Learning Organizational Memory and Microlearning (Semantics for Microlearning)

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Abstract: this article, present several scenarios showing the pertinence of the concept of microlearning. It also describes the main requirements for structuring microlearning sessions and in particular the definition of micro-content. We also present an environment designed in another context. The objective is to show the elements that could be updated for enhancing the system with microlearning scenarios.

1. Introduction

Microlearning is a new concept dealing with the constant need to learn and the difficulty to access the right information when it is necessary. These difficulties are coming from the large amount of information and its non adaptation to learner's profile and agenda. Microlearning community claims that people can learn better, more effectively and in an easier and more enjoyable manner if information is broken down into smaller and attractive units and if learning takes the shape of small steps.
In this way, pedagogical micro-content can better support microlearning steps. It has to be based on a simple technology that can be run on all web-based platforms and devices, including web-enabled phones, personal assistant and TV. Micro-content contains a very limited amount of information compared with other forms of classical contents due to several constraints: (i) physical device limitations (screen size, interaction), (ii) limitation of cognitive effort due to short time dedicated to learning sequences.
Micro-content can be either self-contained, individually referable, allowing its reuse in different structured macro-contexts and macro-containers, or it can be filtered from macro-content with specific algorithms generally based on device limitations. In conclusion, micro-content can be considered as a kind of learning object requiring some dedicated metadata.

In the Information System context, the "Semantic Learning Organization" (SLO) is an emerging concept that extends the notion of learning organization in a semantic dimension. A SLO must be considered as a learning organization in which learning activities are mediated and enhanced through a shared knowledge representation of the domain and context of the organization.
Within the project MEMORAe we developed an environment based on the concept of organizational memory in which pedagogical content is broken down into notions to learn. This environment has been designed and evaluated, and is dedicated to be used by a SLO. In such a system notions are linked together according to a pedagogical scenario in order to guide learners during their training. Learning content is indexed on notions described and organized by the means of ontology. Learners can acquire these notions by doing different tasks (solving problem or exercise, reading examples, definitions …). Learning content can be expressed according different formats and for different access supports, that is why they are also indexed by corresponding metadata.
In this article, we first present several microlearning scenarios; some of them are related to mobile learning. Then we present some requirements for microlearning and in particular the definition of micro-content. Finally, we describe the most important results of the project MEMORAe (which in French stands for Organizational Memory dedicated to eLearning). Our objective is to show how the resource indexing process used in the project could be adapted for storing specific micro-content. Its environment could be enhanced with scenarios based on microlearning sequences.

2. Scenarios of microlearning

Microlearning can be seen as a contextual lifelong learning process. Microlearning activities rely on the access to learning resources which may happen at anytime, anywhere and with the support of any device. These activities generally requires a short sequences and do not intend deep cognitive implication.

The first scenario describe a secretary having a break of 15 minutes and willing to know more about a text editor, for example the use of the format option. She has to access for a while to relevant resources displayed on a computer screen. In the case she is not in her office but has her PDA, she can access the same content but with resources adapted to the specific screen of this device.

Other scenarios directly involve the use of mobile devices. The specificity of the PDA may confer to it the right device for microlearning. In (Trifanova and Ronchetti, 2005) and [Kadyte, 2005], the PDA is presented as the best device for supporting the learning of a language and that may efficiently help the preparation of an exam.

All steps required to achieve a learning objective can be organized around episodes concerning notions to acquire and a microlearning environment must enable learners to record in history, episodes they have already visited. They can access the following episode as soon as they have several minutes free. Several episodes may be required to present the same notion; in this case they are linked into a sequence. It would also be interesting to have different sequences to offer to learners. They could choose the more appropriate one according to the context (time, device) or their preferences (presentation, example, course, exercise…).

In these scenarios, learners could follow, step by step predefined training paths of independent episodes organized around notions to acquire. Micro-content used in these kinds of scenarios need specific meta-data to be described and indexed.

3. Microlearning Requirements

Microlearning is an alternative to respond to two major problems concerning learning:

- The overflow and complexity of information,
- The time and place to learn.

Microlearning uses continuous improvements of ICT technology performance. It proposes to structure information into sequences, small and well linked units which take little time. The power of microlearning results from the repeated use of inter-spaces over time. The assumption is that this enables individuals to manage their information acquisition and thus to reach their personal objectives and those of the organization they work in (Bruck 2005). According to this, we can't realize microlearning without micro-content which necessitates metadata adapted: how to choose one micro-content rather than another one?

