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THE USE OF VISUAL TOOLS IN THE ACADEMIC RESEARCH PROCESS: A LITERATURE REVIEW

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Abstract:

An academic librarian, especially one who works primarily in a research consultation capacity, often encounters individuals who are seeking in-depth help with research projects that they struggle to explain. The number of concepts, interdependencies and assumptions involved in research projects today can make them difficult to define and discuss with other people. The multidisciplinary nature and globalization of many areas of research is forcing researchers to not only discuss, but to collaborate with many others from different academic backgrounds and disparate physical locations. Many researchers struggle with project paralysis at various points along the way as they attempt to manage both the myriad of details and the bigger picture relationships and implications of their project.

A number of visual tools including concept mappers and mind mappers are well suited to help advanced students, faculty, researchers and librarians to organize the ideas and knowledge throughout the various stages of complex research, from envisioning an idea to the early stages of actively researching and documenting research findings. This paper will discuss the potential uses of visual mapping tools and review the current state of academic literature surrounding the topics of mind mapping and concept mapping.

Keywords: Knowledge Mapping; Concept Mapping; Mind Mapping; Information literacy; Visual tools

Introduction:

Pictorial representations to record knowledge and model thought processes go back to the earliest humans who left a history of their life through their drawings on cave walls. Information or Knowledge Mapping as we know it today, however, grew out of several parallel movements in the 1970's. Dr. Joseph D. Novak created the technique of concept mapping as a tool to aid Cornell students who were learning about the latest discoveries in science. Novak (1998) declares that the "central purpose of education is to empower learners to take charge of their own meaning making. Meaning making involves thinking, feeling and acting" (p. 9). All three of these elements must be synthesized together for true knowledge creation, and concept mapping, Novak asserts, is one valuable tool in facilitating this process.

In parallel with Dr. Novak, Tony Buzan began in 1974 to promote a visual technique to aid in many different kinds of sensemaking activities. He called his tool a mind map. Buzan defines a mind map as "a powerful graphic technique which provides a universal key to unlock the potential of the brain. It harnesses the full range of cortical skills – word, image, number, logic, rhythm, colour and spatial awareness – in a single, uniquely powerful manner. In so doing," he asserts, "it gives you the freedom to roam the infinite expanses of your brain. The Mind Map can be applied to every aspect of a life where improved learning and clearer thinking will enhance human performance" (Buzan, 2011).

Whether we call it mind mapping, concept mapping, information mapping, knowledge mapping, or knowledge cartography (Okada, Buckingham, Simon, and Sherbourne, 2008), using visual tools to

facilitate knowledge creation and knowledge transfer has played an important role in research and academic pursuits. It is surprising, therefore, that librarians have not been more deeply involved than the literature seems to indicate. In this paper the author intends to review the current state of visual tool usage in the academic research process, concluding with ways in which academic librarians, especially those in STEM fields, have found to support their researchers and students in these techniques.

