# The Role of a Computerised Concept Mapping Tool in the Context of the Australian PhD Candidature

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**Abstract:** This paper presents a human-computer interaction study aimed at understanding the roles and consequences of a computerised concept mapping tool in the context of the Australian PhD candidature. Unlike most educational technology research, it is situated in a non-formal learning context, and it addresses technology use in terms of the learner's agency. The study presented is longitudinal and exploratory in nature. It involved participants, who are PhD candidates from the University of Melbourne, reflecting on the conceptual structure of their research using three different approaches: thinking aloud, writing using Microsoft Word and mapping using CmapTools. This paper reports on the preliminary findings of this study. The findings are presented in terms of three emerging themes relating to thinking styles, maintaining perspective of the coherence of ideas, and explicitness and tangibility of cognitive strategies and processes.

## Introduction

As a field of research, human-computer interaction (HCI) is concerned with studying and understanding the impacts of computing technology in all aspects of human life. While this includes learning, there has been, surprisingly, little research into computing technology for learning within the HCI community. This was previously observed and highlighted by the late David Squires (1999) more than ten years ago. Even so, the situation remains relatively unchanged today (Prates and Figueiredo, 2005). But while there are no lack of research into computing technology for learning within the educational technology community, the research conducted are often situated in a formal learning context. As such, there are opportunities for the two communities to collaborate in order for computing technology in various learning contexts, especially ones that are not formal, to be better understood. Inspired by the ideal of the 'learning society' (Delors, et al., 1996), we conducted a study aimed at understanding the roles and consequences of computing technology in an authentic non-formal learning context. Specifically, we focused on the use of a computerised concept mapping tool in the context of reflecting on the conceptual structure of Australian PhD research projects.

## The Australian PhD Program

The PhD program in Australia is built on a discipline-focused undergraduate education, which in turn is built on a broad and academic secondary education (Evans, 2007). This PhD program is a three year program and is mainly research-based. To be admitted, potential candidates need to possess at least an upper second class honours degree in a relevant area. In comparison to the American PhD program, there are no qualifying examinations and there are no compulsory discipline-specific coursework components required to be completed beforehand. Upon acceptance into the program, the candidate is designated a 'probationary' candidate (as opposed to student). Towards the end of the candidate's first year candidature, he/she goes through a confirmation process to affirm the candidate's suitability to remain in the program. If allowed to remain, he/she becomes a 'confirmed' candidate. The confirmation process involves the submission of a formal research proposal, an oral presentation to peers and a formal interview by a confirmation panel.

The Australian PhD program requires candidates to undertake an independent research project under the supervision of a qualified academic staff member. Candidates are further required to make a significant contribution to knowledge as part of the outcomes of their research. In terms of learning demands, the challenges involved are not trivial. As illustrated by Green and Macauley (2007), the transition from knowledge consumption to knowledge production is less structured for candidates in the Australian program than it is for candidates in the American program. As such, advisors have a responsibility to academically mentor their candidates in addition to supervising the conduct of their research project. However, studies instead suggest advisors see their role as one of imparting discipline-specific knowledge and less of imparting research related skills (Genoni and Partridge, 2000). Therefore, Australian candidates experience relatively higher learning demands in comparison to their American counterparts.

