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KNOWLEDGE MAPPING WITH COMPENDIUM
IN ACADEMIC RESEARCH AND ONLINE EDUCATION

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Research and New Developments in the general field of interest to the conference

Post-Secondary or University Education

Abstract

This paper focuses on mapping information, ideas and arguments in virtual learning environments, as part of ongoing research into how this can contribute to distance education, open content learning communities, and distance research training. We introduce the idea of cartographic representations for learning, before describing the freely available *Compendium* hypermedia knowledge mapping tool developed at the UK's Open University (OU), which provides an open architecture, information management environment supporting multiple ways to manage connections between ideas and documents. We then summarise several contexts in which it is being deployed with promising results: (1) *e-PhDs*: supervision and knowledge management for distance doctoral students; (2) *Literature Analysis*: mapping argument structures in order to identify emergent themes and cross-paper connections; (3) *Online Tutoring* of e-learning students, investigating a post-graduate online course at PUC-Cogeae, Brazil. We conclude by outlining how ongoing and future work Is integrating knowledge mapping with replayable video conferences, and a major new investigation into knowledge mapping to support self-organising communities of learners and educators around OU Open Content.

Keywords: Knowledge Cartography, Information Maps, Argument Maps, Compendium, Academic Investigation, Online Distance Education.

1- Introduction

One of the primary challenges in academic research and online education is to provide students and educators with strategies and tools to construct meaning from the oceans of data, information and opinion now available. How is the user to capture, organise and *make sense* of the deluge from search engines, news feeds, digital libraries, blogs and emails, not to mention the course content or research literature, which can often feel like an overwhelming ocean in its own right. New online research techniques are important to organize better the whole process of investigation.

On the one hand, research students are benefiting from fast internet access. They can select digital libraries, electronic journals, conference papers and multimedia archives such as video, presentations, graphs, etc. On the other hand, they 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 work that motivates our contention that a key capability to foster in students to tackle this challenge is the ability (1) to map information, ideas and arguments, and (2) to manage the rich connections that emerge between them using a range of hypertext techniques.

2- Background

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. It requires learners to think deeply and make sense of what they are studying. Through information maps, students can create, represent and visualize what they know and do not know (Novak, 1998). Mapping scaffolds different forms of reasoning about content engaging students in critical thinking (Jonassen, Carr and Yueh, 1996).

For that, cartography software helps learners to map information, organize their understanding through relationships between ideas. They can add several kinds of files establishing connections between all components.

3- Compendium: Hypermedia Knowledge Mapping

Compendium is a software tool for recording ideas and managing the connections between them. While it can be treated simply as a text editor, it is designed to exploit the power of recording different ideas in different 'nodes' (icons on the screen) which may then be tagged with keywords, and linked

graphically into hypertext networks. The software is a free Java application for all platforms, including the source code. Downloads, papers, training and community discussions are coordinated via the not-for-profit Compendium Institute: www.CompendiumInstitute.org