3.1 Micro-content

We can find many definitions of micro-content (MC) but according to microwiki[1], MC is a (very) small unit of digital information that is self-contained, individually referable/addressable, allowing use/re-use in different loosely structured macro-contexts and macro-containers.

- MC is small: It contains a very limited amount of information compared with other forms of cultural "content". The reasons are physical limitations (screen size, interface complexity) and cognitive limitations (limited attention span of PC and Web users, but also of media users in general).
- MC is individually referable and addressable: It is defined or at least definable by a set of formally declared metadata (like a specific URL / permalink, a time-stamp, an author name, an IP address, connection data, a subject line, a tag or keyword …).
- MC is self-contained: It is a unit of information that can stand for itself not only formally (through metadata) but also semantically. It can clearly be separated from its macro-context. It is not locked into a macro-text or into an application. It is focused around a single idea or small set of related ideas. It is accompanied and defined by explicit or implicit metadata.
- MC is reusable: It is content set free to separate and form new patterns, in the mind of the user, on the screen of a device or within the processing logic of an application. It is "small pieces loosely joined", enabling new technologies of aggregation and syndication and new socio-cultural practices. It allows new "fuzzy" forms of texts, new open patterns of sign, new collaborative practices of communication.

According to the Ltsc working group on Learning Object Metadata[2], Learning Objects (LO) are defined as any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning. Examples of technology supported learning include computer-based training systems, interactive learning environments, intelligent computer-aided instruction systems, distance learning systems, and collaborative learning environments. Examples of Learning Objects include multimedia content, instructional content, learning objectives, instructional software and software tools, and persons, organizations, or events referenced during technology supported learning.

1 http://www.microlearning.org/MicroWiki.html (accessed Oct, 2006)
2 http://ltsc.ieee.org/wg12/ (accessed Oct, 2006)

According to (Hall 2001), LO, also called *Reusable Learning Objects*, are rather philosophies for how content can be created and deployed. LO refer to self-contained chunks of training content that can be assembled with other Learning Objects to create courses and curricula, much the same way a child's Lego blocks are assembled to create all types of structures.
Learning Objects are designed to be used in multiple training contexts, aim at increasing the flexibility of training, and make course updating much easier to manage. When a learning object is updated, the change appears in any course using that learning object.
Because micro-content and learning object are both self-contained chunks of training that can be associated to others MC or LO, we can say that micro-content is a kind of digital learning object which is small information, knowledge dedicated. We can call it microlearning object.

3.2 Metadata for Microlearning

In order to be accessed or to be reused, a micro-content necessitates adapted metadata. According to (Hug 2005), different definitions of Microlearning are brought forth by different interpretations of particular dimensions such as:

- Time: relativity short effort, operating expense, degree of time consumption, measurable time, subjective time, etc.
- Content: small or very small units, narrow topics, rather simplex issues, etc.
- Curriculum: part of curricular setting, parts of modules, elements of informal learning, etc.
- Form: fragments, facets, episodes, "knowledge nuggets", skill elements, etc.,
- Process: separate, concomitant or actual, situated or integrated activities, iterative method, attention management, etc.,
- Mediality: face-to-face, mono-media vs. multimedia, information object or learning object, etc.,
- Learning type: repetitive, activist, reflective, pragmatist, corporate learning, learning by example, etc.

We think these dimensions must be considered in order to define MC metadata. Because MC is a kind of LO, we were interested in the Learning Object Metadata (LOM). The LOM standards will focus on the minimal set of attributes needed to enable LO to be managed, located, and evaluated. The IEEE Learning Object Metadata

Draft defines eight meaningful categories of descriptors[3]:

- General: groups the general information that describes LO as a whole: Identifier, Catalog, Entry, Title, Language, Description, Keyword, Coverage, Structure, Aggregation Level.
- LifeCycle: features related to the life cycle of the resource, like Version or Status.
- MetaMetaData: origin and edition of the metadata.
- Technical: this category describes the technical requirements and characteristics of LO: format, size, location, requirement (OrComposite, Type), installation remarks, Other Platform requirement, duration).
- Educational: this category describes the key educational or pedagogic characteristics of LO: Interactivity Type (active, expositive, mixed document), Learning Resource Type (exercise, diagram, graph, experiment, table, slide…), Interactive Level, Semantic density, Intended End User Role, Context, Typical Ange Range, Difficluty, Typical Learning Time, description, Language.
- Rights: this category describes the intellectual property rights and conditions of use LO;
- Relation: this category defines the relationship between one LO and others, if any;
- Annotation: comments on the educational use of LO and information on when and by whom the comments were created.

