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Citation

Okada, Alexandra (2008). Mapping knowledge to develop academic research in collaborative learning environments. In: Concept Mapping: Connecting Educators, A. J. Cañas, P. Reiska, M. Åhlberg & J. D. Novak, Eds., pp. 516–523.

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MAPPING KNOWLEDGE TO DEVELOP ACADEMIC RESEARCH IN COLLABORATIVE LEARNING ENVIRONMENTS

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Abstract. This paper describes four techniques of mapping knowledge through concept maps for developing inquiry-based research projects. This qualitative study based on participatory action research focuses on identifying benefits and difficulties of research students in applying these techniques in their academic investigations. The background for this work is based on collaborative learning environments (CLE) for engaging students in learning mapping techniques and software tools together, and sharing ways in which they can apply knowledge mapping to elaborate their inquiry-based projects. Quantitative data is also presented to describe the fieldwork: an online course, which was organized by the author. The participants were lecturers and research students from different countries: Brazil, United Kingdom and Portugal. This research group is now interacting in the CoLearn community in the OpenLearn project. Findings based on qualitative analysis of their research maps, discussion forum and learning diaries show some benefits and challenges of using concept maps for developing research projects.

1 Introduction

The innovative use of technology has been promoting the free access to knowledge networks, communities of practice and social learning. New pedagogic approaches, based on the uses of technology to develop thinking skills and collaborative learning, are opening up new opportunities in online education. However the simple access to information does not necessarily mean acquisition of knowledge. *“In order to develop understanding, students need to be engaged in higher order thinking which operates beyond mere exposure to factual or conceptual information. Understanding means going beyond the information given to make inferences, connections and explanations”* (Okada et al, 2008:8).

The aim of this paper is to present the usage patterns of knowledge mapping in academic research for developing inquiry based research projects. This work describes a collaborative learning environment (CLE) that was designed for research students and lecturers to learn mapping software tools and apply mapping techniques to develop their research projects.

The methodology used was participatory action research, in which four kinds of knowledge mapping based on concept maps were applied by researchers to develop their inquiry based projects:

1. Profile Map for representing personal and professional path.
2. Research Map for designing a research project.
3. Theory Map for organising key concepts and definitions from the literature.
4. Writing Map for integrating key arguments for an essay.

In order to explain each technique above, this qualitative study analyses some concept maps developed by participants from a research community created during an online course organized by the author for postgraduate students and lecturers. This online community started their interactions using Moodle at the PUCSP University in Brazil from 2004 to 2005. In 2006, this group interested in knowledge mapping restarted their collaborations using the LabSpace OpenLearn Project developed also in Moodle by the Open University, UK. Some examples of maps and information about knowledge mapping techniques can be accessed in this Research Community – CoLearn (<http://colearn.open.ac.uk>).

2 Theoretical principles

Collaborative learning environments (CLE) means a cognitive system (Maturana and Varela, 1980) constituted by active participants (Freire, 1967) whose interactions produce and improve a network of knowledge (Levy, 1990) and collaboration in order to keep its existence A CLE is a space of common aims, collective interactions, contributions and production that are developed by social actors and their social networks (Okada, 2005).

In order to construct knowledge in collaborative learning environments, it is essential to foster thinking skills and inquiry-based learning as important strategies to avoid reproductive and passive learning. Learners should not construct their knowledge just by memorising and repeating the content offered in a course. Copying and pasting information in order to reproduce knowledge leaves students with lots of fragments disconnected, disintegrated and without meaning. Meaningful learning involves critical thinking (Novak, 1998; Jonassen, 2000).

As it can be observed, critical thinking is a complex process. It comprises several cognitive functions and mental skills resulting in a hard abstract process. According to all definitions above, thinking should not count as critical merely because it is intended to be. Thinking has to meet several requirements to be critical. In this context, knowledge mapping can help users to mediate the process of abstracting from the Latin “*abstractere*”, “take it from” the external world, to concreteness give it back to the world, mapped, interpreted, modified by critical thinking (Okada, 2006).