Compendium supports user-defined icon palettes, but comes with a default set of icons which support the recording of meetings in terms of key *Issues, Ideas, Arguments and Decisions*. It comes 'pre-loaded' with node and link types for using the Issue-Based Information System (IBIS) (Kunz and Rittel, 1973). IBIS focuses attention on the key issues, possible responses to these, and relevant arguments. (Kirschner, Buckingham Shum, Carr, 2003). Figure 1 shows the default node types, which include additional nodes beyond IBIS for *Lists and Maps* (containers for nodes), *Decisions, Notes,* and *References* that can hyperlink to open a web page or other document**.**
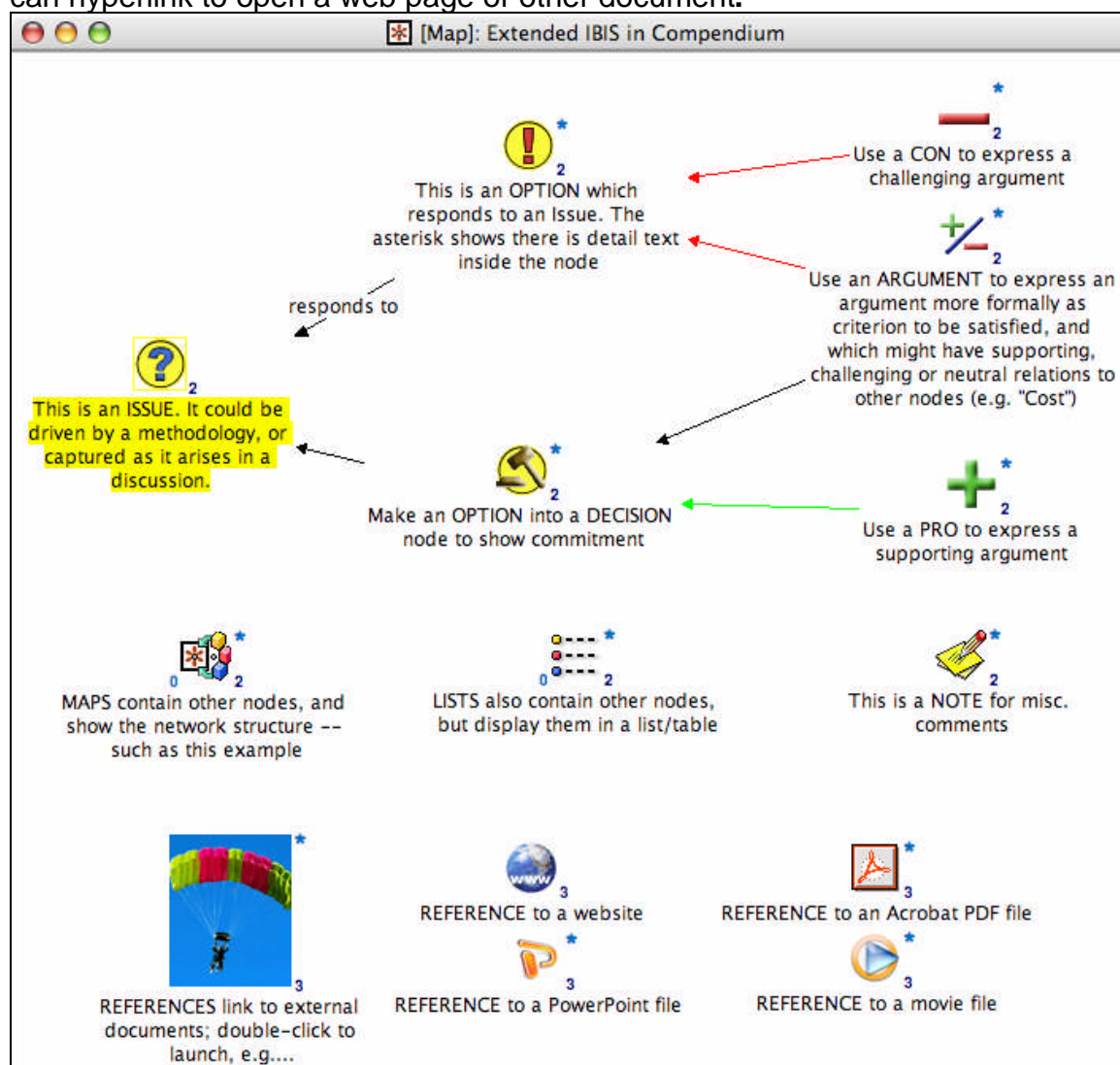

Figure 1: IBIS plus additional node types rendered in Compendium. Any application document or website can be dropped in to create a hyperlink. Nodes can contain text content, and links can be labeled if desired.

Compendium maps are not 'flat' drawings, but views onto a relational database (with an API for interoperability) that can be rendered in multiple formats. It provides ways to manage connections between nodes in three ways, which makes it a flexible, visual information management tool:

1. *Connections between ideas within a context:* within a map, one can draw graphical links between nodes, in the usual way one expects in a drawing package. These links can be coloured, labelled arbitrarily, or labelled according to a constrained *linkset*, such as IBIS or a learner/educator-defined one.

