Abstract
This work focuses on knowledge mapping applied to open learning. This paper focuses on how knowledge maps can contribute to distance education, online learning and open sensemaking communities. Cartographic representations through Compendium can be very useful for organising knowledge in several contexts: conceptual studies, problem-solving, literature review, learning path planning, argumentative discussions and learning design. In this paper we present some mapping techniques such as mind mapping, concept mapping, web mapping and argumentative mapping showing different possibilities of applications and examples. We also outline how ongoing and future work is integrating knowledge mapping with replayable video conferences, and support self-organising communities of learners and educators around OU OpenLearn Project.

1- Introduction
Knowledge Mapping can be a useful strategy for students and educators to construct meaning from the oceans of data, information and opinion. Due to the widespread uses of new technologies and open learning movement, people have greater access to information, interaction and reconstruction than ever before. However, one of the primary challenges in online education and research is to capture, organise and make sense of the deluge from search engines, news feeds and online communities. It also includes blogs and emails, course content and research literature. For that, knowledge mapping techniques can be used to organize better the process of learning, research teaching and producing materials.

Any people are now benefiting from fast internet access. They can select digital libraries, electronic journals, conference papers and multimedia archives such as video, presentations, graphs, etc. However, they can face many difficulties concerning to structure their investigation and learning effectively. The construction of meaning involves many processes: dealing with lots of data, systematizing relevant information, demonstrating intermediate steps, developing critical thinking, argumentative discussions and connecting theory and practice.

In this paper, we report different uses of knowledge mapping applied to open learning. We discuss some mapping techniques and some examples about knowledge maps published on the openlearn project.
2- Context
OpenLearn Project is a large scale OER project that makes a selection of higher education learning resources freely available on the internet to anyone, anywhere in the world. It also provides knowledge media tools to manage learning and support the development of open learning communities.

OpenLearn was created by the Open University UK launched in October 2006. It is supported by the Hewlett Foundation's Open Educational Resources Programme. By April 2008 its aims is to release 5,000 learning hours of content of the OU’s distance learning resources for free access and modification by learners and educators under the Creative Commons license. (Kmi Open Sense Communities, 2006; OpenLearn, 2006).

"The Open University mission is to make education accessible to all. OpenLearn offers the opportunity to take that to another level, reaching tens of millions of people each year around the world, not just the hundreds of thousands as at present"(Lane, 2006).

Through OpenLearn, people can access higher educational materials in their own time from anywhere in the World. It is an opportunity for informal study and collaborative interaction in areas of interests. Participants can learn in their peace, alone or in communities, assess their own progress by keeping a learning journal, discussing the topics with other online learners in forums and completing self assessment exercises. They can manage their learning process by themselves experiencing informal graduation studies free.

Information and communication technologies can promote the rapid and flexible dissemination of open resources. However, in order to construct and share knowledge, innovative tools are necessary to facilitate not only interactivity but also sense making. In this context, knowledge cartography can be used to represent thinking, stimulate critical reflections and apprehend meanings.

3 - Knowledge Cartography and Mapping techniques
Cartographic representation is a way to build schemes to enable understanding through spatial relations (Kitchin and Tate, 1999; Lévy, 1994). Well-designed maps are effective resources for building knowledge. They:

- exploit the mind’s ability in establishing relationships in physical structures;
- allow a clear understanding of a complex environment;
- reduce search time and reveal relations that might otherwise not be noticed.

For centuries, maps have been used to store and represent knowledge about the world. They are a concentrated database of information on location and a powerful graphic tool to classify, represent and communicate connections among diverse elements (Dodge and Kitchin, 2002; Hodgkiss, 1980).

Cartography is one of the most promising resources to support knowledge construction. It helps us to integrate information on a hypertextual structure organized within various hierarchies and levels of representations. The process of mapping facilitates meaningful learning (Novak, 1998). It requires learners to think deeply and make sense of what they are studying. Mapping scaffolds different forms of reasoning about content engaging students in critical thinking (Jonassen, Carr and Yueh, 1996). Through information maps, students can create, represent and visualize what they know and do not know.

For that, cartography software help learners to map information, organize their understanding through relationships between ideas. They can add several kinds of files establishing connections between all components.
Participants in virtual learning communities can literally “make” sense by giving shape or modelling their abstract thoughts into concrete representations. Knowledge Media Tools are designed to assist users in giving form to their ideas as they evolve from ill-formed, inchoate structures to more formal, rigorously organised expressions (Buckingham Shum, 2005a).

