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Beyond concept analysis: Uses of mind mapping software for visual representation, management, and analysis of diverse digital data

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Use of mind mapping software to support research and qualitative data analysis

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Abstract

Mind mapping is a visual-spatial method of representing information using nodes (information segments) to show ideas and connecting lines to define relationships between content. As a critical thinking tool, it is applicable to a range of research activities, including information management, project development, and data analysis. The purposes of this manuscript are to describe the use of mapping for qualitative data analysis, provide step-by-step instructions of how to construct mind maps, and present examples specific to qualitative data analysis. An example from a recent study of patient and provider perceptions of virtual visits demonstrates the use of *Xmind* in conjunction with *Atlas.ti* for qualitative content analysis of open-ended survey data. While coding in *Atlas.ti*, we used *Xmind* to develop dynamic memos, code networks, and themes. The memo map served to identify common coding patterns and informed subsequent coding stages. After coding in *Atlas.ti*, the entire code list was imported into a new map in *Xmind* and iteratively organized to identify conceptual groupings, similarities/differences, and key ideas. Themes were identified through pattern coding and refining code networks within the *Xmind* map. Map iterations formed part of the analytic trail and facilitated peer-to-peer discussions. The final map served as the model for publication. The use of mind mapping enhances the rigor, credibility, and transparency of analyses and facilitates peer-to-peer communication. This technique can be used to manage diverse content (documents, audio/video file, image, web links, and personal notes) and thus has great potential to contribute to a variety of data management tasks.

Key words: Qualitative, Mind mapping, Data analysis, Critical thinking

Background

In recent years, analytic mapping approaches have gained popularity as a strategy to promote creativity and critical thinking (Buzan, 1974; Kunsch, Schnarr, & van Tyle, 2014; Novak, 1990). While there are several variations of the process, such as mind mapping, argument mapping, and concept mapping, all broadly refer to the analysis and organization of words and ideas in a diagrammatic manner that emphasizes visual and spatial layout of information within logical groupings (Davies, 2011; Pudelko, Young, Lamarre, & Charlin, 2012). There is a growing body of research that demonstrates mapping stimulates thinking, promotes knowledge construction, and improves learning. For this reason, mind mapping is being increasingly adopted in diverse educational settings (e.g., nursing, medical, legal, advanced mathematics, grade school) (Edwards & Cooper, 2010; Hsu, Chang, & Hsieh, 2008; Kirschner, 2003; Moon, 2011). Although mind mapping is popular in education, what is often overlooked is that mapping may hold equal benefit for research, particularly with the advent of free computer software (Burgess-Allen & Owen-Smith, 2010; Tattersall, Watts, & Vernon, 2007; Wheeldon & Faubert, 2009).

Mind mapping programs support the creation of colorful and robust digital mind maps that can be used to facilitate many research tasks (Berglund, 2015). In addition to diagramming words and ideas, current mind maps can contain practically *any* form of digital content, including entire documents, pictures, audio/video files, and hyperlinks (Cañas & Novak, 2014). Furthermore, these digital maps are highly flexible, and can be iteratively and collaboratively revised to fine-tune a developing structure. This capacity has several research applications, including a more integrated approach to information management (based on ability to organize documents together with ideas and related information), team-based project development, and data analysis. For instance, a literature review map might offer a succinct diagrammatic breakdown of what is currently known versus unknown, with links to manuscripts for key studies and personal notes on articles. If carefully constructed, visual examination of the map can help the researcher to identify topic areas that are well developed, versus those lacking detail and needing further exploration. A subsequent map of a research project might include a section on methods with details of possible methodological approaches, data collection instruments, planned statistical analyses, and links to key documents and forms.

When applied to qualitative data analysis (QDA), mind mapping offers an excellent means to memo, keep track of developing ideas, and visually examine relationships between codes and data sources. These capabilities can be important, as QDA relies heavily on the ability of the analyst to identify new, similar, or divergent ideas. Mapping not only allows the researcher to play with different coding arrangements to identify best fit, but also to examine the validity of conceptual groupings and make adjustments easily. Because a map produces an image that can be easily shared, it is possible to compare, discuss, and critique potential analytic groupings with others, look for divergent data, and clearly track decision making via serial maps images. Strategies such as search for discrepant evidence, member checking, and peer debriefing can help to reduce the risk of unreflective biases, promote rigor, and enhance the credibility of subsequent findings (Lincoln & Guba, 1985; Maxwell, 2012)

The unique features of mind mapping programs have the potential to transform mapping from an occasional activity into a mainstream research tool (Burgess-Allen & Owen-Smith, 2010; Lin, 2011; Tattersall et al., 2007). While all of the tasks listed above can be accomplished without mapping, this approach offers a way to engage with content in a highly organized, visually transparent, creative, and personally meaningful manner, and may benefit both novice and expert researchers. Currently however, there is little instruction on how to use this technique in a research context (Cañas & Novak, 2014; Novak & Cañas, 2008) The purposes of this manuscript are to describe the use of mapping for qualitative data analysis, provide instruction on how to construct research maps with common, free mind mapping software, present examples specific to qualitative data analysis, and describe various applications to research.

How to Develop a Digital Map

The goal of mapping is to create an intuitive, logical, and parsimonious structure that represents pertinent content, complex concepts, or single ideas and the relationships between them in an easily understandable manner. Maps do not begin as orderly structures and may be disorganized at first. Achieving a useful and meaningful product often requires prolonged engagement, consistent effort, and extended concentration. However, the potential benefits are extensive and worth exploring.

While the diverse analytic processes behind mapping may be complex conceptually, the physical process is comparatively simple. The physical process resembles the hermeneutic spiral, in that it iteratively cycles between part (individual content/ideas) and whole (the greater structure of meaning) to create understanding (Motahari, 2008). However, unlike the hermeneutic spiral, which is typically used to analyze narrative text, the mapping process may be inductive or deductive, and may incorporate diverse electronic content with varying degrees of relationships to one another, with or without traditional narrative form. Thus, epistemologically, the approach is more often understood as being constructivist in nature, because content is added frequently and arranged in different ways to create meaningful structures (Novak & Cañas, 2008; Pudelko et al., 2012).