Jonassen (2000) points out several requirements for developing thinking skills which are very useful for inquiry-based research projects. Inquiry-based learning focuses on constructivist approach, in which knowledge is constructed through critical thinking, problem solving and community-based tasks. In order to develop thinking skills, it is necessary to integrate content/basic thinking, critical thinking and creative thinking.

- Content/Basic Thinking represents skills, attitudes and dispositions required to select and understand accepted information. It refers to declarative and explicit knowledge – basic academic content, general knowledge, common sense information.
- Critical Thinking represents the dynamic process of mapping knowledge in meaningful and usable ways through analysis, evaluation and connections. It integrates important skills such as evaluating the process by recognising fallacies, analysing understanding and interrelationships among relevant elements.
- Creative Thinking shows the ability to go beyond accepted knowledge to create and reconstruct new knowledge. It must be used to connected content and critical thinking in order to integrated existing knowledge with the skill of creating and innovating process and products.

3 Case Study

This study focuses on a community of researchers interested in learning and applying mapping techniques for designing inquiry-based research project. This community started their interactions during a semester-long course - Using mapping Software tool in Qualitative Research (USQR), offered in 2004 and 2005. During this course, participants produced a paper with maps, which was published in an electronic book (<http://www.projeto.org.br/emapbook>). Most of them finished their master and doctoral research using knowledge mapping techniques in 2006 and 2007. In 2008, most of them authored a chapter in the Brazilian book (*Cartografia Cognitiva*) and some of them in the *Knowledge Cartography*, book published by Springer.

The learning outcomes of the USQR course in 2004 and 2005 were:

- ✓ Understand concepts which underpin the uses of mapping for qualitative research.
- ✓ Be able to apply mapping techniques in a research project to collect web resources (web mapping), generate new ideas (mind mapping), organise concepts (concept mapping) and structure arguments (argument mapping).
- ✓ Be able to use different mapping software tools, depending on the context and interests, such as: Nestor Web Cartographer, CmapTools, FreeMind and Compendium.

During these first two years, 52 people from Higher Education took this course. Some of them are now participating in the CoLearn Community that has currently more than 160 members. Participants in the online course were from different fields such as: Education, Business, Economy, Medicine, Psychology, Languages and Computer Science. They had different background (e.g. lecturers, scholars, educators, MA students, PhD students and researchers).

Community-based activities were planned to engage participants in exploring collectively mapping techniques in their individual research projects and also in reflecting and discussing about the uses of mapping techniques to develop academic projects. The methodology used in this research was participatory action research (Whyte, 1991). “*Participatory action research aims to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people*” (Reason & Bradbury, 2001:1)

The course was organized in two parts: (1) Mapping techniques with software tools and (2) Mapping techniques for inquiry-based project. In this participatory action study, the online instruments used to collect data were: discussion forums, knowledge maps and research and learning diaries developed by each participant. Regarding to learning activities, in the first part, participants introduced themselves in the forum; they installed the software tools and explore different kinds of mapping technique such as concept maps, mind maps and webmaps. The second part, focused on principles to support the uses of maps in qualitative research. Its content was presented through a learning path map (figure 3). Its first activity was a “round table”, where four authors (Moraes, Macedo, Cañas and Zeiliger) presented papers with discussion forums with questions related to

authors' papers. In the second activity, participants should improve their research map based on teacher's feedback and colleagues' comments. In the third activity, they should work in groups in order to evaluate and improve their maps. Finally, they should write a map-paper, describing their maps.