There are several mapping techniques useful for learner or open sensemaking communities. Through these techniques they can create knowledge maps to explore learning materials, solve activities, systematize ideas, construct and represent their argumentation, organize and share additional references.

3.1 Mind Map - this mapping technique was developed by Tony Buzan, around 1974 when he published his book “Use your head”. This strategy facilitates the registration of thoughts through a creative visual representation. Our mind is full of ideas that can be expressed through keywords, sentences, pictures. Our thoughts normally are difficult to represent in a linear order. The ideas can initially appear without logic structure. This information can be easily mapped through words, sentences or symbols annotated in different spaces and connected through lines and arrows with some short descriptions.

![Figure 1. Mind Map about Strategy – Course Strategic view of Performance](image)

This image, which represents a “brainstorm”, constitutes a mind map. Mind mapping can be used as the first step to represent collective or personal ideas about a specific subject in the course. The students can be encouraged to record their initial ideas using Compendium.

3.2 Concept Map - this is another mapping technique developed by Prof. Joseph D. Novak around 1972. His research is based on the meaningful learning theory presented by David Ausubel. New approaches can be developed from experiences and concepts already built. The connection between pre and new concepts can facilitate the understanding process. This strategy is also based on constructive theory. The learners can construct their knowledge from connection among diverse concepts. This process facilitates the systematization of new information through organization of concepts and their connections.
Students can create concept maps to describe relationship between key concepts in order to represent their understanding. This map above is a concept mapping about Global Warming, which integrates different resources: image, video, text, graphics, geographic maps and also the most interesting webpages about climate change in the OpenLearn - LearningSpace.

3.3 Web Mapping appeared recently as a result of the rapid growth of the internet. The huge number of websites and overflow of information can cause users to become lost in cyberspace. Users can record their navigation through web maps using icons, hypertext and hyperlinks. Two important researchers in this area are Martin Dodge and Robert Kitchin who have been researching about cognitive web mapping and cybergeography. Cartography tools let users select what is relevant in cyberspace and index and retrieve hypermedia web material in meaningful ways.
Web Mapping is a useful technique to group and share important references from learning materials and from the web. For example, this webmap above shows interesting websites about “The five forces of competition” grouped by categories: webpages, images, documents, papers, video and news.

3.4 Argument Mapping was invented by J.H. Wigmore to help in the analysis of legal arguments. This class of technique decomposes an argument into claims, reasons and objections. Argument maps show the evidence for each claim, and how they are related in the structure of the argument. They are used for preparing and presenting arguments and for developing critical thinking skills, both individually and collectively.

Argument maps also derive from the Issue-based Information System (IBIS) developed by Rittel in the 1970s to solve ill-structured “wicked problems”. IBIS is a rhetorical grammar with three core elements: issues, positions and arguments, which can be rendered as textual outlines and graphical maps that grow with the conversation. Argument Mapping is a useful technique to structure reasoning based on statements, pros, cons and conclusions. Learners can create argument maps to organize argumentation in a discussion forum, essay or presentation, talks in web video conferences.

Argument Map from the perspective of Dr. Magee

Argumentative design focuses on issues, inferences or evidences structured among questions, answers and arguments. This representation shows the main questions, statements, pros and cons about a web video about Global Warming. Through argumentative maps, students can identify the main ideas and logical connections of evidences more objectively and clearly. This representation allows us to get an overview of the video and the coherent structure of arguments.

Figure 4. – Argument Map about the web video Global Warming published on YouTube
4 - Knowledge Mapping for Open Learning.

The representation of information organized by icons, tags, details, numbers and the description of connectors facilitated comprehension of the map structure and the critical thinking. The visual representation of the arguments encouraged the users to reflect and map new elements. This provoked new ways of thinking and new opportunities to think about thinking. The categories described through tags attached to nodes also helped in interpreting the map. Users could list all questions, or all advantages recorded in different maps relating to their projects. This enriches the process of searching and analyzing lots of information.