USES OF MIND MAPPING FOR QDA

Whether inductive or deductive, the actual steps of creating a map are fairly consistent. The steps are: (1) ADD content, (2) ANALYZE structure and content, and (3) REVISE structure and content. While listed sequentially, these often co-occur and are iterative in nature (spiraling). The application of these steps may vary depending on the type of content being mapped (e.g. ideas, codes, documents), and preexisting constraints (e.g., specific analytic methods or a predefined structure). Figure 1 depicts the three steps of mapping along with common activities specific to each.

ADD. New information is added to the map by the researcher in the form of individual *nodes*. Nodes are single cells that contain discrete segments of information, and which can be revised or repositioned as needed. Initially nodes may be added to the map with minimal regard for order or organization. The content of individual nodes might include research data, codes, images, tables, graphs, charts, documents, audio files, video links, and hyperlinks. Often, it is important to enter ideas quickly so that they are not forgotten, postponing organizing until later. New information can be typed into nodes directly or copied from other documents and pasted into the map. It is also possible to include links to external sources and documents, embedded attachments, notes, or images. In some cases, dictation may be useful, with use of the keyboard carriage return to create new nodes. Where possible, concise wording should be used, as full or compound sentences are more difficult to separate and rearrange. Furthermore, shorter phrases are easier to analyze visually than longer sentences. Thus, it is preferable if each node represents a single discrete idea.

ANALYZE. Next, the researcher should look at the content of the map and consider a few questions: Is the information contained in each individual node clear, concise, and accurate? Does the wording make sense? Are nodes easy to understand? Is the content of the map

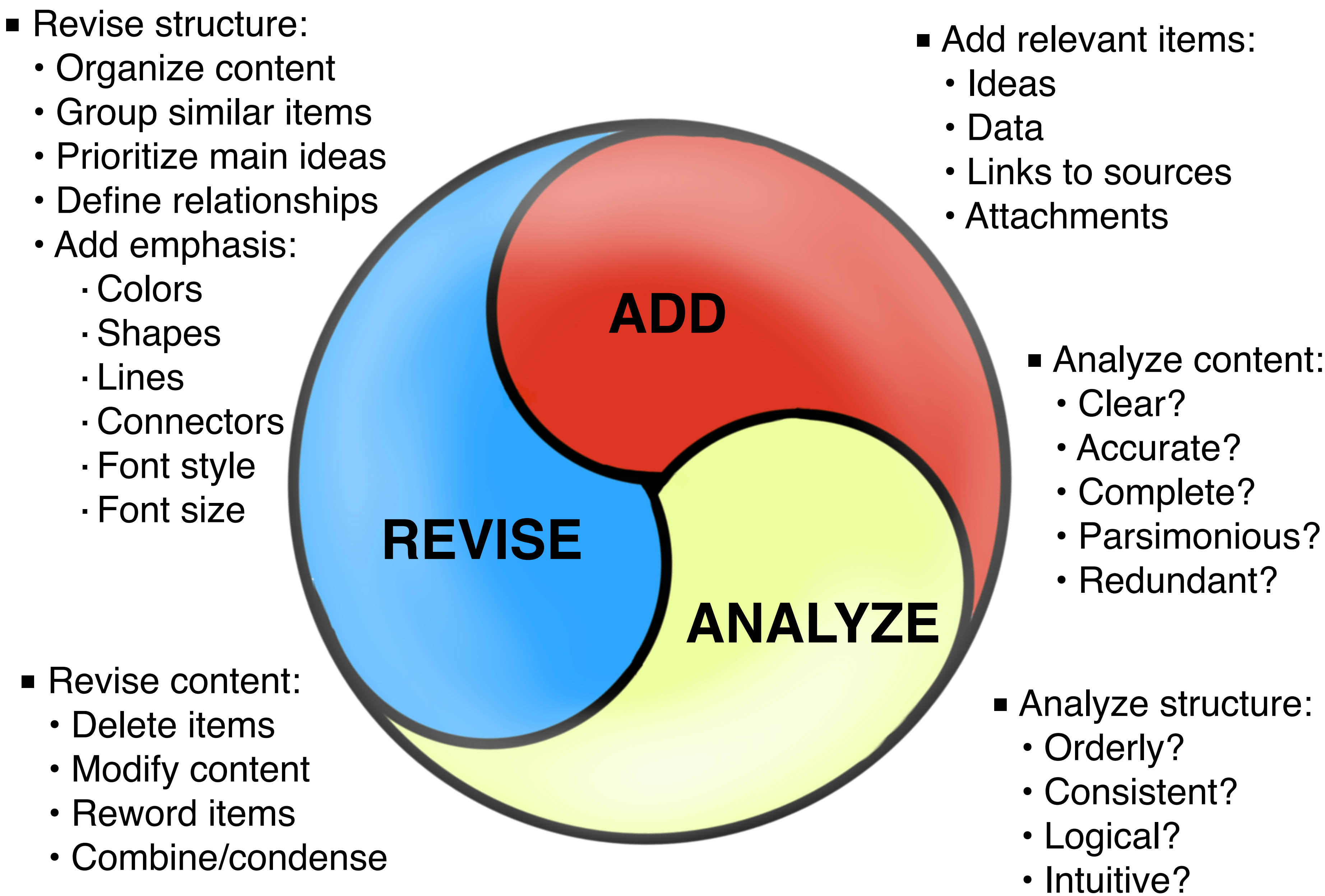

Figure 1. How to create digital information maps

complete, incomplete, or redundant? Structure should also be evaluated along with content. In most situations the structure will likely be quite messy at first. Begin by assessing whether the layout is orderly and if current groupings are logical, cohesive, and intuitive. Often, there are multiple ways to arrange or display the content of nodes and clusters of nodes, some of which may be more informative than others. The careful analysis of structure and content is an essential precursor to meaningful revision.