2. *Same node recurring across multiple contexts:* A given node can appear and be updated in multiple views (the number in the lower right corner shows how many views it is in). Since any application document or URL can be dragged and dropped into a map as a *Reference* node, so an external document can be linked into one or more discussions and tracked – that is, given one or more meaningful contexts where it plays a role. Corrections or updates to a node are immediately updated in every context in which it appears. This provides precisely the representational capability needed to build semi-structured models in which a particular object is systematically reused (e.g. an idea, document, slideshow, question, criterion).

3. *Same attribute shared by multiple nodes:* now popularized by social bookmarking websites, Compendium enables the user to define and evolve a set of keyword tags that they can apply to nodes, so indicate category membership. These can then be searched for and (through the transclusion mechanism described above) placed into multiple arrangements in different maps.

These then, are the representational building blocks provided by the tool. As we report later, there are many mapping approaches that can be followed in Compendium. However, the tool's intellectual ancestory in IBIS has been a particular focus of study: *how can the affordances of this medium and notation be used effectively in different contexts? Dialogue Mapping* (Conklin, 2005) is a set of skills for mapping ideas as IBIS structures in real time during a meeting in order to support the analysis of "wicked problems", as defined by Rittel. *Conversational Modelling* (Selvin, 1999) extends Dialogue Mapping by deriving the issues raised from whatever modelling approach one wishes, and building a conversational modelling environment with libraries of reusable nodes, metadata tags and linked issue templates. Conversational Modelling thus enables the capture of both expected, well-structured information through the use of issue templates, but in real time, and with the facility to capture unexpected, ad hoc information and discussions as they arise.

4- Online Doctoral Training

The *e-PhD project* is investigating next generation tools for doctoral training. An objective of a good doctoral training program is to help students to be active members of a scientific community, both local and global. It is important that distance research students do not become invisible to their host research groups, and unaware of events and daily social life. They must also be able to work synchronously and asynchronously with their supervisors and other colleagues.

More than half of the United Kingdom's postgraduate research students are participating in part-time PhD course and have limited opportunities to take part in face-to-face training sessions. They have difficulties in attending standard courses, sessions and events e.g. live at a distance.

Many full-time students are researching off campus. They are doing workplace learning or fieldwork spending substantial periods away. They also cannot participate in the studying group meetings that are so powerful for developing research skills. The main purpose of the e-PhD project is to investigate what alternatives could help students at a distance, including webcasting, social software and knowledge mapping. In this context, we have a longitudinal case study under way in which a UK supervisor and a student in New York are experimenting with different kinds of map. Results to date demonstrate how the tool provides support for managing the huge amounts of information, ideas and emergent questions associated with a multi-year research project, including the recording and structuring of online supervision meetings (Selvin and Buckingham Shum, 2005).
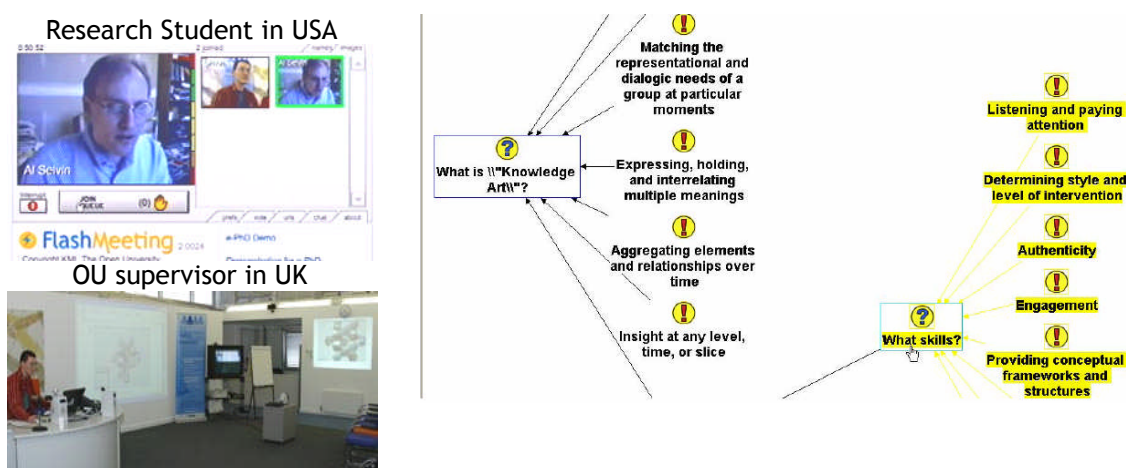

Figure3- e-PhD Project - http://kmi.open.ac.uk/projects/e-phd/

As part of the dissemination of this work, readers can replay a webcast workshop which was held to demonstrate these tools and open discussion, with both co-present and online participants able to engage with each other (Stainton Rogers and Buckingham Shum, 2005).