The categories Technical and Educational seem to correspond particularly to microlearning requirements. In the same way, sequences could be described by the means of descriptors Aggregation Level and Relation. However, it should be interesting to define a sequence as an entity. Even if all these descriptors are important; we think they must not be used in such a way because we do not agree, for example, to associate various activity types like exercise or exam, with data representation like diagram, figure or graph in the same set (Learning Resource Type). Moreover, because micro-content is a very small unit concerning a piece of knowledge, we think it is meaningful to index it by this one: Keywords are not sufficient. For example, how to access MC concerning the format option of an editor and to choose the part about paragraph rather than column? It is important, when you have small time to learn to have access to this kind of information in order to better reach your objective: (general) format option, paragraph format option, or column format option?

3 http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf (accessed Oct, 2006)

Finally, in order to index MC, we think it is necessary at least to define and organize by the means of ontology:

- Descriptors from the LOM.
- Knowledge to acquire.

Both are necessary to access the right MC at anytime and anyplace.

4. The project MEMORAe

4.1 Presentation

Numerous learning resources may be used during eLearning. eLearning becomes part of a complex organizational conduct, in which lacks of required knowledge trigger the search for appropriate contents. Different approaches may be adopted to exploit such contents. They can be stored in learning objects repositories and then reused, combined and adapted in different contexts. They can also be selected and organized in learning memories that are directly accessed by learners. These approaches offer a goal-driven organizational learning.

Within the project MEMORAe our goal is to let learners directly access the resources of a course memory. Following a knowledge engineering approach, we organise the resources in a learning organizational memory based on ontologies (Abel, Barry, Benayache, Chaput, Lenne, & Moulin, 2004). In fact, it is a course memory, where a course is seen as an organization. This memory is different from a classical organizational memory because its goal is to provide pedagogically users with content. This content is the result of two pieces of work: (1) the capitalization of knowledge, information and learning resources relating to the learning context (a course unit), (2) a pedagogical work concerning the choice and the organization of this capitalization.

The pedagogical content is composed of the notions to learn, the links between these notions and the learning resources they index. Notions are not only chosen because they are related to the course unit, they are also the result of a reflection on the course itself. Resources have to be selected relying on pedagogical goals. The choice of their indexing terms is related to this goal too. It is not an automatic indexing. The course manager is responsible for the relevance of the links. It is not because a document treats of a notion to acquire that it will be necessary indexed by this notion. The choice is explicit, that is to say that the document must have been evaluated as sufficiently

adapted to the learning of this notion. These choices are part of the pedagogical scenario the course manager wants to implement.
The learning organizational memory we propose aims at facilitating knowledge organization and management for a given course or training, and at clarifying competencies it permits to acquire.
In order to give learners direct access to the memory, part of the instructional design work has to be made earlier. The advantage is that the memory is ready to be used by learners, provided that pedagogical and didactical choices made earlier are acceptable. This can therefore lead to a loss of flexibility, but we make the assumption that these choices can at least be shared by a teacher community, that could act as a "community of practice" (Wenger, 1998).
Within the project MEMORAe, we realized two pilot applications to evaluate our propositions. The first one concerns NF01, a course on algorithms and programming at the University of Technology of Compiègne and the second one concerns B31.1, a course on applied mathematics at the University of Picardy (France).

4.2 The MEMORAe model

The MEMORAe model relies on the expected use of the memory: eLearning. We mainly tried to:

- Determine and present the notions to learn and resources describing these notions.
- Offer a natural and easy access to the memory contents.

For this purpose, we were interested on the one hand in ontologies to represent the notions to learn and their links (definition of a common vocabulary) and on the other hand in Topic Maps (XTM, 2001) as representation formalism facilitating navigation and access to the learning resources. The ontology structure is also used to navigate among the concepts as in a roadmap. The learner has to reach the learning resources that are appropriate for him.