REVISE. In the case of qualitative data analysis, revisions to the map should be made based on analysis and interpretation of coded data, and to refine emerging ideas. If complex or compound ideas were added (e.g.. several ideas in one node), it may be necessary to deconstruct these into smaller nodes, each containing one idea. Related items should be grouped together, and redundant content refined, merged, or eliminated. Recurrent and key ideas can be relocated higher up the conceptual structure, and subtopics and supporting content can be moved to appropriate dependent locations. Relocating nodes is simple and is accomplished by either cutting and pasting or dragging and dropping nodes into new positions. As the structure develops, relationships can be further clarified by adding connecting lines and arrows, and labeling relationships as applicable. The use of varying colors, shapes, font sizes, and font styles can substantially enhance the meaning of the structure and make it visually easier to understand. If an idea is important, this can be indicated by enlarging text size, adding borders, or using a bright color to make the node stand out. A benefit of mapping is the ability to play with content and try out new conceptual groupings. If mistakes are made, they can be quickly corrected by use of the “undo” button. However, it is prudent to create duplicate versions of maps at periodic intervals, so that a map can be restored to an earlier version if needed.

Over time, the ongoing process of adding, analyzing, and revising should lead to a progressively more logical, complete, yet parsimonious representation of pertinent content, where the resulting visual taxonomy defines *how* individual items relate to each other conceptually, categorically, hierarchically, and directionally.

Lastly, in selecting which software to use, it may be beneficial to explore several options (e.g. *Xmind, MindMaple, CMap*), as the operating characteristics and technical capabilities differ between programs. There are many free options available, and comparison of the strengths and weaknesses is available elsewhere (Mammen, 2016). In Table 1, we provide specific mapping techniques and keyboard shortcuts for *Xmind* (n.d.) and *MindMaple* (n.d.), which are the two free programs we have found most useful. These programs have similar capabilities with minor cosmetic and technical differences. For larger analyses, *MindMaple* may be preferable, as it appears to handle larger quantities of data without evidence of crashing, which happened occasionally in *Xmind* (version 2013). However, despite occasionally crashing, *Xmind* was slightly more intuitive with easier keyboard shortcuts (as opposed to mouse clicks) and drag and drop insertion of external files. Thus, for those who need to link to multiple external sources, or prefer to use keyboard shortcuts to minimize clicks, *Xmind* may be easier to use.

Example of Mapping for Qualitative Data Analysis

The following example illustrates the use of mind mapping as a qualitative data analysis tool. During a recent qualitative content analysis, we used *Xmind* as an adjunct to *Atlas.ti,* to develop themes, a coding diagram, and a publication quality model, as well to assist with memoing and maintaining an audit trail.

Methodological context. Patients with Parkinson disease and neurologists participated in a series of home-based telemedicine visits over the course of one year (Dorsey et. al., 2017).

After each visit, patients and their physicians answered open-ended survey questions regarding their perceptions of the intervention for remote management of Parkinson disease. Free text responses (five questions per visit) were uploaded into *Atlas.ti* in matrix form, with each row containing all the responses from a single post-visit survey, each column representing a single question over time, and blocks of data representing the cumulative responses of a patient/provider dyad from all four visits (Mammen et al., 2017).

Approach. We began by open coding in *Atlas.ti,* and simultaneously making notes of recurring ideas in *Xmind* as a "memo" map, which also served to document our analytic process. We first mapped ideas according to whether they were patients' or providers' and also noted which of the four visits they occurred in. This generated a highly segmented view of the data *within* visits and patient/provider groups, as depicted in Figure 2. With this approach, we found that when patients disliked their virtual visits, they indicated it was due to trouble with the internet connection, poor video quality (grainy), and unstable audio that made it hard to understand what the provider was saying and decreased the perception of having a quality encounter. Issues like these resulted in a new super code called "technological troubles," which repeated across successive visits, but generally diminished in frequency over the year of the study. The change in relative importance over time was further reflected in the memo map by the font size and colors of nodes. As ideas recurred they were assigned a larger text size and brighter coloring, to indicate that this was a more dominant issue. Contrasting ideas were also integrated into the developing structure, such as positive perceptions being attributed by patients to the absence of technological problems, which enhanced their sense of closeness to the provider.