5- Mapping Ideas and Arguments in a Literature

Modelling the Iraq Debate is a case study that illustrates the use of Compendium to support a form of conventional concept mapping, plus post-hoc Dialogue Mapping as a way to tease out and integrate, at various granularities, the Issues, Positions and Arguments raised in a set of published articles on the Iraq war.
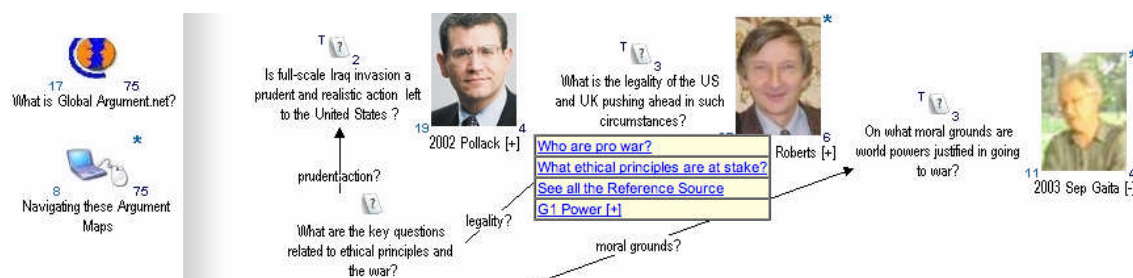

Figure 4- Modelling the Iraq Debate - http://www.kmi.open.ac.uk/projects/compendium/iraq/

This analysis was conducted as part of the GlobalArgument.net experiment which we initiated in early 2005 as a forum for systematically comparing computer-supported argumentation tools. We used compendium to analyse a

corpus of 25 articles by leading commentators with different backgrounds, who with varying degrees of vehemence, were either in favour of, relatively neutral on, or opposed to, the invasion of Iraq and the toppling of Saddam Hussein.

We have detailed the methodology and outcomes of our first interaction in modelling this corpus (Buckingham Shum & Okada, 2005). It demonstrates the extent to which Compendium serves as an analyst's tool for making sense of a corpus of texts:

- *for a given article:* mapping tools should help to clarify (at some level of granularity, dependent on the analyst) the contributions it claims to make and its argumentative structure
- *for the "gestalt" of the whole corpus:* mapping tools should help to clarify the cross-connections and emerging themes which one would expect someone with a grasp of the debate (as expressed in the articles) to have, and communicate clearly.

In particular, the cognitive discipline of mapping the content promotes a greater level of engagement, than just reading conventionally:

Node	Number of and relationships between	"Depth" in terms of	"Weight" in terms of	Classifications assigned to
T 17 75 What is Global Argument.net?	Questions, concepts and definitions, statistical data, facts, statements and hypotheses	The number of transclusions on a node shown by the lower right digit on the icon	The number of nodes in a map shown by the lower left digit on the icon	An idea shown by the tag rollover hint in the upper left of the icon

Table 1- Information in the map that is not accessible at a glance in a prose document

6 – Online Course using Compendium at PUC-SP University

The intention of this PhD investigation was to analyze contributions of information mapping for academic research and online education in order to develop critical thinking. For that, this study focused on the specialization post-graduation online course "*Software Use in Qualitative Research*" offered by Pontifical Catholic University PUC-SP. In 2004 and 2005, 45 researchers - teachers and PhD students from different areas and universities in Brazil participated in this online course. The aims of this specialization course were to:

- discuss important concepts about cartography and qualitative research;
- explore cartography software available in internet;
- develop maps to facilitate the investigation process.

The course content was organized through 3 modules: mapping Information, qualitative research and improving investigation through maps.