## Demands and Challenges of Learning in the Australian PhD Candidature

The literature involving the demands and challenges of learning in the Australian PhD candidature is scant (Holbrook, Bourke, Fairbairn, and Lovat, 2007). Nevertheless, existing materials do provide useful, if limited, insights into the demands and challenges faced by candidates. Green and Macauley's (2007) study on how candidates engage with information suggest candidates in general 'know how to learn'. They are also metacognitively aware, and strategic in the operationalisation of their learning. Even so, they found it challenging to reconcile their learning with the limited time available and the cognitive load that is encountered. The lack of a structured transition from knowledge consumption to knowledge production highlighted earlier was addressed by Holbrook's et al. in the form of better guidance from advisors. They recommend advisors should impart strategies on how to engage with the literature effectively. This includes pointing out, explicitly, discipline-specific nuances encountered in the literature. The need to effectively engage with the literature is further supported by Bruce (1994). But in her arguments, this need is presented as candidates' lack of appreciation for the role of the literature review in the thesis. Holbrook's et al. analysis of the feedbacks relating to the literature review, as provided by examiners of Australian PhD theses, suggests the ability to demonstrate a coherent and substantive use of the literature is highly valued. However, what constituted quality in the use of the literature was arbitrary and was reflective of the examiners subjectivity as well as personal preferences. As such, there is no ideal demonstration of scholarship in this regard. Parry's (2007, p. 3) study on disciplines and doctorates in Australian academia describes the PhD as an award that 'connotes mastery of a discipline area, confidence and agility in the making and reporting of new knowledge in a particular field, and know-how in the construction of a sustained argument'. She further describes the award as one conveying an 'acquisition of disciplinary savvy, as well as a confidence in using the knowledge and reporting tools of a discipline'. Nevertheless, such qualities are 'often difficult to define and articulate' although they are 'instantly recognisable by examiners of considerable standing in their fields' (p. 3). In general, the demands and challenges of learning in the Australian PhD candidature briefly highlighted here is implicit of the need to think at a higher order, and for this to be operationalised strategically. It is suggested through ideas such as Jonassen's mindtools (Jonassen, 2006) that computing technology may have a role to play in ameliorating the situation. Unfortunately, the roles and consequences of computing technology in the context of this study are still little understood.

## Computerised Concept Mapping

The study was focused on the use of a computerised concept mapping tool in the context of reflecting on the conceptual structure of the candidate's research. The choice of a computerised concept mapping tool was inspired by Novak and Gowin's (1984) technique of concept mapping, which in turn was inspired by Ausubel's (2000) theory of meaningful learning. Meaningful learning is said to occur when the 'interaction between potentially new meanings and relevant ideas in the learner's cognitive structure gives rise to actual or psychological meanings' (Ausubel, 2000, p. 1). Novak and Gowin's basis for their concept mapping technique was premised on the argument that ideas that are novel, powerful and profound are very difficult to think about, is time consuming, and benefits from activities that mediate the process. The controlled act of 'pushing and pulling of concepts, putting them together and separating them again' (Novak and Gowin, 1984, p. 19) is an example of such an activity that is characteristic of their technique of concept mapping. According to Ausubel's theory of meaningful learning, this may result in a cognitive structure that is more coherent, and that subsequently, facilitates the emergence of precise and unambiguous meanings.

In terms of computing technology, a computerised concept mapping tool such as the one used in this study was suggested to facilitate the mechanical operationalisation of the concept mapping process. The Institute for Human and Machine Cognition's *CmapTools*, the tool used in this study, was designed based on Novak and Gowin's technique of concept mapping. However, the study was not interested in the technique but the possibilities that might be made apparent by a tool which design is based on. Figure 1 below shows what CmapTools looks like. The map shown in the figure below was magnified 150% so that concepts and connecting relationships can be seen.