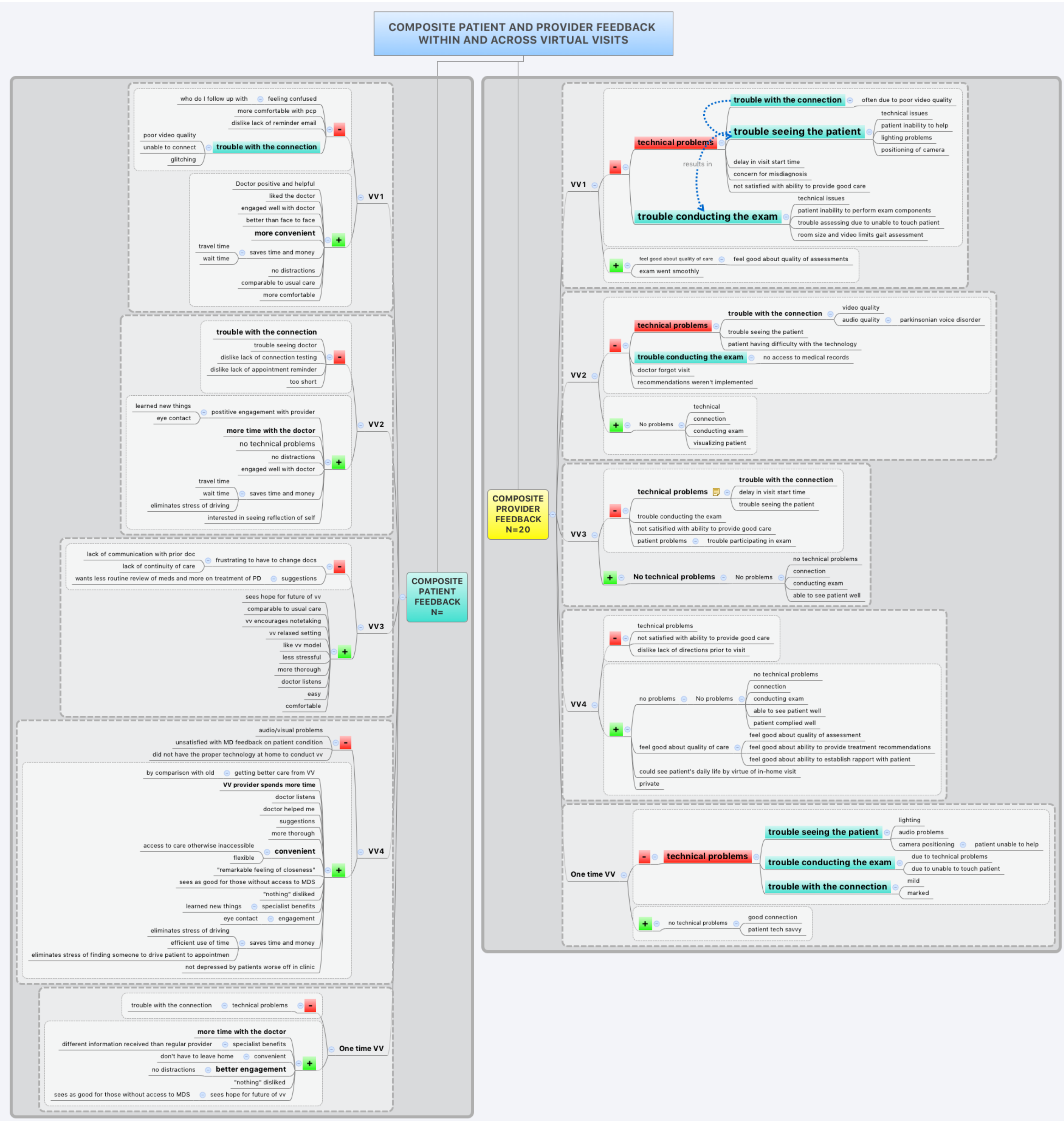

Figure 2. Preliminary map of qualitative survey data

Similar findings were seen with providers, who indicated that they disliked the virtual visits when technological problems interfered with their ability to assess the patient, communicate effectively, and make clinical decisions. Thus, for providers, the same super code of "technological troubles" also occurred across visits, diminishing over time, but not as much as it did for patients. The memo map made it visually apparent that both patients' and providers' responses were categorically similar across the separate groups as well as across the multiple visits (over time). This finding altered our coding approach, and instead of looking at data from the two groups and four visits separately, we looked at the data holistically.

Next, we went back and recoded all entries in *Atlas.ti*, this time focusing on common themes *across*, instead of *within*, patient and provider categories and visits, and included the new super codes identified via the memo map. After coding was completed, we extracted the entire code list from *Atlas.ti* (i.e. "export to code list") and imported all codes into a new map in *Xmind* using the copy and paste function. We then began pattern coding and grouping similar codes together, regularly referencing back to the data using the *Atlas.ti* code-query tool, along with the original memo map, which now formed part of the analytic trail. While doing this, we merged codes that represented the same idea, and clustered codes that represented similar concepts to develop branching networks of related codes, being careful to save images of major decisions along the way to promote transparency. For example, patient concepts of *didn't have to leave home, efficient use of time, relaxed setting, didn't miss work time, and saved money/time/travel* were clustered under the broader concepts of *convenience* and *personal benefits* (Figure 3).

After merging, collapsing and clustering codes, we reexamined the newly formed code clusters, together with source data in *Atlas.ti*, to identify bigger ideas and dominant themes that represented both patients' and providers' perceptions of visits (Figure 4). To assist with this, we

