*Master thesis*

# ENGAGING WITH A LIVING TEXTBOOK:

*An exploratory study on the way in which students and teachers interact with and perceive a web based concept map visualization tool.*

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Dublin, September 2017

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MASTER EDUCATIONAL SCIENCE AND TECHNOLOGY

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## SUMMARY

The ability to recognise the relationships between concepts is a crucial aspect of meaningful learning. However, facilitating students to identify and understand these cross connections can be a challenge for teachers in higher education as concepts are often dealt with in isolation. Expert generated concept maps have been shown to help students in forging connections by acting as scaffolds for cognitive processing. The Geo-Information Science (ITC) faculty at the University of Twente are prototyping a Living Textbook which combines an online knowledge repository with an interactive map visualizing the relationships between concepts. The pedagogical beliefs of teachers play an important role in whether or not such a tool is effectively integrated into the learning process. This study explored how teachers conceptualize the pedagogical value of visualizations, how students engage with these visualizations in their learning journey, and what elements of the current prototype of the Living Textbook concept map are usable and which are not. ITC students and teachers were interviewed about their experience with the concept map tool, and a think aloud walkthrough and usability test was conducted with students. The findings show that both students and teachers perceive the tool's capacity for highlighting conceptual connections as a valuable learning aid, but are intimidated by the cluttered layout of the concept map. Faculty emphasize the tool's value in helping to order and structure course content, and stress the importance of introducing hierarchy to make its navigation more effective. Two sets of design guidelines for the tool are proposed, one related to the support needed by students (mitigate cognitive overload, prioritize certain content and increase content depth, introduce detail on demand, improve ease of access) and another related to what teachers need (increase ability to manipulate tool, track frequently visited concepts, enable student teacher interaction, reduce effort to update content).

**KEYWORDS:** Student Engagement ● Pedagogical Beliefs ● Concept Maps ● Visualizations

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# ACKNOWLEDGEMENTS

This thesis is written as the final element in my completion of the MSc program in Educational Science and Technology at the University of Twente, and represents the end of a journey of almost two years. Along the way, there have been many people who have played an integral role in this research and in my development, and there are some in particular that I want to make special mention of.

First of all, I want to thank all those who took part in this study, and who gave of their time to voluntarily participate in the interviews and usability tests. These students and teachers have a multitude of other commitments and pressures drawing on their time, but without their willingness to give of themselves, this research would not have been possible in its current guise.

Alongside this, I want to thank both of my supervisors for all of their guidance and help over the past twelve months or so since this project was initiated. My first supervisor, Dr. Susan McKenny, has remained patient with me throughout this process, and provided remarkably meticulous feedback often at very short notice. For this, and for her unending supply of optimism and faith in my ability to get there in the end, I am very grateful. Also I would like to thank my second supervisor Dr. Rob Lemmens, who has always been very open to new directions for this project, and whose passion for this area has consistently motivated me.

Finally, I would like to thank my parents, who have been a great support to me in these past six months back at home in Ireland, and who have always believed in my abilities even when I have had doubts. My girlfriend too deserves a special mention, as has put up with me talking about this project for the past year or so, and has always been there for me on both the good days and the bad.

# 1. CONCEPT MAPS AS KEY TO UNLOCKING CONNECTED THINKING

*The ability to recognise relationships is a key aspect of meaningful learning, and a key component of expert behaviour in a professional context. Teachers often struggle to facilitate students to see such interconnections in their classes as concepts are taught in isolation, but online knowledge repositories combined with digital concept maps represent a possible solution. While expert generated concept maps have been shown to have a positive effect on learning and retention, they run the risk of causing the viewer to disengage if the information visualized is too cluttered or overbearing. The present study explores how students engage with a prototype of such a tool developed by the Geo-Information Science faculty at the University of Twente. The data gathered will reveal not only to the ways in which students interact with the tool, but will also explore the critical role that teacher beliefs and perceptions play in the adoption of such educational software. The study will use the insights gleaned to generate a set of design guidelines that can improve how the tool augments the teaching and learning experience.*

## 1.1 BACKGROUND OF THE STUDY

Meaningful learning takes place when the learner assimilates new concepts and propositions into existing concept and propositional frameworks (Ausubel, 1968). This type of learning is critical as it allows students to build the interconnected cognitive schemas necessary for problem solving (Mayer, 2002). Teachers often struggle to facilitate this kind of interconnected learning due to the fact that traditional education breaks wholes into parts, focusing separately on each section, and learners often experience difficulty conceptualizing the big picture (Wang, Peng, Cheng, Zhou & Liu, 2011) as a result. This is out of sync with many contemporary theories about how people learn and the highly interconnected cognitive schemas that experts need (Moore, 2013). Novak (2002) emphasizes that students must engage in meaningful learning activities to form conceptual understanding. and proposes concept maps as a tool to help achieve this. Concept mapping as a tool has been defined as the process of visually linking two or more concepts with propositions to form statements from which meaning can be induced (Novak & Cañas, 2008). Initially, concept mapping was developed primarily as a medium to help learners visualize what they did and did not know (Novak & Cañas, 2008) but concept knowledge maps generated by experts have also been shown to have a positive effect on learning and retention (Nesbit & Adescope, 2006). These expert generated learning aids have the capacity to act as advance organizers for students (Moore, 2015), thus enabling them to more easily develop the cognitive schemas needed to develop conceptual understanding of complex curriculum (Moore, 2013).

Concept mapping has been found to benefit students across all education levels (Shaw, 2010) and digital concept maps in particular have the ability to both represent abstract propositional knowledge and hyperlink to information resources in digital repositories (Tergan, Keller & Burkhard, 2006). Leveraging on modern computer mapping software and the internet, such knowledge visualization maps can enable navigation of large bodies of information and facilitate students to engage in self-regulated resource based learning (Coffey & Cañas, 2003). However, it is critical to ensure that any software with an educational purpose is designed to enable meaningful learning activities (Mayer, 2002) and adaptive concept map tools can function both as effective navigation interfaces and as an aid in helping students

see connections between concepts (Moore, 2013). There has also been research which highlights that concept map tools can specifically benefit students with low verbal ability (O'Donnell, Dansereau & Hall, 2002) as they provide a more straightforward way to access complex knowledge.

With the growth in digital textbooks across a wide range of subject domains in higher education (Reynolds, 2011), there is an opportunity for such web based concept map tools to be integrated with online course wide knowledge repositories and offer an alternative to the traditional textbook approach. However, any single concept map that covers a cognitive schema as complex as that involved in an entire third level course runs the risk of becoming unmanageable for students to comprehend, display or manipulate (Cañas et al, 2005). This can then lead to a phenomenon known as 'map shock' (Blankenship & Dansereau, 2000), a cognitive and affective reaction that a learner has to the presentation of an overly large and complex concept map which leads to incomplete processing (Moore, 2013). Tergan et al. (2006) highlight that such cognitive overload and navigational disorientation can be mediated by effective visualizations which can be used to unburden cognitive processing and memory functions.

## 1.2 CONTEXT

In order to help students gain greater conceptual understanding of content, faculty at the Geo-Information Science (ITC) department in the University of Twente in the Netherlands have developed a prototype of one such visualization in what has been termed 'The Living Textbook'. This textbook is comprised primarily of an online knowledge repository in the form of a wiki that is drawn from the content of the core curriculum module of the Masters in Geo-Information Science. Alongside this, the tool also contains an interactive map visualizing the relationships between concepts. This map has the dual function of allowing students to see how concepts interconnect and also serving as a portal through which users can access more in-depth wiki pages by clicking on hyperlinked concept nodes. An example of how the Living Textbook concept map functions is visualized on the following page in Figure 1.

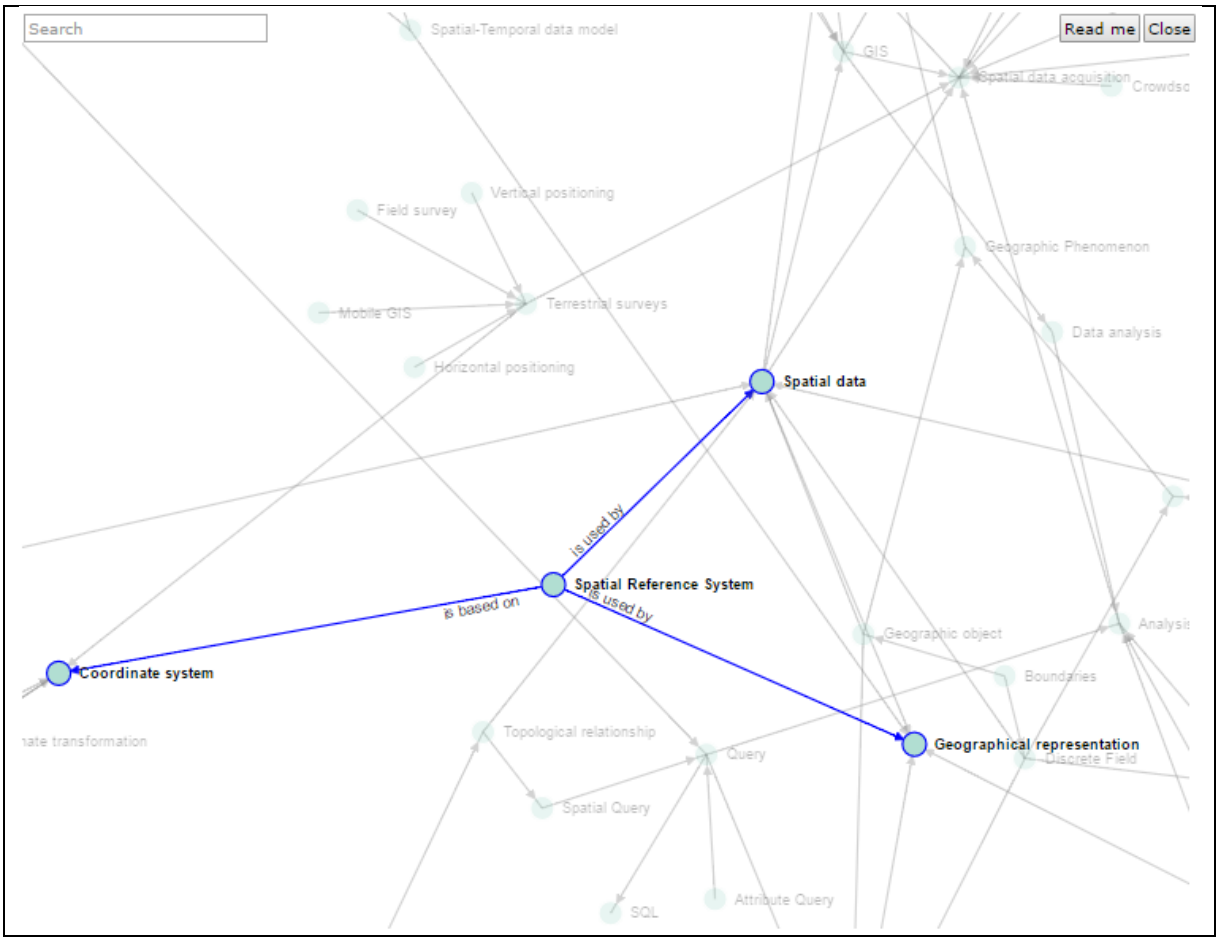


*Figure 1:* Example of the Living Textbook concept map interface

The present study will be carried out in the context of the Living Textbook project. The content for the concept map has been created in-house at ITC, with individual faculty members providing the ontology for their respective pieces of the core curriculum module. An ontology is a set of concepts and categories in a subject area or domain that shows their properties and the relations between them. The Living Textbook team have previously trialled the wiki only version of the tool with students in the Distance Education (DE) core curriculum module and are seeking now to gain feedback on how students interact with the concept map visualization and navigation tool. The team are aiming to further improve their prototype in order to better enable students in the ITC department to develop interconnected conceptual knowledge. The present study is aiming to help evaluate the tool's potential capacity from both a student and a teacher perspective.

## 1.3 PROBLEM STATEMENT

Digital concept map tools such as the Living Textbook could be the solution to the current difficulty of enabling students understand the big picture, and could help students developed better interconnected knowledge and increased conceptual understanding. However, there is at present scant evidence of such tools successfully improving student learning outcomes. Alongside this, it remains to be seen whether tools such as this can promote student engagement with content, which is a concern given that

visualizations such as these are not something many students are familiar with. Engagement is a critical construct to explore in relation to any such prototype of educational software, given it has shown to lead to student learning and retention and can be indirectly associated with student outcomes (Umbach & Wawrzynski, 2005). While exploring the ways in which students engage with the tool is important, it is critical to also gain their perspective on the elements of the tool that are usable, and those that are not. Understanding the reasons behind this is crucial if developers wish to develop educational software that is efficient, effective and satisfactory for the user (Carvalho, 2001). With specific relation to expert generated concept map tools, it is important to explore how students respond to course wide visualizations in the tool, as there is the danger that such visualizations can overwhelm the user as a result of their complexity (Cañas et al, 2005).

Given the critical role that teachers play in engaging students (Umbach & Wawrzynski, 2005; Bryson & Hand, 2007), any educational software that is being designed to meet the needs of the diverse student body must also take into account the teacher perspectives on the pedagogical value and efficacy of such tools. There have been claims that teachers can benefit directly from the process of generating content for adaptive concept map tools as they can enable instructors to spot gaps in their course content and ensure greater flow between courses (Moore, Pierce & Williams, 2012). Alongside this, having teachers refer to the tool during instruction can help students to see the big picture and motivate them to learn topics (Schwab et al., 2017). However, teacher beliefs have an impact on the pedagogy they practice (Ertmer, 2005) and understanding these beliefs plays a vital role in determining the ways in which teachers are likely to adopt and encourage adoption of new technologies. Thus, it is necessary to explore the beliefs that teacher's hold in relation to the potential use of the current prototype of the Living Textbook concept map tool.

## 1.4 GOALS OF THE STUDY

While there is a plethora of research investigating engagement in higher education (Kuh, 2003; Coates, 2006), this is a very broad construct and there has been little investigation into the ways in which students engage specifically with web based educational software such as concept map visualizations. The present study seeks to explore the way in which students interact with such tools, and provide insights on the challenges students face in this process and their perspective on the value that these visualizations offer them in the learning process. While the Living Textbook tool comprises both a wiki and an interactive concept map, the core focus of this research will be on the latter, as this particular form of interactive digital concept map has received very little attention in the literature to date and has significant potential in aiding students build interconnected concept knowledge (Moore, 2015). Alongside this, a consistent problem with new educational software is that the teacher perspective is often absent in the design and construction of these resources, and this ultimately ignores the critical role that teachers play in the adoption and integration of new learning approaches. The beliefs that teacher's hold about how to teach are a key factor in how they integrate new technology into their

teaching practice, and thus the present study also seeks to understand in more detail the pedagogical beliefs that faculty hold about the value of expert generated concept map tools for both teachers and students. The data gained from this study will offer insights more broadly into the nature of student engagement with web based visualizations and the kinds of beliefs that teacher's hold about web based concept map tools. This will be of value to future researchers seeking to understand how to better support teachers and students in visualizing and developing interconnected knowledge.

In the short term, the Living Textbook project group will benefit from the study, as the research will generate a set of design guidelines for how the tool could be improved to better support faculty and students in the teaching and learning process. Insights regarding ITC teacher attitudes towards the pedagogical value of the tool will be gathered, as well as potential suggestions and concerns that exist among staff as the project and tool develops further. Alongside this, the study will seek to understand how Geo-Information Science students at ITC perceive the usefulness of the tool and catalogue suggestions they have in relation to how it could better suit their learning needs. The aim for the long term is that these design guidelines will benefit other developers building web based concept map tools to sculpt resources that are more likely to support teachers in increasing student engagement and developing increased conceptual understanding.

# 2. CONCEPTUAL FRAMEWORK

*The goal of this study is to explore how teachers and students engage with and perceive course wide digital concept map visualizations. The factors which play a role in the adoption and integration of these tools into the teaching and learning process will be discussed in this chapter. Engagement has been indirectly associated with learning outcomes, and thus it is important to explore how students are cognitively, behaviourally and emotionally engaged with the Living Textbook concept map. Alongside engagement, it is also critical to explore the usability of any web based educational software, as if the tool is not easy to use and navigate it can hinder engagement. Course wide concept maps also have the potential to better enable teachers to plan and structure their courses, and to spot content gaps or inconsistencies. The degree to which teachers adopt such tools is connected with their pedagogical beliefs, and thus it is important to explore these beliefs and the institutional factors which may influence them. Faculty members' perspective on the pedagogical value of the digital concept map is vital to explore as teachers have the ability to increase the propensity with which students engage with such tools.*

## 2.1 FACTORS INFLUENCING THE USE OF DIGITAL LEARNING TOOLS

Despite the increased availability and popularity of digital learning tools, there are still numerous barriers to the integration of such instructional technology into higher education. Some of these factors include the effort faculty are willing to invest, the degree of technology satisfaction expressed by students, and the competency of the students themselves (Surry, Ensminger, & Haab, 2005). The degree of technology satisfaction students express is informed to a large degree by the value they perceive in such tools, and the usability of the tool determines whether users can easily or efficiently meet their learning goals and needs (Koohang, 2004). It is of critical importance to study usability in order to aid developers and designers to better understand how students perceive and react to different elements of web based learning (Koohang & Durante, 2003). Usability has an influence on student engagement, and well-designed web based learning technology has been shown to have a positive impact on student engagement (Chen, Lambert & Guidry, 2010). However, it is also important to understand how students interact with and perceive such web based learning tools and explore in more depth how and why students engage with them.

The pedagogical beliefs that teachers hold have an impact on their classroom practice (Ertmer, 2005), and the way in which they teach has an impact on student engagement (Smith, Sheppard, Johnson & Johnson, 2005). The willingness of teachers to invest in the promotion and adoption of digital learning tools stems from the pedagogical beliefs they hold in relation to technology (Chen, 2008), as well as the usability of the specific tool in question. As such, it is important to explore the beliefs that teachers hold in relation to web based digital learning tools, and to understand the way in which they perceive the value of these tools in the teaching and learning process. Teacher's pedagogical beliefs are also influenced by what is constituted as good teaching in the institutional culture in which they work (Windschitl & Sahl, 2002) so it is important also to understand the institutional influences which inform the beliefs that teachers enact in their practice. Figure 2 below maps out the factors that play a role in

how students and teachers interact with web based learning tools, and each of these constructs will be elaborated in the following sections.

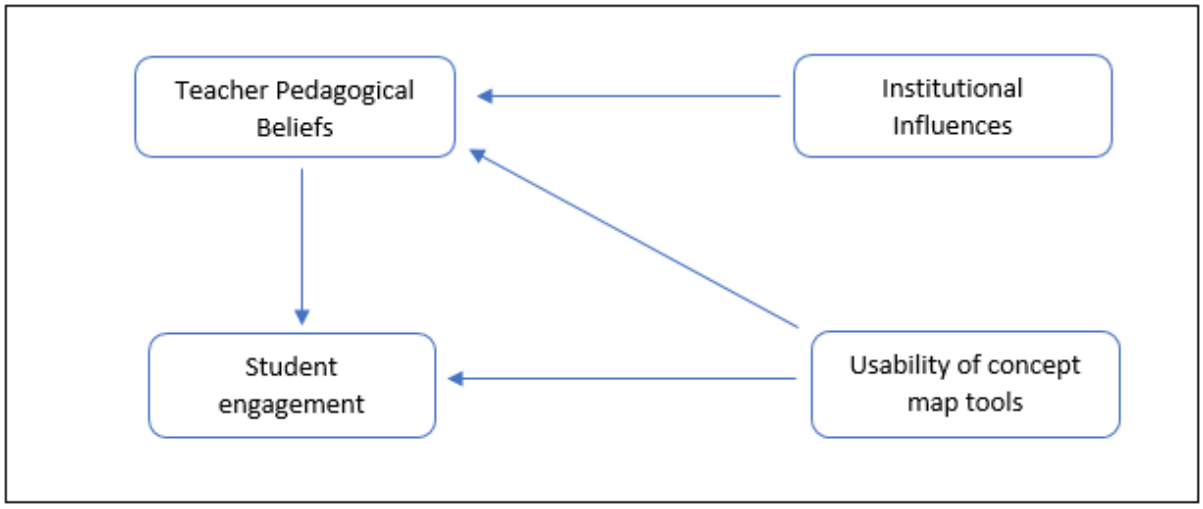


*Figure 2:* Theoretical model of how students and teachers interact with digital learning tools

## 2.2 STUDENT ENGAGEMENT WITH EXPERT GENERATED VISUALIZATIONS

Understanding the role that student engagement plays in higher education is currently a vital research issue, with growing evidence of the key role it can play in achievement and learning (Kahu, 2013). In the most prevalent higher education surveys on engagement (Kuh, 2003; Coates, 2006) the construct is defined as the degree of student's involvement with and time invested in activities and conditions likely to generate high quality and meaningful learning. More attention needs to be paid though towards the reasons why students engage with specific forms of digital technologies during their studies (Henderson, Selwyn & Aston, 2017) as well as to the ways in which students use these technologies in the learning process. Interactive web based learning tools can amplify, enhance and guide the cognitive processes of learners (Agostinho, Bennett, Lockyer & Harper, 2004) but in order to understand the way that students interact with these tools, it is important to study the meta construct of engagement. Most researchers agree that this meta-construct is comprised of emotional, cognitive and behavioural elements that adequately capture the psychological state of engagement (Fredricks, Blumenfeld & Paris, 2004). The focus of the present study is on student engagement in technology mediated learning experiences, and in this context these three facets of engagement are elaborated upon in detail below.

### 2.2.1 Behavioural Engagement

Behavioural engagement is defined as sustained participation in a given learning activity (Fredricks et al., 2004) and in the context of this study, the sustained use of digital learning aids or participation in technology mediated environments. Skinner & