1994) it is clear that cognitive processes are responsible for generating discriminations in the environment (e.g., Maturana 1970, 1991) leading to particular forms of knowledge.

2.1 Why Observations and Facts Do Not Suffice

What is the starting point of any process of knowledge creation? Normally, we start with perceiving a phenomenon via our senses. Level 1 concerns these "superficial" properties of the phenomenon of interest: our primary observation, perception, and cognitive processes bring about a rather superficial and singular (in the sense of referring to a single concrete object or phenomenon) kind of knowledge in a first step. This knowledge is realized as a list of observations, descriptions of behaviors or behavioral dynamics, a list of data, facts, etc. It is not about more general and universal properties of the observed phenomenon, but describes this phenomenon on its *behavioral level* as it presents itself to our senses. Both from an intellectual and cognitive perspective the resulting knowledge of this process is not really very interesting, as it deals only with particular singular events/phenomena leading to descriptions which do not show any patterns or regularities of the observed phenomenon.

Taking this descriptive knowledge as a point of departure and progressing in the processes of knowledge construction, we are reaching the level of *(emerging) patterns, trends*, and *relationships*: they are not "directly perceivable" with our senses. In order to arrive at that level more complex and active construction processes are necessary. Normally, this is the domain of the (natural) sciences, where relationships are constructed by relating facts and descriptions, and behavioral patterns begin to emerge. I.e., these patterns are the result of more or less complex inductive and constructive processes (in many cases being realized as statistical procedures). Most so-called (scientific) explanations are situated on that level: they offer cognitive, mental, or even physical mechanisms explicating the relationship between hidden (theoretical) structures and the observed behavioral dynamics of a phenomenon. These mechanisms are assumed to be "responsible" for generating the observed phenomena (compare, for instance, Maturana's concept of scientific methodology; Maturana 1980, 1991) – by offering such a mechanism one can also offer an explanation for the constructed patterns and regularities by providing this pattern-generating mechanism. Hence the resulting knowledge mainly is concerned with the "how" and the dynamics of the observed phenomena. In many cases it has the form of "recipe-knowledge" (i.e., more or less complex structures of if-then rules). The cognitive activities leading to this kind of knowledge have strong structural similarities with the processes of theory/hypothesis construction well known from the natural sciences (e.g., Peschl 2001). From a learning perspective, these construction processes can be considered as epistemological optimization aiming at finding the best possible level of functional fitness (in the constructivist sense; e.g., Glasersfeld 1984, 1991, 1995); they are realized in a single-loop learning cycle (Argyris and Schön 1996; for a detailed argument see Peschl 2005, 2006).

So far, we have come to the point of overcoming the level of descriptions by constructing relationships "explaining" how the observed behavior comes about on a material level. On level 3 we are going one step further: on that level more qualitative issues are at stake. While level 2 was mainly concerned with rather quantitative and measurable matters, level 3 construction processes aim at the realm of a phenomenon going beyond its material, measurable, and tangible properties, such as its meaning, finality, etc. Philosophically speaking, this level concerns the exploration and the construction of causes (for instance, in an Aristotelian sense [1989]). It can be reached by applying intellectual tools, such as radically questioning, exploring the meaning, or trying to reach "deep understanding" of a phenomenon. The resulting knowledge, in a way, is the *source* for a deeper understanding of a phenomenon – i.e., the construction of a kind of *"deep knowing/knowledge"* (e.g., Jaworski et al. 2000; Scharmer 2000, 2001; Senge et al. 2004), knowing reality "from within". From a constructivist perspective this may sound quite metaphysically, and, in fact, it is close to metaphysics in the original sense (Aristotle 1989, Philippe 1991). However, that is *not* a contradiction to a constructivist approach. Rather, it makes a statement about how classical natural science inspired (and limited) construction processes can be overcome and be led into a more qualitative understanding of a phenomenon, e.g., by exploring its finality. From an intellectual perspective we are confronted with knowledge concerning the "core" of a phenomenon on that level. This type of knowledge which is not taken into consideration in most approaches in technology enhanced learning/teaching settings is rather difficult to acquire. It cannot be "transferred" from A to B; so, for eLearning processes it is not so much a question of how to transfer this knowledge to the student – rather the learner him-/herself has to take a path of intellectual discovery and construction in order to reach that level of insight; hence, technology plays the role of supporting this path. What this means in the context of microlearning will be shown in section 3.2f.