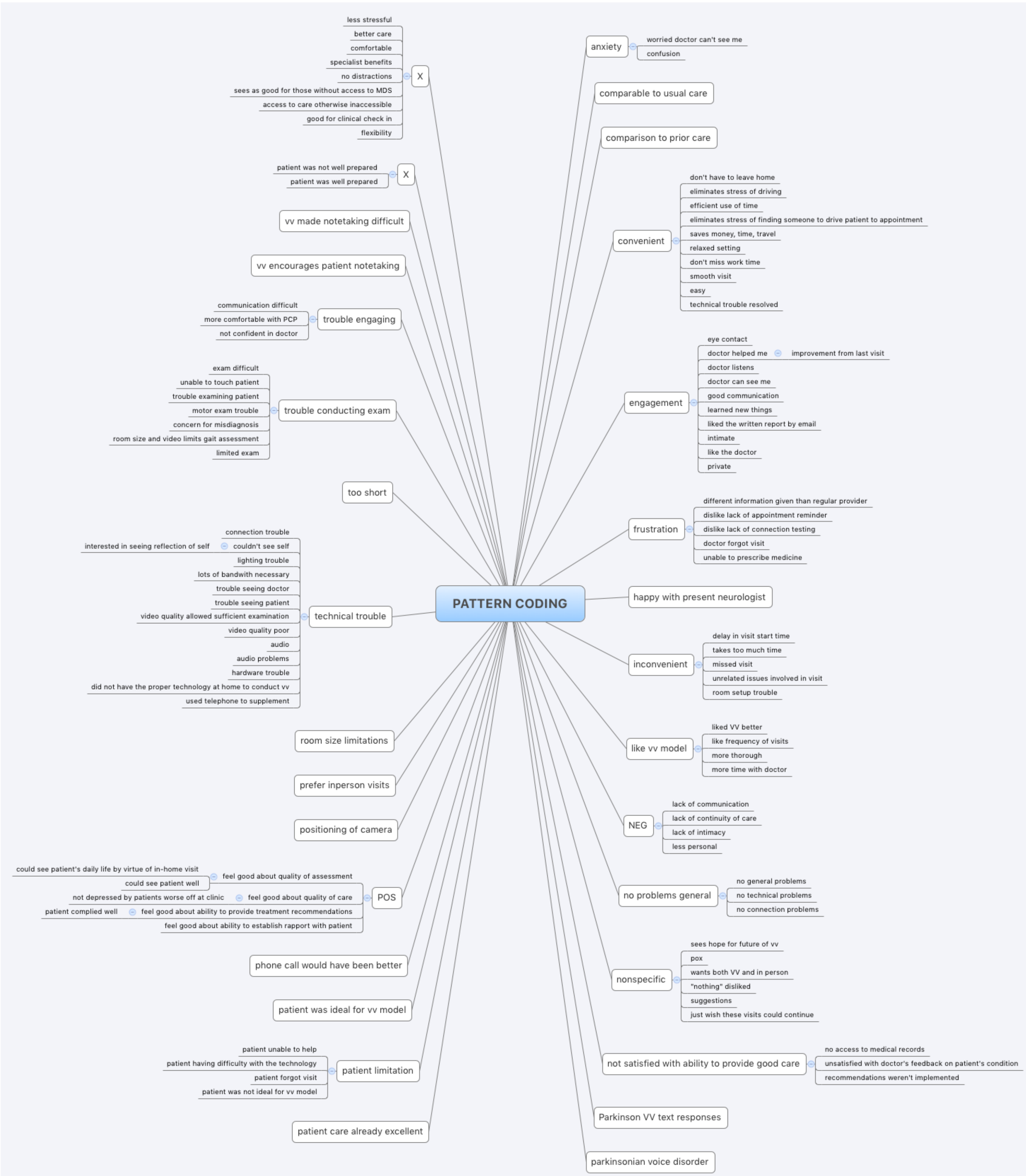

Figure 3. Pattern coding during qualitative data analysis

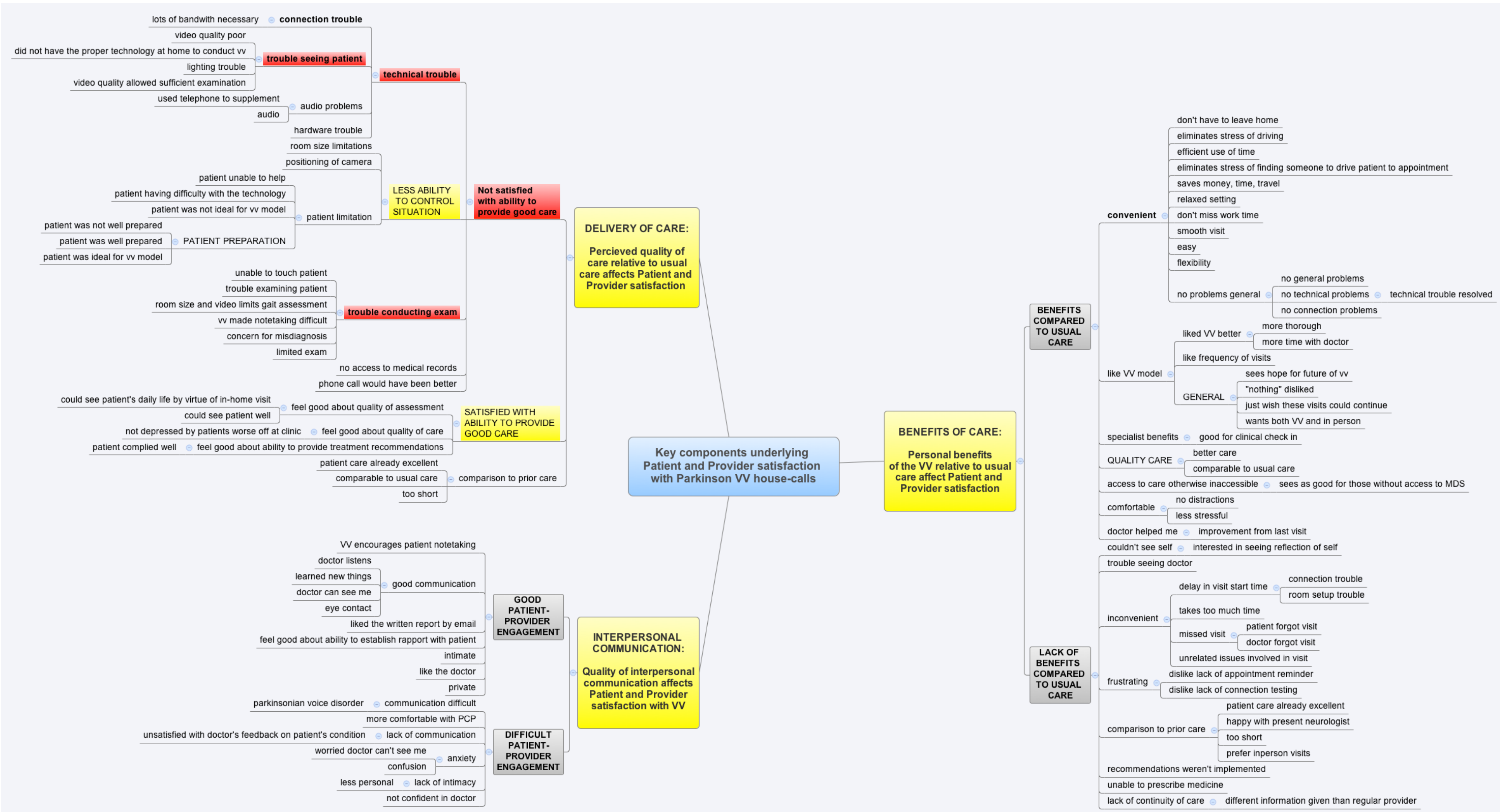

Figure 4. Super coding during qualitative data analysis

selectively collapsed sections to look at the congruence of ideas within a branch, and then expanded sections to look at the logic of the "big ideas." Code clusters were iteratively examined and rearranged to refine and clarify the main themes in the thematic diagram. As part of this process, we met regularly with our research team to visually analyze and critique the developing map structure. This involved looking at individual groupings, referencing supporting data, and discussing the correct representation of emerging themes. Through this process, we identified three key ideas that influenced both patients' and providers' perceptions of in-home virtual visits: (1) perceived quality of care, (2) perceived personal benefits of the virtual visit, and (3) perceived quality of the interpersonal communication. These themes were interrelated and influenced each other reciprocally. For instance, if the quality of the interpersonal communication was poor (i.e. patient not feeling that the provider listened well) the patient often reported lower quality of care as a reason for dissatisfaction. The final map diagram (Figure 5) showing key themes and supporting code networks was used in publication (Mammen et al., 2017). Further examples of published mind maps can be viewed in our other works (Mammen, 2016; Mammen et al., 2017; Mammen et al., 2018).

Figure 6 graphically represents the combined use of Computer-Assisted Qualitative Data Analysis Software (CAQDAS) and mind mapping techniques for qualitative analysis, beginning with initial coding of raw data and progressing through development of memos, code networks, and themes to a final conceptual model. As shown by the arrows in the figure, there is typically a bi-directional or cyclical relationship between coding and mapping, which serves to inform each subsequent stage of analysis.