MIND MAPPING

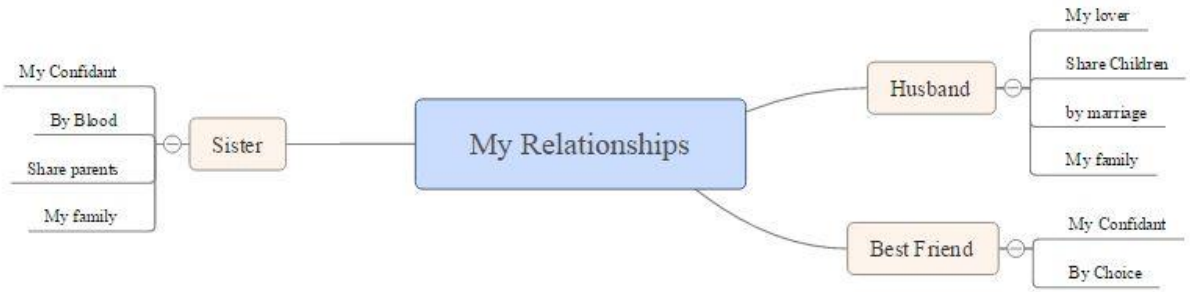

Figure 1: Sample Mind map using Xmind.net

Proponents of mind mapping claim that an individual's ability to remember information, and, more importantly, remember how that information relates to other concepts and facts, increases greatly by the use of mind mapping. The process of placing ideas and facts into circles, and then relating those circles to each other via connecting lines forces the individual to evaluate information and visually identify the relationships of ideas to each other. Even the terminology of mind mapping, with "nodes" of information identified as "parent", "child" or "sibling" assigns basic hierarchical understanding. The process of map creation guides the mapper to think about the information more deeply and to recognize how new information relates to an already existing knowledge base.

Significant research in various educational fields shows a correlation between increased short-term memory retention and the use of various kinds of knowledge mapping techniques. Hall and Sidio-Hall (1994) found that the spatial display of mind mapping made concepts easier for students to assimilate, and that freedom of recording their new knowledge in the order that made the most sense to them helped students concentrate better and remember more when later tested.

Brinkmann (2005) found that by utilizing mind maps in the mathematics classroom, students demonstrated, not only their own method of knowledge organization, but also the gaps in their understanding of new concepts. The maps could then serve as a guide for the teacher so that further instruction could focus on the weaker concepts, allowing students the opportunity to achieve more well-rounded mastery of the material.

While a successful tool for K-12 students, mind mapping becomes even more valuable for students at the university level. "Adult learning literature supports the notion that relational linking of new information to old information promotes cognitive knowledge development in the learner" (Pinto, Maher and D'Antoni, 2015, p. 43). Indeed, by mastering the tool in lower grades, students are more equipped upon entering higher education to use their mind mapping skills to help them integrate the more complex ideas and concepts they will encounter in their college study. Schwendimann (2015) explains that STEM subjects are good candidates for benefiting from mind mapping. Often, the complexity of these subjects forces professors to split the concepts and facts into isolated chunks in order to cover the material in the depth required. This can lead to students learning many facts, but not assimilating these facts into a cohesive body of knowledge. Focused mind mapping can help students identify and solidify the relationships of material from different classes together, thus achieving a better mastery of their field of study.

However, while the value of mind mapping for clarifying relationships is well documented, there are several other valuable uses for mind maps in the classroom, including their value in a group setting. Peer review of mind maps can help students sharpen their ability to support their ideas by grounding them in scientific thinking and fact. In the scientific world in particular, the ability to respond appropriately to peer critique with logical thinking is critical, and the ability to relate interdisciplinary concepts to problem solving can be an effective negotiation tool. Kotcherlakota, Zimmerman and Berger, (2013) successfully used the fishbowl technique to this end in their graduate level nursing classes. The authors had their classes research various topics, presenting their theses in the form of mind maps. Each student then participated in a "fishbowl" exercise where the student was placed in the center of a circle of their classmates and instructors. They then had to field probing questions about their topic, leading them to view their findings from alternative points of view and to approach their work more critically.

Another discipline which has embraced the use of mind mapping is the field of management. Developing creative thinking skills when dealing with large volumes of information is a necessary skill for today's business professional. Eriksson and Hauer (2004) had their students use mind mapping in a MBA marketing course to document and clarify many of the steps required when analyzing complex business problems on topics such as customer relationship management, SWOT analysis, strategic opportunity analysis and stakeholder analysis. Solutions required the consideration of both domestic and international situations and mind mapping provided visual clarity on viable options. When the added complexity of science and engineering topics are added to the mix, mind mapping can be a powerful management tool for STEM executives.

Mento, Martinelli and Jones (1999) encourage the use of mind maps in their EMBA classes by guiding their students through several stages, first of mind mapping the key points of assigned readings, then progressing to having the students assimilate several different readings into one mind map and finally having the students prepare and then lead a class discussion of a case study that was mind mapped. Many of the students reported a side benefit of increased confidence in their presentations when it had first been mind mapped.