2.2 Going Beyond Causes – Entering the World of Second Order Knowledge Processes

It is that level of deep knowing which also reveals another dimension of a phenomenon or reality: its *potential(-ity)* with regard to change. I.e., at every point in time each phenomenon is in a certain state and that state can change over time. Hence, there exists a space of potential change(s) at every moment; a space of possible changes which can happen or which can be induced to that phenomenon. As a simple example, think of a stone which is given a new form by an artist: a process of *"transformation"* into a sculpture according to the artist's plan or knowledge. This sculpture is one possible instantiation in the space of potentiality of that stone. Only if one has a profound knowledge (level 3) about an object, a phenomenon, etc., it is possible to explore, construct, and develop the full potential of that reality. I.e., on level 4 we are changing the perspective from the mode of "contemplation" to the mode of "facere"/doing. The interesting point is that this level of knowledge does not only explore the space of potentiality, but also realizes (some of) these possibilities. I.e., we do not remain in the space of intentionality/knowledge by constructing new (knowledge) realities as a result of applying knowledge from the levels 1-3; rather new physical realities are created or existing (physical) realities are changed by externalizing or instantiating this new knowledge in(to) reality.

In a way it is a "materialized constructivism" where artifacts, design, technology, etc. are in the same way a product of this level 4 knowledge-process as creating cultural, scientific, social, etc. realities. This mode of knowledge is the key for most processes of *knowledge creation*, of *innovation*, and of finding and instantiating a *vision*.

Finally, level 5 knowledge brings in a completely new quality in the process of knowledge construction: the dimension of *reflection*. This step has the potential to fundamentally question the knowledge having been constructed so far by reflecting on the knowledge, its premises, as well as on the construction – and learning processes having led to that knowledge. The cognitive activities, methods, and "epistemological technologies" being applied in that mode of knowing include processes of deep reflection and questioning, systematic reframing, questioning the premises, ideologies, the construction processes, uncovering mental models and hidden assumptions, etc. This level of knowing introduces a completely new dynamics into the whole process of knowledge construction and knowledge creation, because it is situated on a *meta-level* and it can bring up completely unexpected results and new perspectives which have not been considered so far. This mode of knowing and knowledge acquisition is realized in the *double-loop learning* strategy (Argyris and Schön 1996) – it is especially powerful when it is performed in a collective setting. Rogers 2001 gives a good overview for the role of reflection in higher education – the author shows the importance of this concept for *all levels of knowledge* having been developed above.

3. Microlearning as Continuous Knowledge Creation

Knowledge-oriented educational processes in the microlearning paradigm do not mean that one only abstractly knows these modes of knowledge and knowing, but that these modes explicitly find their way into the design of the particular course or contents. Normally, educational processes at university level do not go beyond level 2 (especially in the natural and technical sciences) and level 3 of Table 1. If students are supposed to reach a profound understanding and a high level of sovereignty and autonomy in a certain domain (of reality/knowledge), it is necessary to consider all of these levels of knowing and to concretely implement them in a particular course or curriculum. Reducing knowledge to only one or two of these levels perhaps leads to highly specialized and efficient "optimizers" and well adapted "recipe applicators", but surely will not bring forth persons with a highly open attitude, with exceptional potential for innovation and for developing radically new perspectives, and with a high level of reflection. Looking closer at concrete settings of knowledge creation/construction it is evident that these processes are not limited to a single knowledge-level of Table 1. The knowledge-levels having developed above do not exclude each other – rather, they depend on each other and there is strong interaction between them in order to bring forth knowledge which is as rich as possible.

3.1 Microlearning Features Reconsidered

What is the relevance of this typology concerning modes of knowing and of coming to know for the domain of *microlearning*? Apart from classical forms of learning/teaching as well as from classical media-supported forms of learning/teaching (e.g., eLearing, communication tools, knowledge management tools, etc.) the microlearning approach offers features and possibilities going beyond these forms of learning/teaching. These "microlearning-features" provide solutions and procedures for the requirements of knowledge creation in the domains of knowledge having been developed above.

Here are some of these features which seem to be of high relevance for our question of knowledge creation in the spectrum of types of knowing (see also Hug et al. 2006): Learning takes place in micro steps:

- These micro steps have proven to be the basis for a learning success with a high level of sustainability (e.g., Hug et al. 2006);
- Furthermore, these microlearning steps facilitate the process of deep understanding and creation of profound knowledge, if the microlearning process is embedded in an appropriate learning design/setting (e.g., Peschl 2005, 2006);
- Microlearning offers the possibility of *ubiquitous learning* and by that
- supports a continuous process of learning over a longer period of time;
- Ubiquitous learning and mobile technologies provide the basis that microlearning can be realized as situated learning (situatedness) implying learning from direct interaction with reality;
- Due to a continuous accompanying character of microlearning these technologies can be applied also in the field of in the personality (development) & existential issues.

It is not a particular feature which is responsible for a successful process of learning or knowledge creation. Rather, it is the combination of these features bringing about the high impact of the microlearning paradigm. If these features are combined explicitly considering the meta-structure of knowledge processes (e.g., the typology of knowing having been developed in Table 1) this paradigm becomes even more powerful.