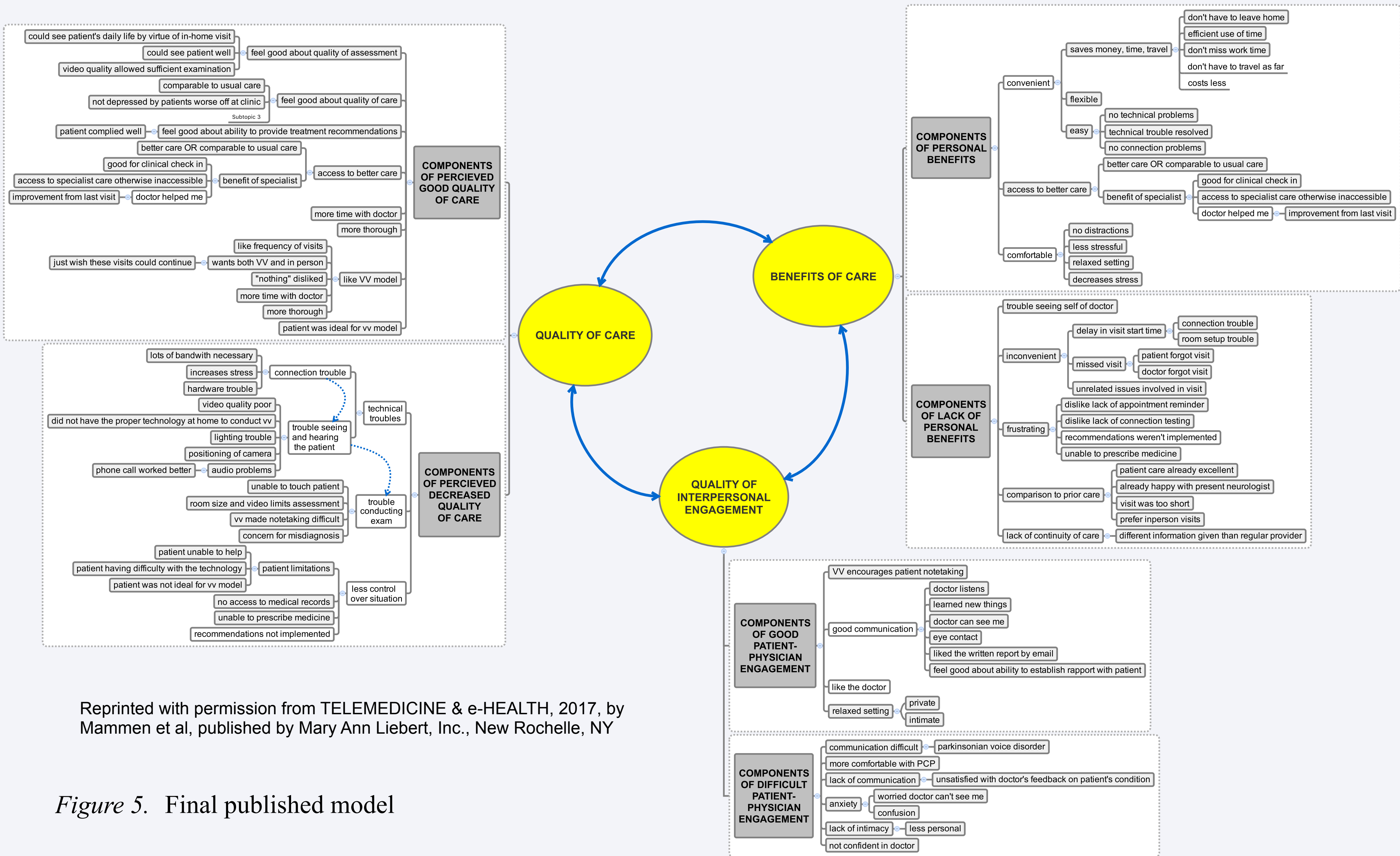

Figure 5. Final published model

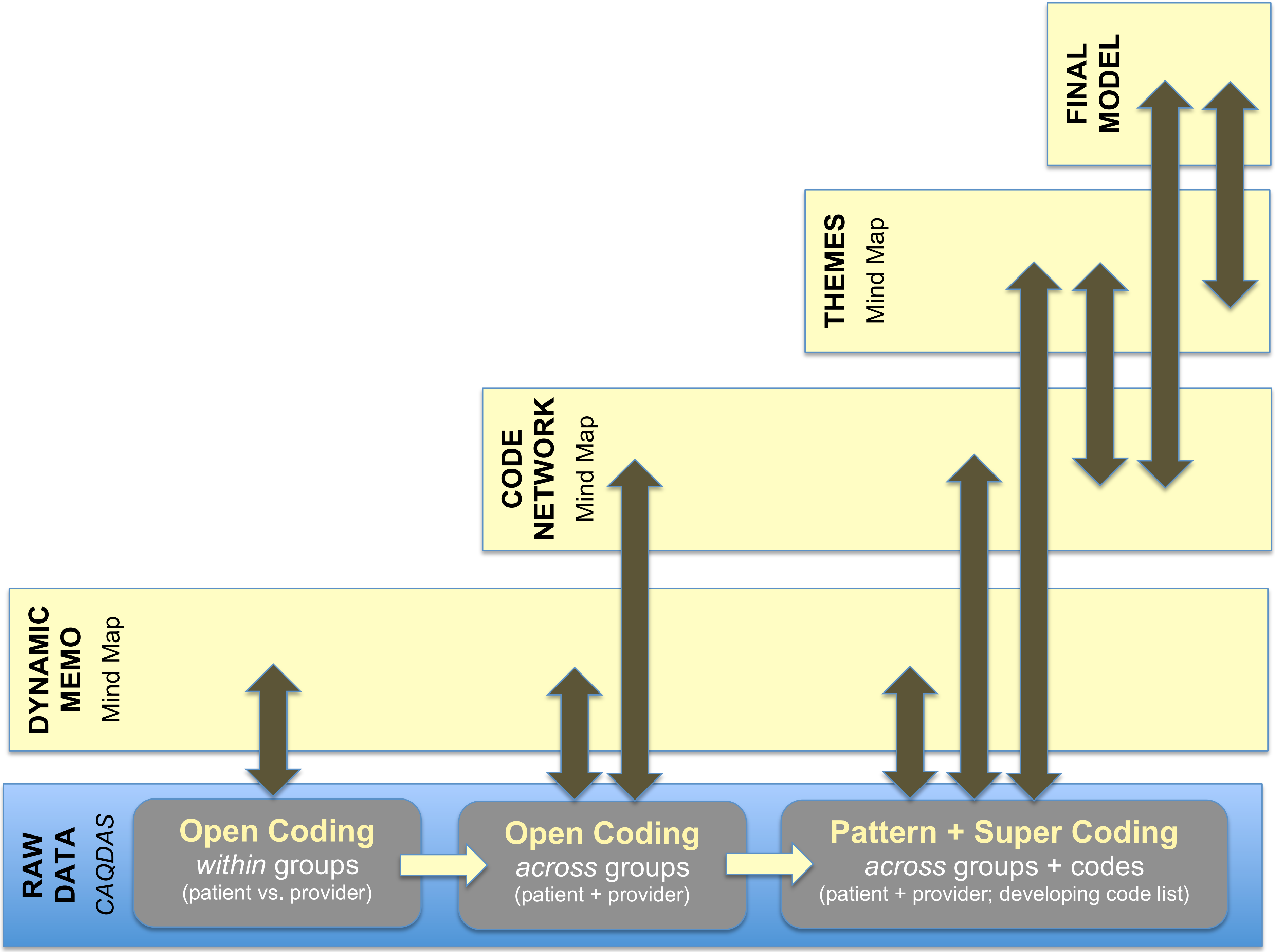

Figure 6. Process of using combined CAQDAS and Mind mapping techniques for qualitative data analysis

Discussion

Digital mind mapping is a technique that can be applied to many core research tasks. It is a useful adjunct to traditional CAQDAS for creating dynamic memos, developing themes, and building models. In particular, the ability to play with conceptual groupings, code networks, and spatial layout of ideas helps with identifying similarities and differences within and across groups of participants. This approach is conceptually similar to the traditional qualitative method of using index cards to develop ideas and themes, as has been reported in grounded theory and qualitative or interpretive description (Byrne, 2001; Corbin & Strauss, 2008; Zimmerman, 2016). As with index cards, a digital map allows the researcher to place content on the figurative "table" and shuffle it around to explore emerging concepts. The ease of rearranging concepts can be helpful in identifying if content is correctly situated, could work better in different groupings, or might be subject to alternate interpretation. Unlike index cards, however, digital maps can manage very large amounts of data, allow the researcher to repeatedly adjust appearance and wording, and easily retain documentation of successive attempts.

It should be observed here that CAQDAS is also designed to allow for the development of code families and can be used to display and manipulate code networks. As moderately sophisticated CAQDAS users, we preferred mind mapping for the manipulation of code networks and families, as it seemed more intuitive, less time consuming, and required less effort to modify and relocate nodes and generate map images. We appreciated the ability to quickly try out new conceptual groupings (by dragging and dropping) without committing to changes, as well as the flexible spatial layout, which we felt enhanced structural meaning. Researchers having extensive CAQDAS experience may derive less benefit from mind mapping as a data analysis tool, yet may still find the technique useful for other analytic tasks, such as brainstorming and record keeping.

In addition to writing memos, exploring code networks, and developing themes, we found that keeping map iterations was useful for documenting our analytic decisions over time. Storing sequential PDFs of maps and duplicating map sheets at key analytic junctures allowed us to quickly flip back and forth to examine progress over time. We also found that maps could be co-created, and were easy to print or share electronically, which facilitated in-person and remote discussion with other researchers (some of whom mapped and most who did not). This allowed us to include a broader range of people in our peer-to-peer discussions, with the map images being particularly useful to colleagues having less qualitative experience. As a final benefit, mapping resulted in a publication quality diagram of key themes, with substantial ability to fine-tune the layout and appearance of concepts to meet our specific needs. While all of these items can undoubtedly be accomplished without mapping, we found the technique useful in that it integrated tasks seamlessly—such that memo writing was blended with theming, theming blended with model development, and the entirety integrated into a visually transparent audit trail, all of which helped to demonstrate the rigor and credibility of our analyses.