Wheeldon and Faubert (2009) encourage their students to use mind maps as a collection tool to document data collected during interviews with research participants. They found mind maps to provide a good starting point for designing more detailed subsequent interviews. By consistently using a

structured map to document the interviews, patterns often emerge when conversation maps are compared. These patterns can then help define or shift the research topic in question as well as point out next steps and other related concepts that need to be explored.

One challenge of mind mapping is the misleading simplicity of the technique. “We suggest that mind mapping be considered a skilled technique, and as with any learning of a skill, thoughtful practice is necessary to develop from a novice learner/performer to a master performer.” (Pinto et al., 2015, p. 46). Parhankangas, Passerini, and Casal (2013) found this clearly illustrated in their study which compared the quality of mind maps created by advanced undergraduate business school students, MBA level students and business school faculty. A clear progression of mind maps which grew significantly more complete and complex occurred as the level of experience and education increased, with the business faculty maps being both more comprehensive and integrated. The lack of the students’ ability to integrate concepts across several courses in order to solve one comprehensive business case study clearly showed how systematically including mind mapping practices into the academic program could benefit the development of students’ problem analysis skills on real-life scenarios.

CONCEPT MAPPING

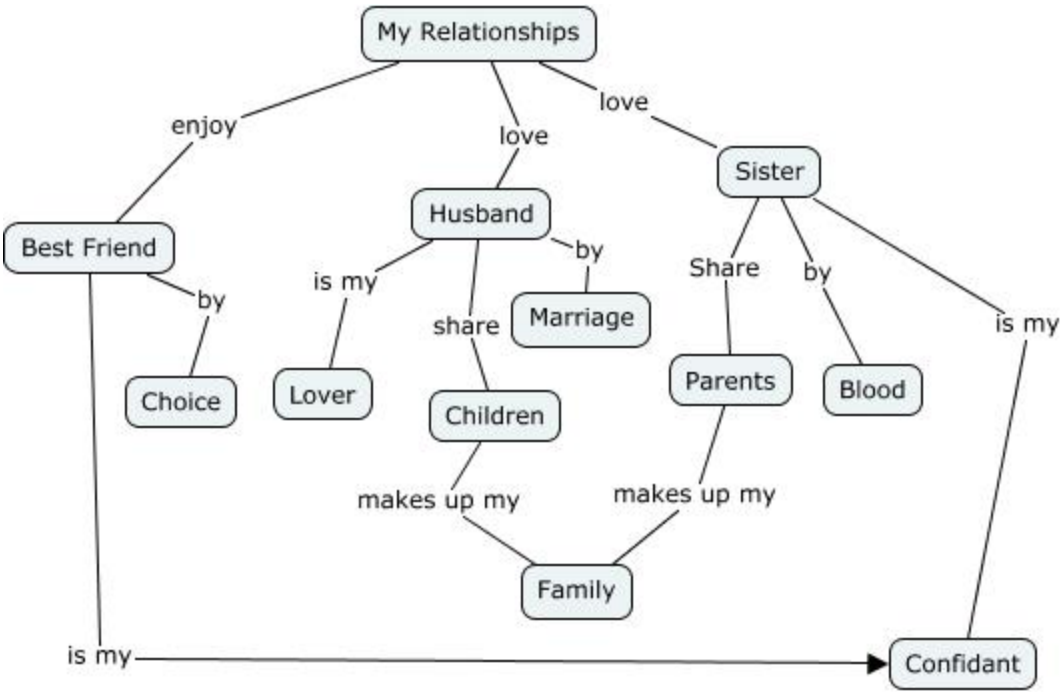

Figure 2: Example of a Concept Map using Cmap.ihmc.us/

The distinction between mind mapping and concept mapping is often blurred in the literature. Whereas mind mapping identifies items which are related to one another, concept mapping is more refined in that the nature of the relationship between two nodes is much more distinctly defined than simply considering the relationship between two nodes as a parent, sibling or child. While mind maps facilitate

the student in connecting ideas together, concept mapping goes the additional step of considering more closely the relationship between those ideas within the lens of a central focus question (Dixon & Lammi, 2014).