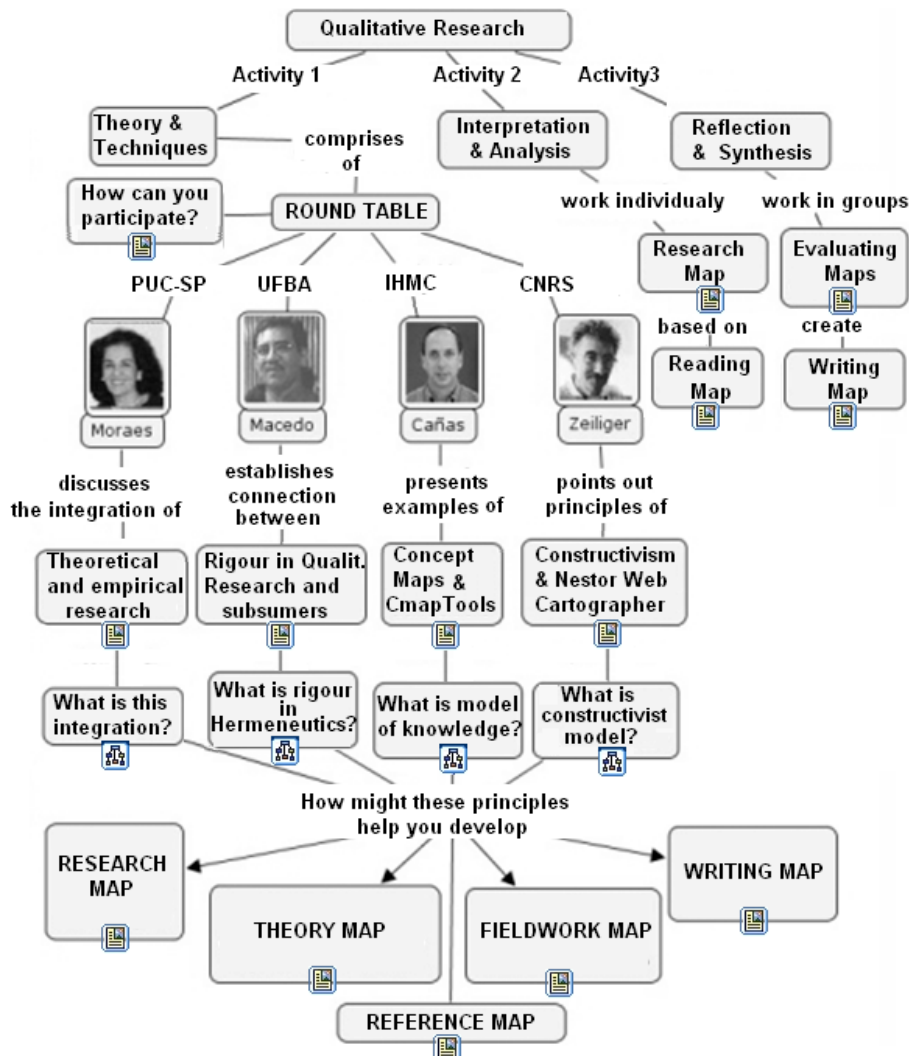


Figure 1: Learning Path Map created in CmapTools by Okada (2004).

Through a learning path map, participants were able to visualise a global picture of learning activities and identify groups to interact and give contributions. They were able to navigate through hyperlinks, select papers to read and choose groups to discuss based on their interests.

In forum, participants exchanged ideas about the papers, raised new questions and shared their reflections about new concepts (e.g. subsumer, theoretical and empirical research, models of knowledge and constructivism approach). Some participants registered in their blogs:

- “The website of an online course is more attractive and objective through concept maps”
- “Maps allow us to visualize different options and select what we are interested in”
- “Maps help us identify relations between concepts while we are browsing the content”
- “Through maps, it is easier to connect our reading to activities and learning goals”

4 CLE – Individual and Collaborative productions

4.1 Profile Map for representing personal and professional path

In the CLE environment, participants introduced themselves through concept maps created in CmapTools with a narrative describing their personal and professional life. Figure 2 shows an example of a MBA student's concept map created to introduce herself in the USQR community. The text shows some information about Laura's professional and personal life. The map presents content different from the text. It shows how she

represents her reflection about herself. In this map, Laura shows that she has dichotomies in her life (body, mind and soul). She indicates some of her skills (e.g. ability to connect ideas and concepts quickly) and difficulties (e.g. low ability to be focused). In this example, it is possible to see that introducing herself through concept map helped her to reflect and share personal aspects that were not described in the text.