In this manuscript, we focused predominantly on the use of mapping in the context of qualitative content analysis. Researchers using other qualitative methodologies, such as interpretive, descriptive, or grounded theory approaches, may find the technique similarly useful for developing themes and exploring conceptual groupings. Use of this technique in more complex qualitative analyses is needed to determine broader utility. Mapping is likely to apply to other areas of research as well (Cañas & Novak, 2014). We have found the ability to include or link to PDF, Word documents, websites, and audio/video files particularly useful for developing research projects, literature reviews, and brainstorming sessions. For example, a map of a research project might contain a data analysis section with breakdown of statistical methods, an article on effect size, a link to the website where effect size can be calculated, and subnodes with information about minimal important differences and appropriate citations. Similarly, information about the study setting might contain a description of the site, population served, list of key contacts, phone numbers, email addresses, and proposed roles in the project. Functional groupings such as these have the potential to save time and effort by maintaining pertinent information in close proximity and minimizing search time. Quantitative studies might also benefit by use of this technique for information management, study planning, or interpretation of findings, such as re-contextualizing machine learning analyses of text-based data (i.e., exploring the implications of high-frequency words within use-context).

While there are clear benefits, there are also limitations to the mind mapping technique. First, it is unlikely that mind mapping can replace CAQDAS. It is possible to use mapping with free coding software (e.g. TAMS Analyzer, Free QDA, QCAmap), but mapping in and of itself cannot be used to code data and cannot support complex queries. Second, mapping is likely to be of greater benefit to visually-oriented learners and to those who are comfortable learning new computer skills. Mapping has a gentle learning curve and is fairly intuitive, but nevertheless presumes a certain level of computer proficiency. Core skills (e.g. adding, organizing, and analyzing content) can generally be acquired in less than an hour, but advanced skills (e.g., model building or merging maps) may take substantially longer to master. Third, analysis of entire or large data sets might be challenging or impossible, as mapping relies on the ability to visualize and compare sections. Thus, importing an entire data set (as opposed to codes or data segments) may be inadvisable, even if working with collapsed sections. Researchers will likely find it more useful to begin with traditional coding and then progress to mapping codes or key ideas.