Canas, Novak and Reiska (2015) defines the qualities that embody an "excellent" concept map. Such a map needs to clearly address the singular focus question of the map. It is a misconception that the larger and more complex the map the better. In fact, an excellent map is concise, neither missing concepts, nor including extraneous ones. All cross-links help the viewer see how the map developer connects concepts in one domain of knowledge to other related domains. When one views an excellent map, the key ideas are easily identifiable, and the appearance of the map is well balanced, with a structure that demonstrates clear understanding of the topic under question. That being said, concept maps that may be considered "excellent" by one group, might not be rated as highly by other areas that are not, perhaps, as well versed in the topic being mapped.

Like any other skill, mastering excellent concept mapping skills is a learning process that develops over time. Indeed, the learning curve is considered by many as one of the more serious limitations of this tool. Gul and Boman (2006) conducted exit interviews of a number of their students and found that many felt "lost" when initially trying to figure out how to create concept maps. Finding the right terms to use on the maps was difficult, and many linear thinkers found the structure of the concept map "chaotic;" they would have preferred to use the time spent in creating the maps for more productive research. However, as Gul and Boman point out, stretching linear thinkers to consider their topics from different perspectives encourages those thinkers to eventually reach a higher level of integrated knowledge. This achievement more than compensates for the challenges of learning to use concept mapping as an integrative tool.

Stewart (2012) defines four major uses for concept mapping in higher education: (1) as a curriculum development tool, (2) as an interactive learning tool for students, (3) as an assessment tool, and (4) as a tool for researchers. Instructors tend to use concept mapping in various ways in their classes, some which are more successful than others. "Concept mapping," declares Kinchin (2014), "should be used in compatible curriculum settings that reflect the constructivist underpinnings of the tool" (p. 46). Indeed, in his opinion, if the method of instruction is not changed, and mapping by the student only occurs as an assignment after the traditional lecture instruction model is finished, the mapping is little more than another form of notetaking and does not really exploit the rich learning that can take place when an instructor intermingles the development of concept maps of the syllabus material within the instruction sessions.

Castles, Lohani and Kachroo (2008) show how this integration of mapping into the instruction process can be achieved. They used concept maps in a freshman engineering class at Virginia Tech that was studying mechatronics. During the preparation stage of the course, the professors created "Knowledge maps" by taking the concept mapping strategy to the next level and embedding multimedia, pdfs, PowerPoint lectures and website links into each node of the map, enriching the document and creating a comprehensive learning framework for the class. Later assessment of the unit exposed those relationships and areas where student mastery of the material was lacking. Indeed, all areas of STEM have experienced successful implementation of concept mapping into their curriculum. Schwendimann (2015) identifies a plethora of articles on the topic of concept mapping in the sciences, matching each

article to the appropriate STEM discipline and the corresponding education level of the case study in his excellent article.

Concept mapping is a tool that takes knowledge structures and displays the information in a visual way that reveals different perspectives of the topics under discussion. Kinchin (2015) believes that recognizing and assimilating these different perspectives is an essential step in developing a powerful knowledge base in a topic. Traditional curriculum pathways can provide all the disparate nodes of knowledge, but the assimilation of nodes into a body of knowledge is not assured by a coherent curriculum plan alone. This is even more critical in today's environment of increased emphasis on multidisciplinarity on a global platform. Any tools, by any names, that can help tomorrow's leaders achieve the broad-based, detail rich knowledge they need to succeed are tools worth learning.