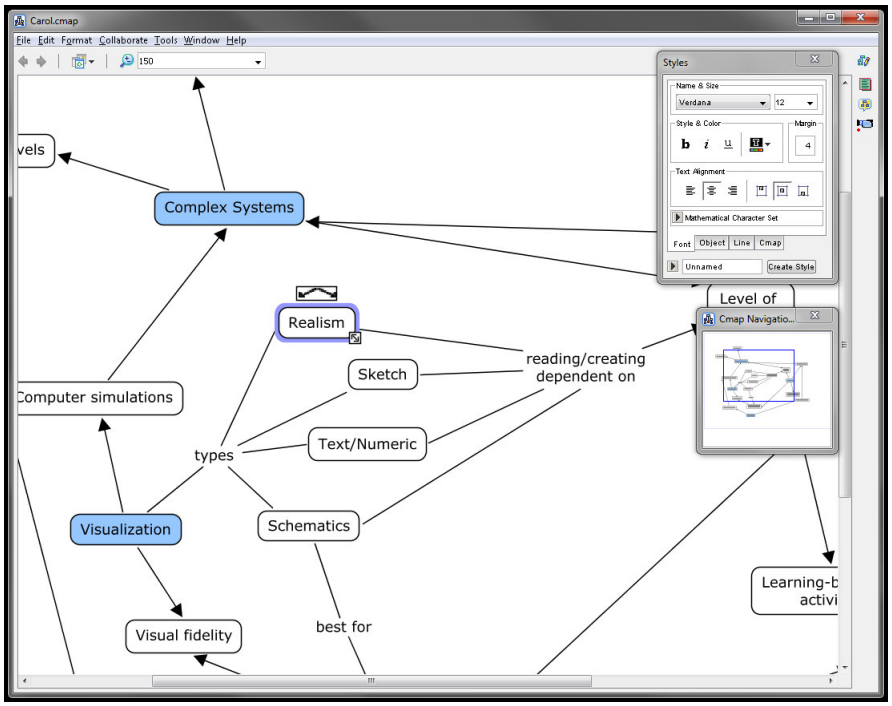


Figure 1: User Interface of CmapTools

In CmapTools, the user double clicks to instantaneously create a concept. Examples of concepts in the map above are 'Complex Systems' and 'Realism'. There is a purple highlight around 'Realism' because it is currently selected. To create a link between two concepts, for example, 'Complex Systems' and 'Computer Simulations', the user clicks on a control box such as the one above 'Realism' to 'pull out' a line that may then be used to connect two concepts together. By default, this action always creates a connection that requires the connecting relationship to be specified. In the above figure, an example of connecting relationship would be 'reading/creating dependent on'. This connecting relationship always defaults to four question marks '????' initially. To create a connection that does not require a connecting relationship to be specified, the user would perform the same action, but with the 'shift' key held down.

## Methodology

The study had a total of nine participants – all PhD candidates from the University of Melbourne, Australia. They were all in their first or second year of their candidature. Of the nine, seven were conducting research characterised by *soft* knowledge, two characterised by *hard* knowledge. Of the nine again, eight were situated in an *applied* science discipline and one situated in a *pure* science discipline. *Hard*, *soft*, *pure*, *applied* are terms all based on Becher's (1989; 2001) treatise on knowledge and disciplinary groupings. *Hard* knowledge is described as having clearly defined boundaries, tends to be concerned with problems that are relatively narrow and circumscribed, focuses on quantitative issues, and tends to have well-developed theoretical structure embracing causal propositions, generalisable findings and universal laws (Becher and Trowler, 2001, p. 184). On the other hand, *soft* knowledge is described as having ill-defined boundaries, problems that are broad in scope and loosely defined, relatively

unspecific theoretical structure, concerned with the qualitative and particular, and characterised by iterative patterns of enquiry. The differences between the pure and applied sciences are described in terms of applied sciences being concerned with utility and the pragmatic, whereas the pure sciences are concerned with discoveries, explanations, understanding and interpretation (Becher and Trowler, 2001, p. 36).

Potential participants were invited to take part in the study through an invitational email that was sent to them, on our behalf, through their department's research administrators. They were informed their participation was voluntary and they were allowed to leave the study at any time. During recruitment, potential participants who were too early (less than three months) or too advanced (third year) in their candidature were turned down.

The study described here was a longitudinal study spanning approximately one year. It involved four sessions scheduled approximately three months apart. The commitments of the participants meant that we had to negotiate each of the session's date and time based on mutual convenience. As such, there were sometimes pronounced variations in the interval between sessions.

All sessions of the study took place at the IDEA Lab located in the ICT Building of the University of Melbourne. The first session was scheduled to last one and a half hour and subsequent sessions were scheduled to last one hour. In the first session, the participant was briefed on the aims of the study and the activities that were lined up. It was also highlighted to the participant that he/she was not being assessed on their knowledge or understanding of their research. Following the brief, the participant was asked to reflect on the conceptual structure of his/her research using *thinking aloud* as an approach, followed by type *writing* on a computer using Microsoft Word. *Thinking aloud* was limited to five minute and *writing* fifteen minutes. The participant was allowed a short break in between the two activities. Prior to commencing concept mapping on a computer using CmapTools, the participant was given a short, but adequate, introduction to the functionalities of CmapTools. He/she was also informed by the researcher to focus on reflecting using CmapTools and if there were any technical questions, to direct them to the researcher immediately. The participant was not asked to use any specific concept mapping techniques. While he/she was asked to 'concept map', the term was understood in a general context and not as a reference to Novak and Gowin's technique. Excluding the introduction, this activity was limited to fifteen minutes. Following the concept mapping activity, a semi-structured interview was conducted. The computer used in the study was configured for usability studies and set up to automatically record audio and screen activity. As such, all activities, including the interview, were audio and screen recorded. The second, third and fourth sessions were all conducted in the same manner as the first. However, the participant was only required to reflect using concept mapping as the approach.

All interviews were transcribed and later analysed using Charmaz's (2006) grounded analysis approach.