Figure 4 – Flashmeeting and Compendium map created by a Brazilian research group

These maps represent discussion about knowledge media technologies Flashmeeting and Compendium applied to OpenLearning. Participants in Brazil were introduced to new tools Compendium and Flashmeeting. At the same time that they were discussing about knowledge mapping, the conversation was captured using Compendium and they could see the representation of the main topics and a real application of the software tool. Knowledge maps have been a useful way to represent an overview of the online discussion, get an overview of the content and retrieve information easily. They can click on the main statement in the map, read more details and also replay the right point on the webconference where that information was discussed.
Compendium maps have been very meaningful to represent complex hypermedia materials and integrate not only different media but also diverse approaches. This example shows several maps that represent the content of the course structured in Compendium. EPoCh is a learning material to enable the user to explore the development of psychological thinking not only across time, but also within the context of social and historical changes; the development and application of different perspectives and methodologies; and through chains of influence between psychological researchers. The profiles of ninety-six important thinkers were mapped and classified by 111 categories to describe: 17 methods, 18 perspectives, 55 topics and 21 contexts. They students can navigate through 109 maps and identify psychologists who have similarities related to these categories. They can see the network of people who have influenced their work and through time line map they can visualize groups of people by decade.

Figure 5. – Course Content Map about EPoCH - the development of psychological thinking – project developed by KMi, Social Science and openlearn academic team.
Knowledge mapping has also been very useful for learning design. Grainne Conole has been developing innovative research about learning design using knowledge maps. She has been developing several templates to help academics to plan online courses.

Figure 6 – Template to plan activities integrating the roles and assets of tutor and student by Conole

Figure 7 – Example of activity integrating tools, tasks, resources, support and outputs by Conole

Figure 7 – WebMap - set of templates to plan different types of activities by Conole
Knowledge mapping has also been applied to organise better the openlearn production process. There are several steps involved. Some of them occur in parallel and involve lots of documents and information. This project has been developed by Teresa Connolly, she has been using Compendium to map the openlearn production process. In this context, openlearn production map can be very useful for planning and assessing the process: people, involved, quality of information and content.

Figure 8 – WebMap - openlearn production process map April 2007 by Connolly
5 – Conclusion and future work

To summarise, Compendium maps applied to learning can offer several benefits:

- allow students to recognize their way to represent their thoughts and their process of learning
- encourage participants to make interventions and improve their productions building knowledge collectively;
- help researchers to apply the mapping techniques in their investigation projects
- facilitate teachers to implement activities and develop feedbacks in VLEs.
- Easy and practical way to seek relevant information
- Cooperative learning, closer engagement in problem with peers
- Answering and generating questions to understand various aspects of the investigation

OpenLearn project is distinctive not only in the quality of the materials to be released (custom designed for distance study, unlike most open content programmes), but also in its focus on developing an environment to deepen the engagement of learners and educators, in self-organising communities, with each other and the learning content. The Knowledge Mapping component forms part of the learning support tools, to investigate how students and educators can use Compendium to develop meaningful representations and foster critical thinking. In an Open Learning context Compendium could be used in diverse contexts:

- to manage personal information by dragging and dropping in any document or website (a form of ‘visual e-portfolio’);
- to manage knowledge and learning by charting questions, ideas, and arguments as they arise;
- to share learning pathway maps over resources; to work through revision question templates;
- to browse or construct argumentation maps associated with learning resources and literatures, or dialogue maps which add value to online meetings.

Users can publish Compendium maps to a Knowledge Map Exchange, thus creating an open content repository of meta-representations to comment on, and forge connections between, the primary learning resources. That is, Compendium serves as a sensemaking tool to mediate layers of interpretation, linking and annotating resources within the Open University site, as well as out to any other site. Maps can then be searched, analysed and visualized in new ways to help students spot new connections and find new peers. Integration with the open source Moodle VLE, social software mediating online presence, identity and reputation, and the broader Web 2.0 paradigm is part of the OCI research programme.

Students, educators and researchers need better tools to manage information, making it meaningful by connecting it to the issues they are wrestling with. Compendium is issue/argument-centric, hypermedia, knowledge mapping software that provides several ways for researchers, teachers and students to manage connections between information and ideas expressed in any medium as visual webs in support of knowledge management and online learning. A community of practice numbering several hundred active researchers and practitioners (in education, business and government) is now using and discussing the tool’s applications in both academic and workplace lifelong learning contexts, and we invite you to join us to advance this initiative.
REFERENCES