In the same way, the importance of students developing critical thinking skills cannot be overemphasized. The ability to identify assumptions, connect those assumptions to one another by way of higher ordered reasoning is a critical step in creating new actionable knowledge. "Complex thinking is the dynamic interdependent relationship between many elements, which enables discernment of all information pertinent to the situation in order to think through a situation with seamless reasoning" (Pinto et al., 2015, p. 47). Concept mapping is one powerful tool that helps develop this level of reasoning.

VISUAL TOOLS AND LIBRARIANS

Librarians build careers on their ability to organize and synthesize knowledge. Librarians are therefore well positioned to help introduce students and faculty to knowledge manipulation and visualization tools like mind mapping and concept mapping. The tools themselves may be unfamiliar to some, but the concepts underlying them are etched into the framework of what librarians have been striving to achieve for centuries: to capture, preserve, organize and provide to others rich, cohesive knowledge. This being said, the literature is surprisingly sparse on the topic of librarians who use visual mapping tools in their work.

In the late 1980's, the Syracuse University School of Information Studies used concept mapping with their library school students who were taking a traditional reference services course (Sherratt & Schlabach, 1990). Students were asked to map the various parts of a reference consultation interaction. Throughout the semester, students enhanced and adjusted their initial maps as they learned more details about reference services in their class. Novak's *Learning How to Learn* (1984) was used as a supplement text to provide a comprehensive overview of how to create concept maps. While Sherratt and Schlabach suggest further applications of concept mapping in the conclusion to this article, most ideas were limited to internal options such as using maps to spark discussions with other librarians or for teaching new librarians how reference services work. In their opinion, the complexity of teaching concept mapping was not an efficient use of a librarian's limited time during most traditional one-shot instruction sessions, although including illustrations of library concepts using mapping during the sessions could prove valuable. (p. 66).

Axford and Renfro (2012) also explore many internal mind mapping uses for librarians in their article; in addition to brainstorming and internal training, they suggest using mind maps for planning library events, preparing for a conference presentation, outlining an article and providing visual documentation for strategic planning or library reorganization discussions for library management. Additionally, they suggest that "Instructional librarians will find mind mapping an indispensable tool in the syllabus design process when planning new classes" (p. 3).

One interesting internal application of mind mapping is as a visualization tool for librarians involved in curriculum mapping. Booth and Matthews (2012) describe curriculum mapping as "a way to visualize the combinations of subjects and requirements that lead specific groups of learners from general prerequisites to a degree in hand, which in turn alerts an instruction or outreach-focused librarian to their most strategic points of intersection along the learner experience"(p. 5). The use of mind mapping tools can clarify this process by providing a visual that organizes and summarizes the data into a single cohesive picture.

Colosimo and Fitzgibbons (2012) also echoed several of the concepts reported by Axford and Renfro (2012) in their article on ways that librarians were using concept mapping as internal tools to aid in designing workshops, preserving institutional knowledge and organizing resources. They emphasize, however, that the true value to students who use concept mapping lies in the facilitation it provides in processing knowledge relationships via active learning. Visual mapping tools provide opportunities for librarians to help students better articulate their research.

The growth of web discovery systems has made finding journal articles and books more straightforward for many students, and undergraduate students in particular can often find quality resources without learning how to traverse multiple library databases as was traditionally required. This simplification allows librarians the opportunity to switch their instruction focus from Boolean search and database idiosyncrasies to focus their one-shot sessions on high level literacy instruction and thinking where concept mapping can be effectively utilized. Authors Cmor and Xin (2012) illustrate this idea by outlining how a discovery-based search on the topic of "cloning" could introduce students to the many different avenues that could be explored with this general topic. The students learn how mapping search results helps them to focus their topic and to explore multidisciplinary angles their topic may take. By introducing concept mapping techniques at the early undergraduate level, librarians are helping to prepare students for the more complex thinking and analysis that will be required for successfully mastering upper level and graduate coursework.