When participants created and shared maps in the community, they started to know each other and themselves in different ways. Participants also registered in their diaries that profile maps helped them to think about their way of thinking, and also identify some similarities between their peers. They described that maps were very useful to see common interests and similarities in the community.

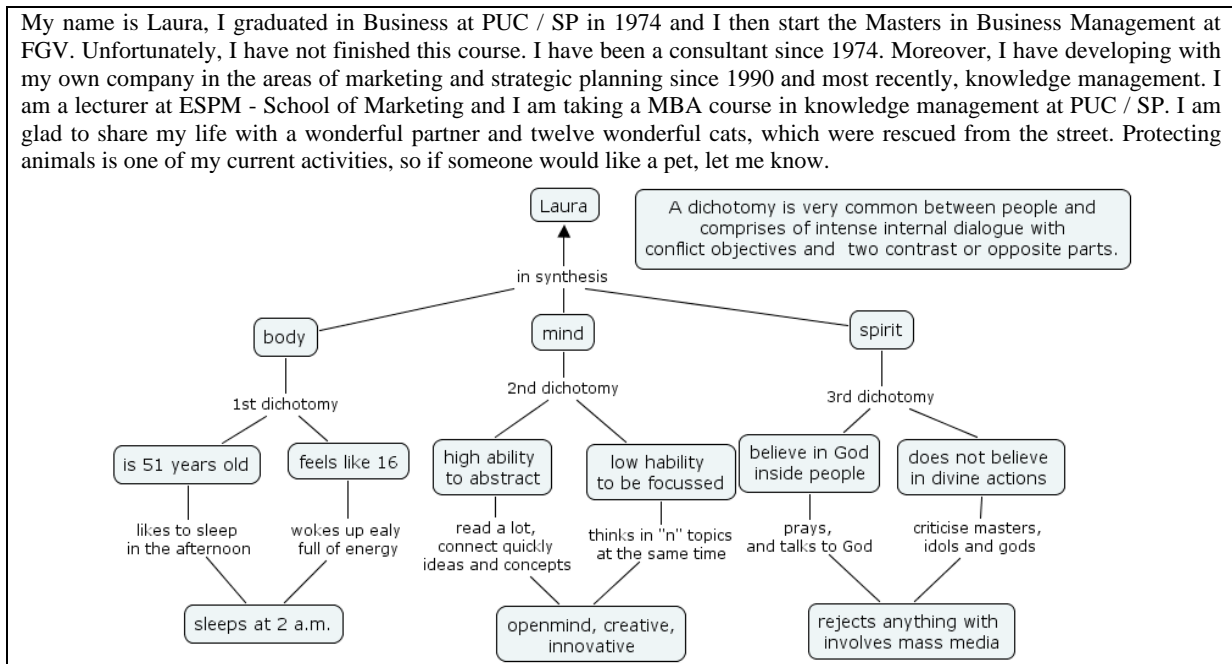


Figure 2: Concept map for introduction created by Laura.

4.2 Research Map for designing a research project

The research map in figure 3 shows the structure of a research project with main key concepts to generate a brainstorm: research questions or aims (*what is the meaning of partnership...?*), relevance of research (*why? ...people needs*), contributions in the field (*for what?... Research Organisations in the areas*), methodology of investigation (*how?... discussion of ideas and Consultation of Community...*) and work field (*where? ...Social Economic Area*). Through a research map, participants described that they were able to select their key question and plan their investigation by establishing connections and visualizing important information. Good inquiry projects depend on significant questions.