## Findings and Analysis

The study reported here was ongoing at this time of writing. It was presently in the data collection phase of its third session. The findings reported here, including the names given to the emerging themes, were preliminary and reflected analysis of the data collected in the first session.

### CmapTools Supported Mapping and Thinking Styles

This theme relates to the consequences and artefacts of reflecting using CmapTools, relative to the other two approaches. The *thinking aloud* and *writing* approaches appear to promote a linear thinking style. Linearity involves a progressive style of thinking where the thinker progresses from one idea coherently to the next as opposed to attending to multiple ideas simultaneously. This is illustrated through Carol's commentary:

> *… for written or oral, I feel like I have to, I can't just introduce four. I need to start off with one and then somehow it has to link to the next one. And then I introduce the next one, and then I would make link … It's kind of like you're forced into being very sequential almost. (Carol)*

Figure 2 below illustrates Carol simultaneously 'introducing' four primary concepts (which she highlighted blue) first before 'introducing' their subordinate concepts.

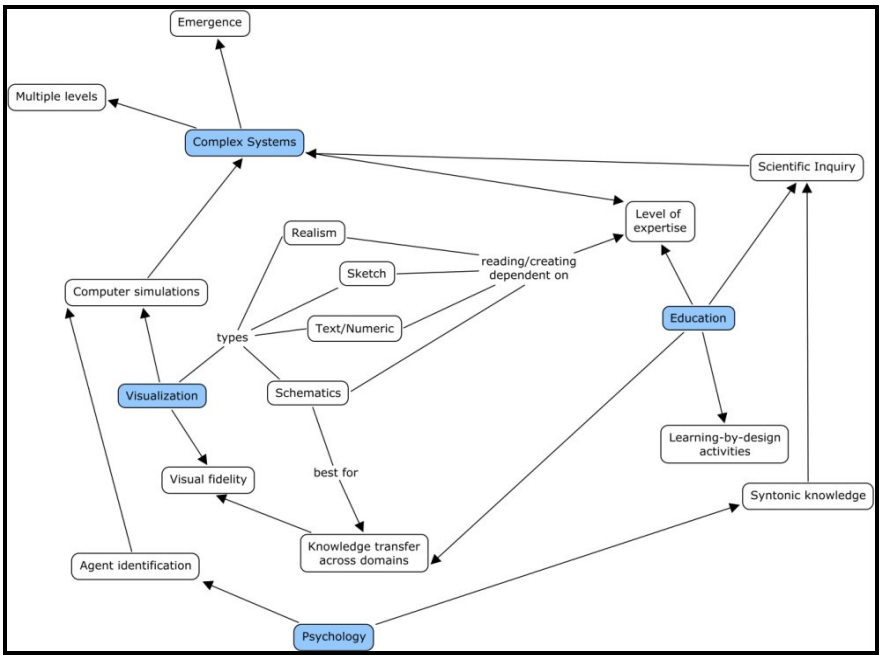


Figure 2: Carol's Map

She indicated she did not feel compelled to be sequential and it was suggested that allowed her to attend to a particular level of her ideas and their relationship. At the same time, a sub-category of linearity was also uncovered. We presently call this *sequentiality*. This also involves a progressive style of thinking where the thinker progresses from one idea coherently to the next. However, the emphasis on coherence here is delimited to the current idea and the next. Therefore, while the thinking style is linear in its progression, the entire sequence of expressed ideas may not flow coherently. Will's commentary suggest the ability to support cumulative thinking is impacted as a result.

> *So [oral] had a part in starting to really clarify what I was doing, or what I was thinking about, except that, don't think it would be a very permanent thing and also it would be difficult to continue thought deeply into a particular avenue because would constantly be losing those previous connections, or that train of thought. (Will)*

Given the context of reflection, the current findings suggest mapping has the potential to remove 'restrictions' that might otherwise impede a participant's ability to reflect effectively. For instance, Carol below said she was able to direct her attention more specifically to a connecting relationship between two ideas from different hierarchical branches:

> *I knew that these two existed ['Schematics' and 'Knowledge transfer across domains'] but I didn't think about how. Because this is also tied to other concepts, so in that sense, it sort of says: oh OK. … Like this isn't just an isolated relationship. It actually does play into other areas. (Carol)*

Even for Carrie who took a hierarchical approach in the representation of her conceptual structure, was made attentive to the interrelationships of her ideas.