While some librarians might find concept mapping to be difficult to teach in one-shot instruction sessions for general undergraduates, it is an extremely valuable tool for graduate students and upper-level undergraduates doing extensive research projects. Tysick (2004), a librarian at the University of Buffalo, developed an active learning, sixty minute session for graduate students in Informatics, Women's Studies and Anthropology that incorporated concept mapping. By focusing the session on the research planning stage instead of moving directly to the literature review, Tysick gave the students several activities to help them direct their research topic. The students brainstormed on the components of their topic and the variables of the hypothesis. Only when students were ready to begin placing their brainstormed data into a hierarchical schematic of ideas was the concept mapping technique introduced. At the end of the 60 minutes, the students were ready to begin gleaning terms from their concept map to use in their search strategies.

Harvard School of Education co-instructors Garson and McGowan (2010) expanded upon the one-shot instruction technique in their year-long, doctoral seminar course on "Writing a Literature Review" The opportunity for the course which paired Garson, Head of Research and Instructional Services at the Gutman Library with Dr. McGowan was the result of complaints from both students and faculty. Faculty complained that doctoral students didn't reach the cutting edge of research with their topics and the research that was done did not reflect an appropriate level of critical analysis or topic synthesis. Doctoral students in their turn were frustrated at their attempts to refine research questions in a dynamic field with inadequate research strategies. The resulting seminar allowed Garson to introduce concept mapping as a way to explore and refine research strategies. She showed the students how concept maps could be a learning repository for keeping their research current, and how concept maps could be combined with Refworks to manage their growing bibliographies.

Professors who work frequently with graduate students recognize the value of mapping tools. Melles (2007) claims that "visualization tools responsive to the dynamic construction and modification of doctoral knowledge domains are needed" (p. 102). He integrates visual maps into his advisory sessions with doctoral students, using the map as the focal point of discussions on the scope of thesis projects, illustrating where gaps in coverage or unsupported leaps in arguments occur. While many instructors and advisors will readily agree to the value of visualization tools in the thesis process, most will also agree that this topic is not one that is covered in their instruction, nor are seminar classes such as those offered by Garson and Mcgowan (2010) the norm. Syllabi classes are already stretched to their limits with necessary curricula; visualization tool instruction simply will not fit, most often leaving the student to discover helpful techniques such as concept mapping on their own. Librarians can help fill this critical gap by offering introductory workshops or tutorials on visualization tools such as mind mapping and concept mapping as a part of their graduate library instruction curriculum.

CONCLUSION

Visual mapping techniques, be they mind mapping, concept mapping or some other visual application, are valuable tools for today's student researcher. From simplistic maps showing how to break research concepts into Boolean searches, to complex maps that help student define the boundaries of their doctoral thesis, visual mapping "reflects the nonlinear, complex reality of concepts and phenomena." (Serig, 2011, p. 249) These tools help the mapper clarify a project and uncover previously unidentified relationships and tangents that a research topic may take. Once the thesis is fully defined, mapping can continue to assist the student to stay on target as they transverse the sea of research material they locate during their literature review. Keeping the scope of their research within pre-determined boundaries and making sure that gaps are identified and appropriately covered are two other benefits for students who continue to use mapping applications throughout these early stages of deep research.

"The choice of mapping tool largely depends on the purpose or aim for which the tool is used and [these] tools may well be converging to offer educators as yet unrealized and potentially complementary functions" (Davies, 2011, p. 279). Whether it is mind mapping with its free-form structure promoting creative thinking, or concept mapping with its structured format that demands relationships between concepts be clearly defined, the use of a visual knowledge mapping application is a valuable tool for university students. Unfortunately this literature review has revealed that mapping is

not always a tool that is widely familiar to students, and their introduction to mapping is often limited to special projects in classes, or not at all. The literature shows that a few librarians have begun to incorporate visual mapping into their work, both behind the scenes and in the front lines working with students, and some library schools have included mapping exercises into their reference coursework. It is the hope of this author that this trend continues and that visual mapping becomes more deeply ingrained in the information literacy outreach of librarians as we continue to evolve in order to meet the changing needs of our academic audience.

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