3.2 Microlearning Technology as Enabler for a Cycle of Knowledge Creation in Different Modes of Knowing

What is the potential of microlearning technology from a knowledge-oriented perspective on learning/teaching and knowledge creation? What are the specific features and knowledge-tools that microlearning can provide, what are the specific challenges, and which knowledge-tasks can be supported by that paradigm? Having in mind the differentiation of levels of knowing from Table 1 we will investigate the strengths and assets (as well as some of the weaknesses and possible problems) which are brought about by the microlearning paradigm. It will turn out that it does not suffice to understand these levels of knowledge/knowing as static domains, but that they form a *process/cycle of knowledge creation*, if they are integrated in a process model – microlearning provides a framework in which such an integration can take place.

3.2.1 Observations and Behavioral Level

The very first step of knowledge creation concerns the processes of observing, collecting data, gauging, going "out in the field", creating descriptions of observations, etc. From an epistemological perspective this is a "hot spot" for the process of knowledge creation as these data are the basis for almost all the other forms of knowledge. That is why it is particularly important to take a closer look at these processes and at how these processes could be improved by applying microlearning techniques.

Microlearning plays an important role in that stage of knowledge creation as many learning processes are based on observation and data collection. Every observation is a micro-step in the process of learning and theory/knowledge construction. The process of observation is essential for almost every empirical study or experiment especially when it takes place in the "field" – the microlearning approach can support these processes in the following ways:

1. Due to its ubiquitous features and in combination with mobile technologies the microlearning paradigm can be used for providing *context information* as well as theoretical foundations for the observation process. The user can use this information for getting some knowledge about the (theoretical) background of the specific learning and/or observation task.

2. Above this background information the knowledge provided may *guide his/her observation.* I.e., the process of observation itself is supported by microlearning technology giving instructions "where to look", what to look for, etc. – this process can be understood as *"augmented observation process"*. In many cases – especially if the learner is not experienced – this leads to more precise observational data. Furthermore, in combination with the theoretical background knowledge the learner gains deeper insights, as he/she can *make more sense* out of what he/she has observed.

3. Microlearning technology allows the user to *collect more data* than normally necessary: taking images or recording audio files which are – at first glace – not necessary for the particular empirical study may turn out as valuable context information in the process of processing and re-assessing these data.

4. Microlearning technology supports the process of documentation of observational knowledge; e.g., by providing structured forms for documentation.

The point concerning the "augmented observation process" has a problematic side as well: *theory-ladenness* is the biggest enemy of any observational process (e.g., Hanson 1958)! Due to precise instructions guiding the process of observation the learner my miss interesting or relevant details of the observed phenomenon which are not covered by the observational pattern/grid being implicitly provided by these instructions. Hence – according to the level of expertise – it is necessary to find a good balance between the narrowness of instructions leading the process of observation and the openness for the observer's unbiased receptivity.

3.2.2 Relationships and Emerging Patterns

At that level of knowledge microlearning is challenged to support the process of constructing relationships and spacio-temporal patterns as well as of theory construction. The particular contribution of microlearning consists in the following tasks:

- In this regime microlearning does not consist in transferring "knowledge nuggets" from A to B. The learning challenge is a task of *knowledge construction.* Microlearning should develop concepts for designing the learning task in such a way that it can be completed in "micro-construction steps" (as an example see Peschl 2006a);

- Providing tools (e.g., statistical tools) for generating relationships and correlations;
- Providing tools for visualization of trends and to support the dynamic generation of relationships (e.g., by visualization);
- Providing tools for making explicit the implications and dynamics being generated by these relationships, mechanisms, explanatory schemata, models/theories modeling the observed behavioral dynamics, etc.

3.2.3 Causes – the Power of "Micro-Questions"

This level of knowledge construction has close relationships to philosophical investigations. The process of *questioning* is a core (cognitive) activity at this level – that is an activity which cannot be "outsourced" to a computer or to automated processes. The goal is to discover, construct, and attribute the meaning, the finality, etc. of a phenomenon. These intellectual activities are intrinsically tied to cognitive processes. Hence the role of microlearning is not so much that of "immediate knowledge production" or of a knowledge provider, but that of supporting and *enabling* these cognitive activities.

Support for the process of (radical) questioning. Microlearning is the ideal strategy for *continuously supporting* the process of questioning by *providing a stream of questions* depending on the current learning *context* ("micro-questions"). These questions (+ their possible answers) enable the learner to go more directly and more deeply to the core of a phenomenon and bring forth knowledge about the intangible and "hidden" dimension of a reality.

Documentation of the process of questioning. By presenting these questions it is a relatively simple task to provide a structure for collecting and aggregating the emerging knowledge.