> *Because that's [connecting relationships] even at a more finer level to rather than just soliciting concepts but also thinking of the relationships, so maybe if I'm being given more time I will be able to figure out more in terms of the relationships or whether there are similarities in for example how this is related to this one, how this is related to that one and things like that.* (Carrie)

None of the participants were aware of Novak and Gowin's technique of concept mapping. It was also very likely they considered concept mapping and mind mapping to be synonymous. As such, the design of CmapTools appeared to influence how participants would otherwise attend to their reflection – in terms of their thinking style.

**Gestalt Appreciation**

This theme relates to the ability to maintain perspective of the ideas that were represented and/or were emerging. This was reflected in the commentaries by Lorraine and Mary below.

> *I mean it makes it a lot easier to order, like all these stuff should be in my head but sometimes it's challenging to lay this out in a way that I can get a handle of the whole thing. So, I'm limited to only thinking about one other thing at a time, my poor little head cannot handle much more. But when I've got this then I can look at all the things that I was thinking about and draw links between them. (Lorraine)*

> *[Mapping with CmapTools is] really helpful because it allows you to create links of where, you know, one piece of literature or one concept links to another and so forth. So it allows you to I guess help, it helps clarify in your mind how the different things that you have read link to one another in your research. (Mary)*

This ability was significant because the findings indicated participants had a tendency to appreciate their ideas discretely or summarily.

> *Because a lot of the reading that I do, it's easy to just slot it into a bucket, but it's harder to kind of bring all of this buckets together. So [mapping with CmapTools] helps … (Carol)*

> *[Mapping with CmapTools] would focus a lot more in the relationship, rather than just sort of a summary of, you know, I read this, this, this, this, this, this, this, this, this, you know, as opposed to sort of looking at, like, the concepts and how they relate, so I guess that's probably the strength of this tool. (Ben)*

Carol and Will's commentaries suggest a gestalt appreciation of their ideas prior to writing may help ease the transition from thinking to writing. In Carol's case, the findings suggested this promoted clarity in terms of how ideas were subsequently made more meaningful.

> *[If I was to map first then write,] I think my written would be, it would have been a lot easier. Because this sort of help, kind of put the main ideas down, and so I was kind of organizing things for making links, so when I, if I switched to writing after this, I have a better idea of what it is that, or how are things are connecting it, how I can write it out. (Carol)*

Will's approach to appreciating the ideas in the relevant literature was not dissimilar to Carol's bucket analogy earlier. This was reflected in his map below (Figure 3), which was characterised by a 'buckets within buckets' approach. Approximately eight minutes into the activity, he made his first meaningful connection between two ideas from different hierarchical branches.

> *['isolation of simple variables' was] definitely something that I've been aware of in the past. The reason I am doing this 'idealised' modellings is essentially to 'isolate' those 'simple variables', but it's not necessarily something that would come to mind if I were to write about it straight away. Whereas with this [CmapTools], it just, within however long, just was clear and apparent that's what the connection is. So, I think it gave a certain kind of clarity to what the connections are. It certainly helped my mind make those connections. (Will)*

As their commentaries above suggested, the approach had a role in making explicit relationships that were not immediately apparent. This eased the transition process from thinking to writing as it allowed the participants to focus on communicating ideas instead of evaluating ideas.