For navigating through the memory, the end-users (learners, teachers, etc.) need a shared vocabulary and knowledge structured. That is why we decided to model the memory with ontologies. From the different ontology types defined by Van Heijst (Van Heijst, Schreiber & Wielinga, 1997), *generic ontologies, domain ontologies*, *application ontologies and meta-ontologies,* we only use the second and third categories. We have to consider two aspects for modelling the memory and building ontologies (Breuker &

Muntjewerff, 1999). First the domain of training has its own characteristics. Secondly, it must be linked to the application domain of a particular training program. The first ontology (domain ontology) we have to specify, describes the concepts of the «training» domain (cf. figure 1). They can be users' types (teacher, administrative), documents types (book, slides for oral presentation, web page, site, etc.), and media types (text, image, audio, and video). They can also be pedagogical characteristics (activity type) and they can refer to point of view (annotation).

The second ontology (application ontology) specifies the organization of theoretical notions which are studied during training session. In the example of B31.1 course, some notions like "set" or "infinite set" are explained. It is possible, but not mandatory, to consider "infinite set" and "finite set" as sub-concepts of the concept "set" and to define the relation "has cardinality" between the concepts "finite set" and "cardinal" (in this case they are the domain and range value of this relation). According the Ontospec method (Kassel, 2005), concepts can be specialized according to "semantic axes". For example, the concept "set" is specialized according to three axes: finite/infinite, countable/uncountable, subset/superset (cf. figure 2).