Support the development of an attitude and a *"habitus" of questioning*: due to its ubiquitous and continuous character microlearning turns out to be a highly efficient strategy for developing attitudes and habitus. I.e., these are (cognitive) predispositions and activities which are very deeply rooted in the human person and which cannot be learned like skills or facts. Hence it is necessary to *persistently train* these attitudes in micro-steps of learning and repeating. Microlearning strategies, such as "microlearning-pulses" are an effective means for developing these attitudes; for instance, the attitude of questioning can be trained almost in every everyday (or scientific) situation and leads to high competence in creating knowledge on the level of causes. Furthermore, this attitude of questioning is highly valuable not only for the specific domain where it is trained in, but also for any intellectual activity in general: it cultivates the learner's openness, receptivity, and readiness to deeply dig into the profound understanding of a phenomenon.

3.2.4 Creating New Realties & Innovation

As has been shown above, this domain of knowing contains two aspects: (i) *discovering the potential(-ity)* of a reality and (ii) actually *realizing* this potential in a concrete action by transforming an aspect of reality and/or by producing a concrete result. Both fields offer interesting possibilities for the microlearning approach:

Here again, microlearning is not concerned so much with the task of knowledge transfer, but with supporting and augmenting the process of individual and collective knowledge creation as well as construction of reality. What is the epistemological challenge of discovering the potentiality of a reality/phenomenon? (a) To understand the core/"substance" of the object one wants to change, (b) to see what would be possible, and (c) to achieve some understanding of the consequences of these possibilities by exploring this space of potentiality. Cases (a) and (b) are very much tied to our cognitive abilities, whereas (c) can be supported in the following way: By making use of *augmented reality technologies* in combination with microlearning strategies the potentiality of a reality can be made accessible to your senses (e.g., via visualization); the user can (inter-)actively shape his/her (virtual) environment by applying simulation and augmented reality techniques – the goal is to explore the space of possibilities on the basis of a profound understanding of the phenomenon under investigation without having to instantaneously realize these possibilities. That is what simulation and anticipation (e.g., in a "Gedankenexperiment") are about. Finally the user will end up with a concrete plan.

While classical learning strategies leave the user alone by him-/herself in the moment of realizing a plan, in the moment where he/she goes out into the world and starts to bring the plan into concrete action and changes in the reality, microlearning offers a real alternative: Due to their mobile and ubiquitous character microlearning devices are present in the moment where the user gets in direct contact with the reality or phenomenon he/she wants to actually change. It is a new challenge for (micro-)learning technologies to develop strategies supporting these processes of realizing something in the physical environment; apart from instructions concerning the proper use and application of tools in order to effectively transform reality, one big advantage is the possibility to establish a feedback-loop between the desired (idea, plan, knowledge, etc.) and the actual result in the environment and, by that, to approach a closer fit between these two domains in a stepwise manner. Furthermore, the community aspect plays in important role in that rather practical context: via ICT *learning communities of practice* can be established in which knowledge is exchanged which cannot be found in textbooks. These microlearning processes in the practical field are not only of interest in the educational domain, but also in the context of *innovation and prototyping*.

3.2.5 Reflection

Finally, in the context of reflection microlearning offers numerous possibilities of supporting this process:

- Reflection is always based on the knowledge, documents, etc. having been created in the course of the learning-/knowledge construction process. In an integrated microlearning framework this knowledge can be brought into the reflection process easily, because it has been created in continuous cooperation with that system and because the knowledge is available in a mobile manner.
- Due to its mobile and collaborative character microlearning supports a *collective* dimension of reflection both in a f2f and a virtual setting (compare also Peschl 2006).
- Due to their ubiquitous character microlearning strategies are capable of developing a habitus of *"reflection-presence"*: i.e., the ability to continuously stay in a mode of reflection accompanying the actual process of knowledge creation. Microlearning strategies do not only play the role of "reminders" (i.e. reminding the user of his/her commitment to reflection), but also actively support the process of reflection, for instance, in the form of offering a leaning journal (which can be shared with others), of questioning diverse knowledge activities ("micro-steps of reflection"), etc.

3.3 Concluding Remarks

In this paper a vision has been developed in which microlearning is embedded not only in a knowledge ontology, but also in a whole process/cycle of *knowledge creation*: i.e., by starting from observations, via constructing relationships, rules, etc. and meaning, to developing the potential and creating new realities as well as reflecting the whole process we have gone through a whole cycle of knowledge creation. It has turned out that microlearning strategies are particularly interesting and beneficial for almost every stage in that process.

As has been shown in this paper each type/level of knowledge and knowing is related to a particular cognitive and or technology supported process of knowledge construction. Taking these tasks together and integrating them in a unified framework these processes form a cycle of knowledge creation. It has been shown that the microlearning paradigm provides a framework in which these modes of knowing can be integrated. The main (epistemological and technological) challenges for such a framework have been outlined in detail in this paper – some of them remain to be proven in concrete applications.

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