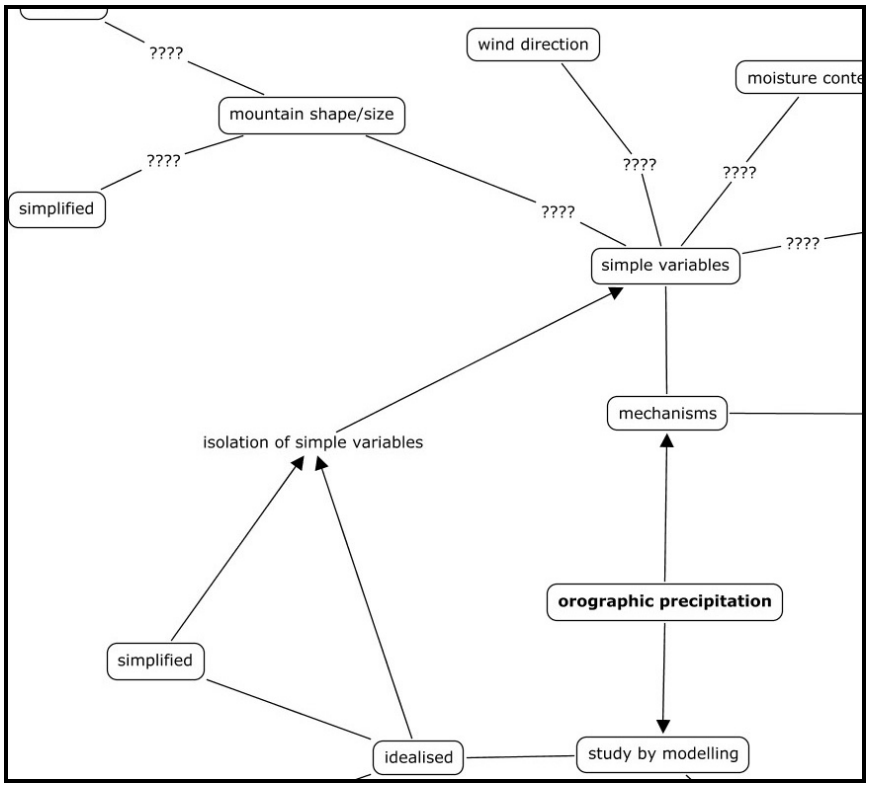


Figure 3: Cropped Section of Will's Map

This ability was further interesting in a temporal context. According to Mary, it allowed for a faster expression of her ideas and their relationships, albeit in a concise format (see Figure 4).

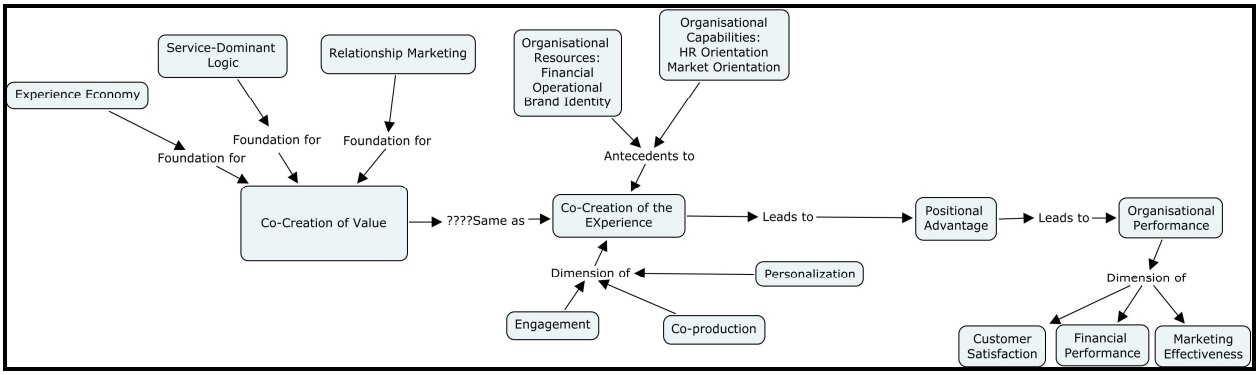


Figure 4: Mary's Map

*This, I think, is useful in that in the same amount of time as I wrote, say a very long paragraph explaining the relationships … and the same amount of time that took me to write that [written reflection], that [written reflection] doesn't give all of that detail, like. This [map] basically gives almost an outline or map of my thesis. This [written reflection] doesn't, this just gives a very small portion of it. So I think in using this tool, it allows you to, it's a lot less detailed in terms of explaining what this different things … but, what it allows you to do is create a bigger picture much quicker, to create that same picture in writing I think it will take a really long time. (Mary)*

It was also worth highlighting that the consequences of a gestalt appreciation were not limited to what was apparent. It also extended to appreciating what was not apparent.

> *I think when I see the 10% [the ideas represented in the map] I see all of the 90% [the specificity not expressed] in so far as I know it at all. There are actually significant gaps in my knowledge of those areas and so that's not there to see but there is. You know, if you like, I have a jigsaw puzzle and when I see that box, I see the whole jigsaw puzzle even though a lot of the pieces are missing. (Hermione)*

The significance of gestalt appreciation applied not only to the participants but also their advisors. As Carrie's experience suggested below, expression of her ideas in formal writing left little room for broader commentaries to her advisors. As such, advisors might not come to fully appreciate the ideas that she was attempting to communicate. This was significant in Carrie's situation because her two advisors had broad, but not specific, knowledge of the issues in her research. Therefore, it was important she conveyed her ideas across effectively.