In conclusion, mind mapping is a robust tool with broad applicability to research, having capabilities that can enhance organization, data analysis, study rigor, and credibility of findings. However, usefulness will be contingent upon careful planning, scientifically rigorous research procedures, critical thinking, prolonged engagement with content, thoughtful analysis, and meticulous documentation habits (Johnstone & Otis, 2006).

References

Berglund, A. (2015). What's in a word? Concept mapping: A graphical tool to reinforce learning of epidemiological concepts. *Journal of Epidemiology and Community Health, 69*(12), 1232-1236. doi:10.1136/jech-2014-205068

Burgess-Allen, J., & Owen-Smith, V. (2010). Using mind mapping techniques for rapid qualitative data analysis in public participation processes. *Health Expectations, 13*(4), 406-415. doi:10.1111/j.1369-7625.2010.00594.x

Buzan, T. (1974). *Use your head*. London: BBC Books.

Byrne, M. (2001). Data analysis strategies for qualitative research. *AORN, 74*(6), 904-905.

Cañas, A., & Novak, J. (2014). Concept Mapping Using Cmap Tools to Enhance Meaningful Learning. In Okada A., Buckingham Shum S., & S. T. (Eds.), *Knowledge Cartography, Advanced Information, and Knowledge Processing.* Springer, London. Retrieved from https://link.springer.com/chapter/10.1007/978-1-4471-6470-8_2 - citeas.

Corbin, J., & Strauss, A. (2008). *Basics of Qualitative Research: Techniques and Prodedures for Developing Grounded Theory* (3rd ed.). Thousand Oaks, CA: Sage.

Davies, M. (2011). Concept mapping, mind mapping and argument mapping: What are the differences and do they matter? *Higher Education, 62*(3), 279-301. doi:10.1007/s10734-010-9387-6

Dorsey et. al., R. (2017). National randomized controlled trial of virtual house calls for individuals with Parkinson disease. *Neurology, 89*(11), 1152-1161. doi:10.1212/WNL.0000000000004357

Edwards, S., & Cooper, N. (2010). Mind mapping as a teaching resource. *Clinical Teaching, 7*(4), 236-239. doi:10.1111/j.1743-498X.2010.00395.x

Hsu, L. L., Chang, M. Y., & Hsieh, S. I. (2008). Mind mapping: a new tool for enhancing student learning strategy. *Hu li za zhi (Journal of Nursing), 55*(2), 76-80.

Johnstone, A., & Otis, K. (2006). Concept mapping in problem based learning: A cautionary tale. *Chemistry Education Research & Practice, 7*, 84-95. doi:10.1039/B5RP90017D

Kirschner, P. A. (2003). *Visualizing Argumentation: Software Tools for Collaborative and Educational Sense-making*. New York: Springer.

Kunsch, D., Schnarr, K., & van Tyle, R. (2014). The use of argument mapping to enhance critical thinking skills in business education. *Journal of Education for Business, 89*(8), 403-410.

Lin, H. (2011). *Digital mind mapping: Innovations for real-time collaborative thinking*. Paper presented at the ACM, Vancouver, BC, Canada.

Lincoln, Y., & Guba, E. (1985). Trustworthiness. In *Naturalistic inquiry*. Beverly Hills: Sage.

Mammen, J. (2016). Computer-assisted concept mapping: Visual aids for knowledge construction. *Journal of Nursing Education, 55*(7), 403-406. doi:10.3928/01484834-20160615-09

Mammen, J., Elson, M., Java, J., Beck, C., Beran, D., Biglan, K., . . . Dorsey, E. (2017). Patient and physician perceptions of virtual visits for Parkinson's disease: A qualitative study. *Journal of Telemedicine and eHealth*. doi:10.1089/tmj.2017.0119

Mammen, J., Rhee, H., Norton, S., Butz, A., Halterman, J., & Arcoleo, K. (2018). An Integrated operational definition and conceptual model of asthma self-management in teens. *Journal of Asthma*. doi: 10.1080/02770903.2017.1418888 [ePub ahead of press]

Maxwell, J. A. (2012). *Qualitative Research Design: an Interactive Approach*. Thousand Oaks, CA: Sage.

MindMaple. (n.d.). *Version 1.2.* Retrieved from http://www.mindmaple.com/Products/Features/

Moon, B. M. (2011). *Applied Concept Mapping: Capturing, Analyzing, and Organizing Knowledge*. Boca Raton, FL: CRC Press.

Motahari, M. (2008). The hermeneutical circle or the hermeneutical spiral? *International Journal of Humanities, 15*(2), 99-111.

Novak, J. (1990). Concept mapping - A useful tool for science education. *Journal of Research in Science Teaching, 27*(10), 937-949. doi:10.1002/Tea.3660271003

Novak, J., & Cañas, A. (2008). The Theory Underlying Concept Maps and How to Construct and Use Them. In: *Technical Report IHMC CmapTools.* Retrieved from : http://eprint.ihmc.us/5/2/TheoryUnderlyingConceptMaps.pdf

Pudelko, B., Young, M., Lamarre, P., & Charlin, B. (2012). Mapping as a learning strategy in health professions education: A critical analysis. *Medical Education, 46*(12), 1215-1225. doi:10.1111/Medu.12032

Tattersall, C., Watts, A., & Vernon, S. (2007). Mind mapping as a tool in qualitative research. *Nursing Times, 103*(26), 32-33.

Wheeldon, J., & Faubert, J. (2009). Framing experience: Concept maps, minds maps, and data collection in qualitative research. *International Journal of Qualitative Methods, 8*(3), 68-83.

XMind. (n.d.). *Version 3.4.1.* Retrieved from http://www.xmind.net

Zimmerman, T. (2016). Card-sorting: From text to themes. In T. Menzies, L. Williams, T. Zimmermann, & M. Kaufmann (Eds.), P*erspectives on Data Science for Software Engineering* (pp. 137-141). Boston. Retrieved from (https://www.sciencedirect.com/science/article/pii/B9780128042069000271).

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