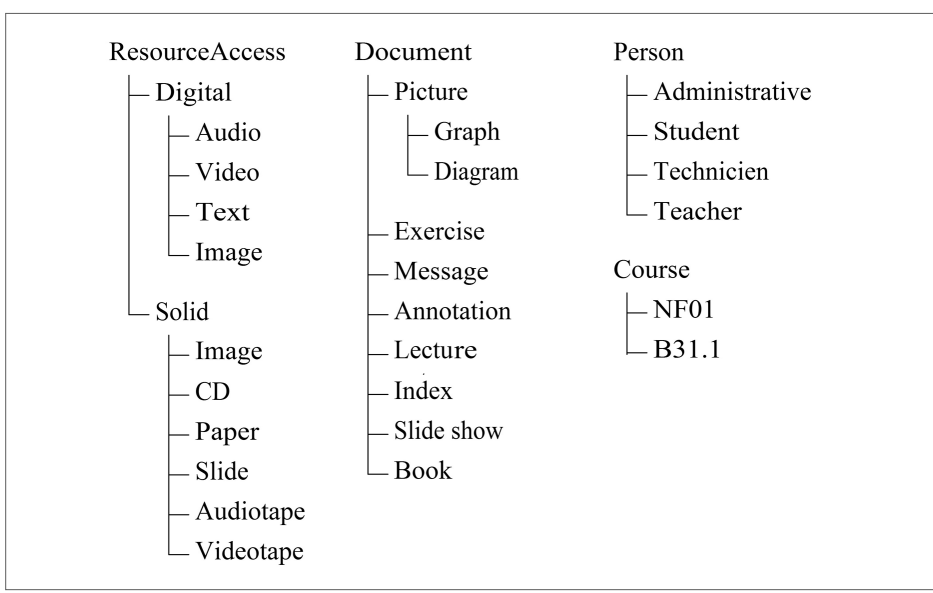

Figure 1. Elements of domain ontology

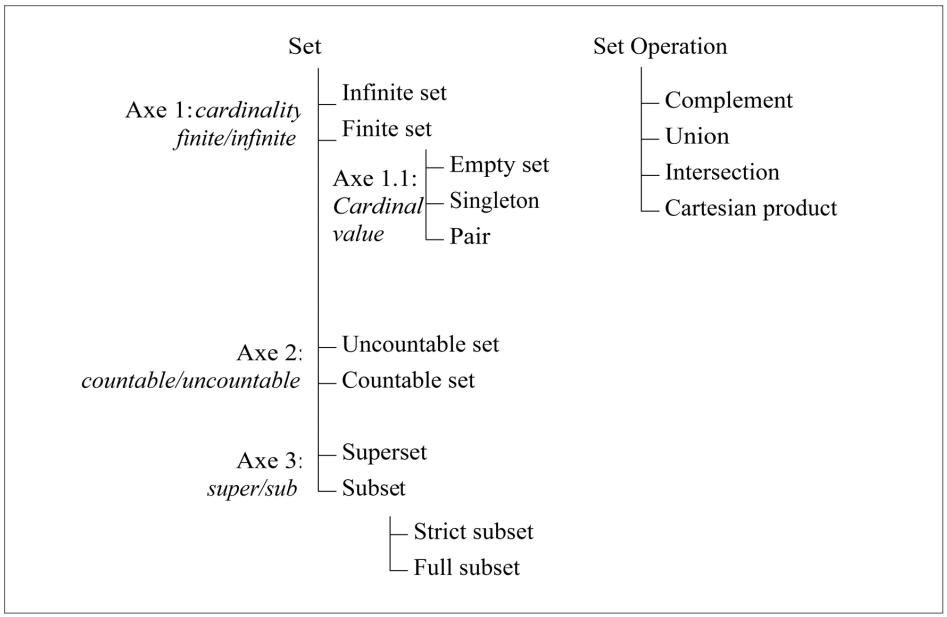

Figure 2. Specializations of the "set" notion

These ontologies are not independent; the second one is necessarily attached to the first one. For example, to express that a document is an introduction to "infinite set" we join the two concepts "introduction" and "infinite set" that do not belong to the same ontology. Pedagogical relations like "prerequisite" or "uses" that occur between concepts of the application ontology are defined in the domain ontology. However, specific roles can belong to the application ontology (for example for the B31.1 application, "has-cardinality").

4.3 The E-MEMORAe Environment

Within the framework of MEMORAe we developed a first prototype: the environment E-MEMORAe[4] .Our objectives within E-MEMORAe are to help the users of the memory to acquire the notions of a given course. To this end, the users have to navigate through the application ontology that is related to the course, and to access to the indexed resources thanks to this ontology.

4 http://www.hds.utc.fr/memorae/ (accessed Oct, 2006)

The general principle is to propose to the learner, at each step, either precise information on what he is searching for, or graphically displayed links that allow him to continue its navigation through the memory. He has no need to use the keyboard in order to formulate a request, even if the environment allows doing it.
To be more precise, the user interface (figure 3) proposes:

- Entry points (left of the screen) allowing to start the navigation with a given concept: an entry point provides a direct access to a concept of the memory and consequently to the part of the memory dedicated to notions. The person who is in charge of the course has to define the notions that (s)he considers as essential.
- Resources (bottom of the screen) which contents are related to the current concept: they are ordered by type (books, course notes, sites, examples, comments[5], etc.). Starting from a notion, an entry point or a notion reached by the mean of the ontology, the user can directly access to associated resources. Descriptions of these resources help the user to choose among them.
- A short definition of the current notion: it enables the learner to get a preview of the notion and allows him (her) to decide if he has to work it or not.
- An history of the navigation: it enables the learner to remind and to be aware of the path he followed before. Of course, (s)he can get back to a previously studied notion if (s)he wants to.

Least but not last, the part of the ontology describing the current resource is displayed at the centre of the screen.

If the learner wants to access to a notion that is not an entry point, he has to choose the entry point that he thinks as being the closest point from the searched notion.

4.4 E-MEMORAe usability

We defined a usability test[6] in order to see how students use the E-MEMORAe environment. Such a test enables to evaluate learning and memorizing facilities, and the usability of the environment. It also enables to evaluate the types of errors and the satisfaction of the user.

5 The comments are the only elements of the memory that the user can modify as (s)he wants. An a posteriori control is made by the editorial committee in order to keep them or not.