> *They have read my chapters, but I suppose the limitation of writing is that you need to limit it to a certain scope. You cannot talk about everything possibly related to an idea. So it needs to have a certain argument that you're making … in an article you don't want to put everything possibly related in this one thing because you need to stick to your argument for example. (Carrie)*

While Carrie's experience above was interesting, she and the other participants also reported having insufficient opportunities to explore the potential of CmapTools outside of the fifteen minute mapping activity. Some of the reasons provided included being occupied with preparation for confirmation and data collection. Nevertheless, this does highlight a need for sensitivity of the temporal context of use of CmapTools in the study.

**Tangibility**

This theme describes the capacity of CmapTools in making explicit and tangible the cognitive process of organising and consequently, how this directed attention to participants' own thinking strategies and processes.

> *... when you're writing, you have to, you're kind of planning it out in your head like: so I'm going to start off with this and then the next section will be title. So it is a very … Yes, so it is a very, seems a lot more formal like you're immensely trying to organise everything. (Carol)*

This had interesting consequences for the thinking and meta-thinking of participants. Carol's commentary suggested that the schematic representation of her ideas allowed her to engage deeper with the conceptual structure of her research than she would normally do. This was suggested to be a refreshing experience.

> *[There is value in seeing how ideas under different hierarchies are cross-interacting.] I guess there is value just because we are always trying to, you know, you look at something the same way for so long, so having a different perspective helps get you thinking again. (Carol)*

Carrie's commentary suggested the process of mapping directed her attention at the metacognitive aspects of her thinking. This in turn directed awareness towards the strategies she imposed that she would normally not be aware of.

> *I suppose it make it helps me to discover connections that I might not be aware of or the way I try to categorise things that I wasn't very conscious of … It helps me to be aware that I am grouping things together or I am taking a certain approach. (Carrie)*

This was similarly expressed by Will to an extent in his commentary below, although he described this in terms of a 'thinking filter'.

> *… I think that's one of the really defining attributes of talking. That filter is definitely lessened, especially compared to writing and especially compared to using this concept map where there is an absolutely strict filter because you are forced to restrict everything so much. (Will)*

We consider the findings in this theme to be the most interesting so far as they resonated with the theory of sensemaking. The sensemaking literature (Leedom, 2001; Ring and Rands, 1989; Weick, 1995) describes sensemaking as a higher level of awareness and interpretation, suggesting a role towards deepening or clarifying knowledge or situations. While the idea of sensemaking is commonly thought to be associated with similar concepts such as comprehension and interpretation, the consensus in the sensemaking literature is that it *is* a discrete concept (Klein, Moon, and Hoffman, 2006; Weick, 1995).

Weick's (1995) theory of sensemaking argues it is a concept distinct from interpretation, further describing interpretation as a component of sensemaking. He argues interpretation is mostly focus on some form of text, with attention to cues, and their interpretation, externalisation and connection. Sensemaking, on the other hand, is focused on how text is constructed and how it is read. It addresses how 'the cues got there in the first place and how these particular cues were singled out from an ongoing flow of experience' (p. 8). He further suggests sensemaking alters and make 'more explicit and sensible' the cues that are attended to as a result of 'concrete activities' (p. 8). He explains that the 'process of sensemaking is intended to include the construction and bracketing of the textlike cues that are interpreted, as well as the revision of those interpretations based on action and its consequences' (p. 8). As such, he describes sensemaking to be a pluralistic process involving authoring, interpretation, creation and also discovery.

The attributes of Weick's sensemaking are so far congruent with the findings in the tangibility theme. This is very interesting and may have broader consequences for candidates as self-regulated learners (Zimmerman, 2002). Self-regulated learning is broadly defined as 'an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behaviour, guided and constrained by their goals and the contextual features in the environment' (Pintrich, 2000, p. 453). With the 'cues' now made 'more explicit and sensible', it can be expected that this will have consequences for participants' short and long term learning performance, given their meta-thinking may potentially be given more attention and made more accessible than usual.

## Conclusion

This paper presented a longitudinal study that was exploratory in nature. It was part of an HCI research project aimed at understanding the roles and consequences of computing technology in a non-formal learning context. While it was concerned with computing technology and learning, its focus remained on the learner's agency as a result of its HCI orientation. This further meant that in studying computing technology in this context, it also examined the conditions that shaped how computing technology might be appropriated.