However, initially, most of participants described that they had difficulties of using concept maps. They found hard to organise maps by facing lots of information. Others mentioned that they selected many questions but no significant references. Experienced researchers described that mapping the starting point in their project helped them visualize the main question. Conklin (2005) states mapping techniques can be used to frame the problem appropriately for tackling wicked problems; however, some skills must be developed in order to apply mapping tools to create good issue-based structure.

4.3 Theory Map for organising key concepts and definitions from the literature

This theory map shows three perspectives (context, key definitions and key concepts) to organise different meanings of "critical thinking". For that, 14 definitions from different authors were selected, grouped by context and ordered by date. From these definitions, 16 words were generated to capture the key ideas, which were integrated in a conceptual area. Researchers consider theory maps as a guide to help them to interpret different viewpoints, compare and combine different approaches to reconstruct their own interpretations.

Clarifying concepts is an important step to understand theories and for meaningful learning (Novak, 1998). Mapping several sources from different authors that explain the same concept helped researchers select and reconstruct maps from a wide and more significant perspective.

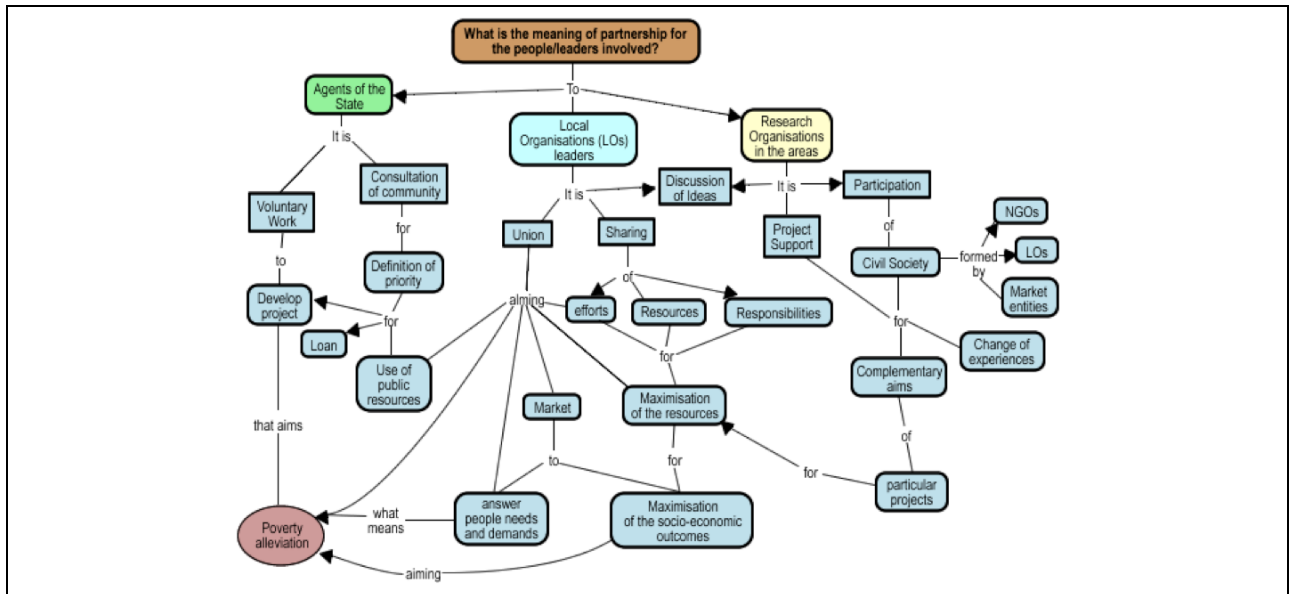


Figure 3: Research Map created by Mario

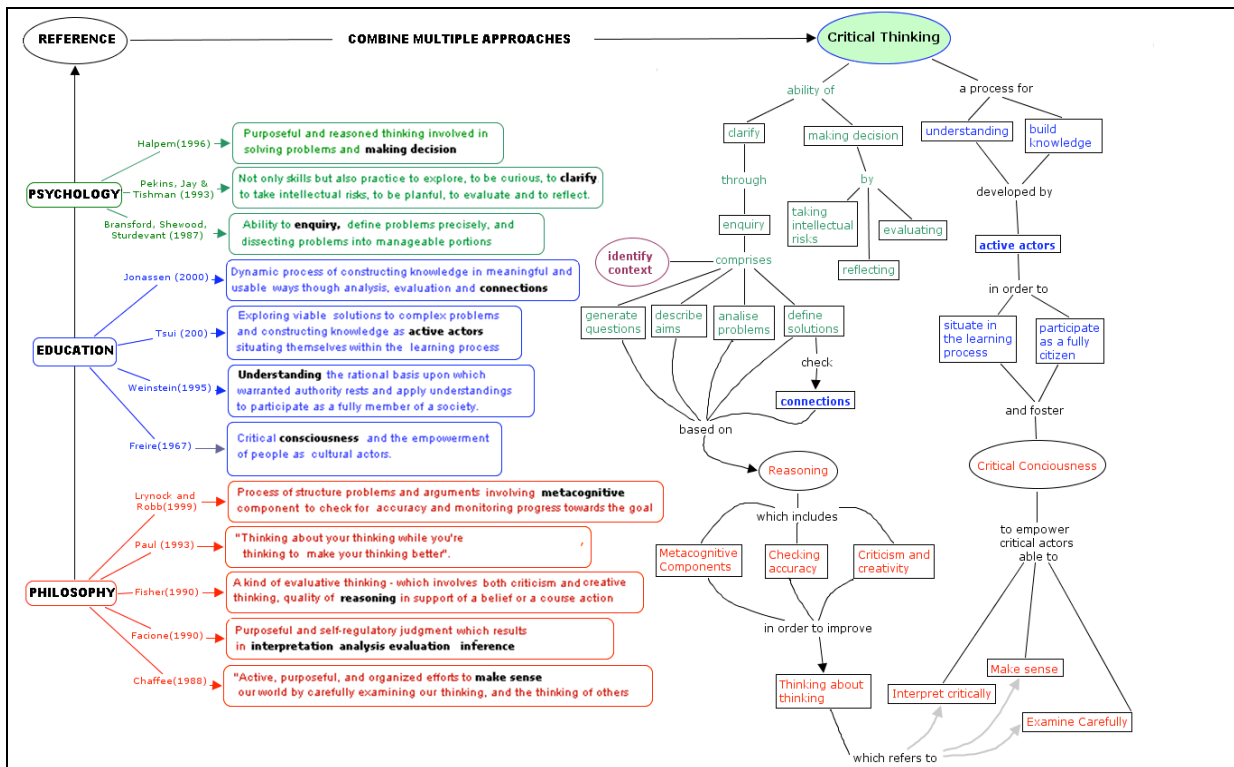


Figure 4: Theoretical Map about Critical Thinking created by Lila, Nely and Ale

Participants discussed in the forum that when concepts are well mapped, learners can compare, combine and reintegrate similar groups of references. Mapping theories are good exercise for reflecting. It helps researchers visualise gaps or misunderstandings that need to be investigated. They can identify new concepts that should be clarified. Through theory maps, researchers can represent and reconstruct semantic networks from their own perspective and reuse them in different research projects. Through theory maps, they can connect concepts, definitions and the original source by organising a graphical memory system of their research.

4.4 Writing Map for integrating key arguments for an essay.

After mapping theories and the fieldwork, another issue is to map the research's outcomes and synthesise a significant conclusion. It means integrating each relevant component to form a coherent whole. For that, a well-structured map is useful to organise ideas clearly and coherently. Researchers and learners can easily describe and visualise their line of reasoning from the maps instead of retrieved from memory (Andriessen, Baker, Suthers, 2003). Visualising argumentation help them to be actively focussed on the main issues. (Kirschner, Buckingham Shum and Carr, 2003). They can integrate all evidence including arguments that justify the conclusion. Through the writing map not only the outcomes can be understood but also how they were found and how the research problem was answered. This map below shows an example of a paper whose author created a concept map to analyse and write about the concept of partnership (figure 3 and figure 5).