The methodology used was based mainly on qualitative research. It involved description and interpretation of data obtained during the course from researchers in their contact with the situation studied. For that, chat, forum, blogs were observed and the main comments were selected. Thus, not only results were analyzed but also (mainly) processes were investigated in order to understand contributions of maps as knowledge representation - biased perspectives of participants involved in.

6.1 - Tutoring Diagnostic through Knowledge Maps

During the online course, teachers used information maps to present the material and activities indicating a learning path. Students navigated through these maps to understand the content and the relations among all the tasks. Then, they produced knowledge maps to organize their researches. The

methodologies used to create knowledge maps were Mind Mapping, Concept Mapping and Argumentative Mapping.

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. This image that represents a "brainstorm" constitutes the mindmap. During this course, Mindmap was used as the first step to represent collective and personal investigation projects. The students were encouraged to record their initial ideas using mindmaps.

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. Participants of this course used concept maps to present their theories, web references and organize concepts discussed in Forum.

IBIS Map - this IBIS mapping technique appeared in the early 1970s. Argumentative design focuses on issues, inferences or evidences structured among questions, answers and arguments. This representation of statements shows different viewpoints, positions, pros and cons organized by logical connections. Through argumentative maps, it is possible to represent thoughts more objectively, clearly and rigorously. This representation allows us understand complex structures of knowledge through overview of coherent structure of arguments. This technique was used mainly by teachers as a way to register their feedback about collective productions occurred during chat and forum. Students could see the systematization of discussions in groups and feel more confident to write from concept maps. They also used this strategy to represent their theoretical arguments approaches used in their investigations facilitating the process of systematization and writing.

6.2 - Online Content Design through Webmaps

The online content during the course was presented through webmaps. In Modulo II – Qualitative research the main activity was the Round Table with professors specializing in qualitative research. In the first step, students made initial questions about qualitative research. Professors were invited and sent a paper. The discussions were organized using a forum. This helped the participants to reflect more about the content and to map the main concepts. Then they systematized the meaningful information in their working teams, answering their first questions.

Students commented that the webmap facilitated the navigation and visualization of the process and each element to be integrated. They also wrote that it was more interesting to navigate around the content and at the same time

see all possible connections using hypermaps than hypertext. This allowed them to understand easily each stage and the whole activity.

6.3 - Assessment applications

The whole process was recorded by the maps built by teachers and students and some reflections about the process. Evaluation was carried out in two ways: teacher feedback on each student's map portfolio and through students' observation.

Another measure of learning was learners' reflection on their own mapping process. They reconstructed their maps and wrote some reflections in their online annotation – blog.

To summarise, Compendium maps used to measure learning had 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.
  Some advantages of Compendium software during online courses:
- 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

7 – Ongoing and Future Research Directions

MEMETIC – *Meeting Memory Technology Informing Collaboration* is a toolkit for recording the normally ephemeral interactions conducted via internet video conferencing, and making these navigable and manipulable in linear and non-linear ways, by integrating Compendium knowledge maps with replayable video of the meeting (Buckingham Shum et al., 2006).

FIG. 4 – The *Memetic* Meeting Replay tool, using Compendium nodes as a means of indexing and navigating meeting videos: www.memetic-vre.net

It thus becomes possible to index significant moments during or after the meeting (eg. an interesting slide; an idea that connects with an assignment; something not understood), and then navigate the meeting video in non-linear ways, jumping directly to the point in a tutorial where, for instance, in a meeting that was missed, a student, educator or researcher might be interested to see the moment when someone asked a particular *Question*, made a particular *Argument*, or followed a *Weblink*.

The OPEN CONTENT INITIATIVE is a new project of the Open University [http://oci.open.ac.uk], going live in Oct. 2006. It 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 build argumentation maps associated with learning resources and literatures, or dialogue maps which add value to online meetings.

Users will be able to 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.

8 - Conclusions

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.

with programming by Michelle Bachler. Its development has been funded most recently by the UK's research councils EPSRC, ESRC and JISC. The Meeting Replay tool is joint work with the Universities of Manchester and Southampton as part of the Memetic project.

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