Of the three emerging themes that were presented, we considered the last theme to be the most interesting. We think there are opportunities for the ideas in the theories of sensemaking and self-regulated learning to be synthesised better. This may in turn allow for better and more informed approaches to studying computing technology in non-formal learning contexts. While the findings in the first two themes were not unexpected, we were able to strengthen our understandings because of the empirical insights that were provided.

## References

Ausubel, D. P. (2000). *The Acquisition and Retention of Knowledge: A Cognitive View*. Dordrecht: Kluwer Academic Publishers.

Becher, T. (1989). *Academic Tribes and Territories: Intellectual Enquiry and the Cultures of Disciplines*. Milton Keynes: Open University Press.

Becher, T., and Trowler, P. R. (2001). *Academic Tribes and Territories: Intellectual Enquiry and the Cultures of Disciplines* (2nd ed.). Buckingham: The Society for Research into Higher Education & Open University Press.

Bruce, C. S. (1994). Research Students' Early Experiences of the Dissertation Literature Review. *Studies in Higher Education, 19*(2), 217-229.

Charmaz, K. (2006). *Constructing Grounded Theory: A Practical Guide Through Qualitative Analysis*. London: SAGE Publications.

Delors, J., Mufti, I. A., Amagi, I., Carneiro, R., Chung, F., Geremek, B., et al. (1996). Learning: The Treasure Within - Report to UNESCO of the International Commission on Education for the Twenty-First Century. Paris: UNESCO.

Evans, B. (2007). Doctoral Education in Australia. In S. Powell and H. Green (Eds.), *The Doctorate Worldwide* (pp. 105-119). Maidenhead, Berks: McGraw-Hill, Society for Research into Higher Education & Open University Press.

Genoni, P., and Partridge, J. (2000). Personal Research Information Management: Information Literacy and the Research Student. In C. Bruce and P. Candy (Eds.), *Information Literacy Around the World: Advances in Programs and Research* (pp. 223-235). Wagga Wagga, N.S.W.: Centre for Information Studies, Charles Sturt University.

Green, R., and Macauley, P. (2007). Doctoral Students' Engagement with Information: An American-Australian Perspective. *portal: Libraries & the Academy, 7*(3), 317-332.

Holbrook, A., Bourke, S., Fairbairn, H., and Lovat, T. (2007). Examiner Comment on the Literature Review in Ph.D. Theses. *Studies in Higher Education, 32*(3), 337-356.

Jonassen, D. H. (2006). *Modeling With Technology: Mindtools for Conceptual Change* (3rd ed.). Upper Saddle River, New Jersey: Merrill.

Klein, G., Moon, B., and Hoffman, R. R. (2006). Making Sense of Sensemaking 1: Alternative Perspectives. *IEEE Intelligent Systems, 21*(4), 70-73.

Leedom, D. K. (2001). Final Report: Sensemaking Symposium. Vienna, VA: Evidence Based Research. Inc.

Novak, J. D., and Gowin, D. B. (1984). *Learning How To Learn*. Cambridge: Cambridge University Press.

Parry, S. (2007). *Disciplines and Doctorates*. Dordrecht: Springer.

Pintrich, P. R. (2000). The Role of Goal Orientation in Self-Regulated Learning. In M. Boekaerts, P. R. Pintrich and M. Zeidner (Eds.), *Handbook of Self-Regulation* (pp. 451-502). San Diego: Academic Press.

Prates, R. O., and Figueiredo, R. M. V. d. (2005). An Experience with an Enriched Task Model for Educational Software *CHI '05 Extended Abstracts on Human Factors in Computing Systems*. New York: ACM.

Ring, P. S., and Rands, G. P. (1989). Sensemaking, Understanding, and Committing: Emergent Intepersonal Transaction Processes in the Evolution of 3M's Microgravity Research Program. In A. H. V. d. Ven, H. L. Angle and M. S. Poole (Eds.), *Research on the Management of Innovation: The Minnesota Studies* (pp. 337-366). New York: Ballinger.

Squires, D. (1999). Usability and Educational Software Design: Special Issue of Interacting with Computers. *Interacting with Computers, 11*(5), 463-466.

Weick, K. E. (1995). *Sensemaking in Organisations*. Thousand Oaks: Sage Publications.

Zimmerman, B. J. (2002). Becoming a Self-Regulated Learner: An Overview. *Theory Into Practice, 41*(2), 64-70.