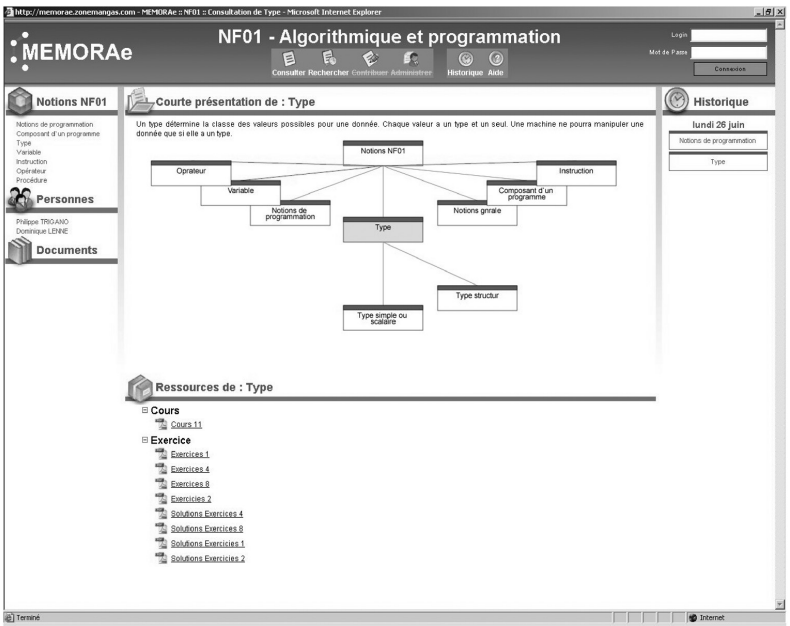

Figure 3: Navigation in the memory

Our objective was to see how E-MEMORAe enables the learners to discover alone new notions to learn. For verifying the understanding of these notions, the learners have to solve some problems concerning these notions and respond to a QCM.
With this test, we can verify the pertinence of our hypothesis on the following points: (i) structuring the content of training by an ontology; (ii) index resources on ontology concepts; (iii) displaying the hierarchy of concepts for facilitating the navigation through the resources; (iv) offering a list of entry points for giving a quick access to the main notions of the course.

The experiments took place at the University of Picardy and the University of Compiègne (France) and were concerning the students attending a master course of

6 http://www.usabilis.com/gb/whatis/usability.htm

statistics or algorithm. Students of the course of statistics were proposed to solve a problem requiring some notions unknown by the students. Students of the course of algorithm were proposed a QCM. They had to use the E-MEMORAe environment to discover the missing knowledge for solving the problem or respond to the QCM.
For each student, the history of the navigation was stored in the memory. We could analyze the way to reach important notions and the resources employed.
After these first experiments, we can conclude that using ontology to index and structure the content of training is a good choice: a majority of students appreciated it. The results obtained by the students show that a majority of them were able to find the indispensable knowledge to solve it in a limited time.

5. Using E-MEMORAe for microlearning

Using the E-MEMORAe environment, it is possible to organize and structure a course around notions to acquire by the means of ontology (application ontology). These notions index resources which currently may be small or big units. In a microlearning context, only the very small capitalized units would be used. However, they must be logically organized in sequences. A priori, the application ontology must not be updated with concepts because even small the units are concerning the same domain.
In order to better index resources, information concerning the generic training domain (domain ontology) is used. Types of documents, types of support and pedagogical characteristics are occurring in this ontology. It must be completed with concepts dedicated to the microlearning context. For example, it would be necessary to add sub-ontology concerning time (subjective time, measurable time, etc), form (fragment, episodes, etc.), mediality (mono-media, multi-media, etc.), device support (PDA, PC, etc.).
A difficulty is to enable the building of sequences of episodes and the resources they involve. A solution could consist in cutting down into small units a bigger one. However, new specific sequences must be envisaged.

The E-MEMORAe environment enables to record the history of notions and resources already accessed. Thus learner can better organize and attend their training. They can consult different resources of different or same type about a same notion, access to a narrow notion, etc. Microlearning requests a more structured organisation of resources because the training path, based on sequences seems more linear.

6. Conclusion

Within the project MEMORAe we developed an environment based on the concept of organizational memory in which pedagogical content refers to the notions to learn. Notions are linked together and organized by the means of an ontology. Documents and resources are indexed on the concept of this ontology but also on a domain ontology. From this experience, we examined the elements which could be reused and those which would need to be updated if the environment were used in a microlearning context. The main issue is the extension of the domain ontology.

We also tried to define the most interesting conditions of microlearning. First, some specific learning scenarios seem better adapted and we presented several of them. Then, the use of mobile devices seems unavoidable because they are very well adapted to situations favorable to microlearning.

We have also presented some particular requirements and in particular the definition of micro-content. This kind of content can be extracted from standard content but it needs to be repackaged in order to fit the technical conditions of microlearning. The creation of new content specifically designed seems completely indispensable.

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