The screenshot shows a web page from 'OpenLearn LabSpace' with the title 'Knowledge Cartography'. The page content includes a navigation menu (Home, Welcome, Preface, Chapters 01-09), the chapter title 'An Experience of the Use of the Cognitive Mapping Method in Qualitative Research' by Mário Vasconcellos, and an abstract. The abstract describes the chapter's aim to analyze the cognitive mapping method as a tool for supporting qualitative research, particularly for literature reviews, concept analysis, and data examination. It mentions the author's experience with the cognitive mapping method and the application of CmapTools software to understand the concept of partnership, highlighting advantages like speed, representation, and consistency, as well as potential challenges like reductionism and misinterpretation.

The concept map, titled 'What is the socio-political environment that goes beyond the partnership process?', illustrates the following relationships:

- 1988 Brazilian Constitution** (yellow box) is a **significant issue** that **promoted** **Decentralisation of public policy** (blue box).
- 1988 Brazilian Constitution** **created** **Constitutional funds** (blue box).
- Constitutional funds** **for the north** **created** the **North Constitutional fund** (blue box).
- Constitutional funds** **influenced** **External NGOs** (blue box) and **Sustainable Development** (green box).
- External NGOs** **brought** **Sustainable Development**.
- External NGOs** **and** **Sustainable Development** **supported** **Social movements** (blue box).
- Social movements** **required creation and changes on** the **North Constitutional fund**.
- North Constitutional fund** **established** **Norms** (blue box).
- Norms** **incentivised for creation of** **Cooperatives** (blue box) and **Associations** (blue box).
- Decentralisation of public policy** **demanding** **Committees at municipal levels** (blue box).
- Committees at municipal levels** **influenced creation of** **Rural Development Committee** (blue box).
- Committees at municipal levels** **among others** **responsible for** **Rural Development Planning** (blue box).
- PRONAF** (blue box) **and** **PRONAF infrastructure** (blue box) **demand** the **Rural Development Committee**.
- Cooperatives** **supported** **Associations**.
- Associations** **supported** **Rural Development Planning**.
- Cooperatives** **and** **Associations** **mutual relationship**.
- 1988 Brazilian Constitution** **influenced creation of** **Elections** (purple box).
- Elections** **influenced creation of** **Committees at municipal levels**.

Figure 5: Map-paper develop by Mario (<http://kmi.open.ac.uk/books/knowledge-cartography>) & (<http://mapweb.org/emapbook/>)

5 Discussion

Knowledge integration environments (Bell et al, 1995) through knowledge maps seem to stimulate learners to develop and apply their thinking skills for inquiry-based research. Knowledge maps can guide them to find different spaces and groups to negotiate meanings, issues, claims and arguments with evidence and references. When CLE stimulate learners to interact, contribute and develop productions together, they feel able to share cognitions and construct more knowledge that is significant together.

Knowledge maps can play an important role in CLE to represent collective construction of knowledge where all participants can access different spaces (figure 1) without feeling lost. They can negotiate meanings and add contributions connecting evidence. In this sense, these knowledge maps can help them develop and apply their thinking skills by analyzing and establishing more connections between referential space,

argumentative space and questioning space in their maps and writing. Concerning difficulties with knowledge maps in CLE, this study shows that learners (10%) who faced problems with their computers, internet or software tools, gave up learning. Participants (14%) who were very busy with deadlines did not find time to interact and were not able to learn and apply knowledge maps in their academic projects. A few participants (10%) who were not familiar with graphical representations with hyperlinks found difficult to understand the content through maps, however when they started to produce their own maps they mentioned that learning path and portfolio maps were very useful.

The second purpose of this study was to identify contributions of applying knowledge mapping techniques and software tools in academic projects. Participants point out that research map used to represent key ideas enabled them to find their key questions. The reference map helped them organise the literature review. The reading map was useful to interpret papers. The theory map facilitated the integration of different viewpoints about the same concept. The fieldwork map provided interesting ways to analyse data. Finally, the writing map was good strategy for summarising key ideas with arguments and evidence. Through these knowledge maps and their discussion in the CLE, teachers could also observe that participants were very engaged in applying these mapping techniques to develop their researches. Most of the participants (80%) in this course were able to create research maps, references maps and theory maps. Few participants (10%) who had already collected electronic data from their fieldwork were able to create fieldwork maps. In addition, some researchers (30%) who were interested in improving their writing skills elaborated reading and writing maps. In this study, participants did not apply six kinds of maps to develop all steps in their research, because most of them were in different stages in their investigations with different interests and short time.

Regarding to difficulties with knowledge maps in academic research, several participants (60%) described that it was hard to explore different methods and technology. However, after get used to mapping techniques and tools, they could identify differences and apply different resources better. In order to illustrate some benefits of using knowledge mapping for inquiry-based research projects, Table 1 shows some researcher's comments from their learning diaries, which were selected and classified based thinking skills. Their messages describe how researchers observe the contributions of mapping for developing their academic projects.

Knowledge Map	Thinking skills & Inquiry Based Learning	Researchers' comments
Profile Map	Designing: formulate goals, draft outcomes, revise process.	<i>"Through the profile map I could see connections between my life and my research. By visualizing this integration I could identify important aspects in my academic project"</i> Antonio
Research Map	Problem solving: reformulate questions, find new alternatives, build acceptance Evaluating: define criteria, assess information, recognise fallacies	<i>"Through my research map I could find a focus of my investigation. After creating several maps of my key issues, I could visualise the main ideas and identify the key questions of my research."</i> Claudio
Theory Map	Connecting: compare and contrast, infer deductively and inductively, identify relationships Analysing: recognise patterns, classify main ideas, find connections. Decision-making: identify possibilities, generate alternatives, compare options.	<i>"Using maps to connect different perspective from the same concept is very challenging. Maps can reduce the meaning of concepts and it is hard to summarise in few words complex definitions." (...)</i> <i>"However, they help us to compare different approaches and identify connections to reconstruct new meanings"</i> Mario
Writing map	Synthesising: plan, hypothesise, summarise. Elaborating: reflect, widen and deepen, update, concretise. Imagining: predict, speculate, visualize.	<i>"Maps applied to writing seems to be a great strategy because it help us visualize and integrate enough evidence to back up our claims, identify ideas to be deepened, approaches to be widened and plan a clear structure for presenting our thinking."</i> Lila

Table 1 –Fostering thinking skills through knowledge maps in research projects

6 Conclusions

In this paper, preliminary findings indicate some contributions of knowledge mapping applied in academic research for developing inquiry-based research. Results of this study also highlight the importance of collaborative learning environments to support researchers in exploring tools and applying mapping techniques in their academic projects.

This study has also identified some difficulties of participants in using different tools, representing thinking graphically and creating maps with lots of data. We will be investigating how participants can create these kinds of maps using the same tool; and how learning activities can help them manipulate graphical language to develop spatial ability and visual navigation (Chen & Czerwinski, 1997).

The emergence of social software and web 2.0 (Anderson, 2007) which create new scenarios for open learning (Willinsky, 2006) and collaborative construction of knowledge (Suthers, 2006) also highlights the importance of ongoing research. Knowledge maps may be considered strategic, speculative and heuristic tools to represent what is important, interpret and reconstruct meanings, record and share new structures of components and connections essential to foster critical thinking and make better decisions in social learning communities.

7 Acknowledgements

This Research Project was supported by CAPES during the PhD thesis from 2004 to 2006 and also supported by the OpenLearn project funded by William and Flora Hewlett Foundation from 2006 to 2008. I would like to thank Simon Buckingham Shum and Tony Sherborne for precious feedback during this research.

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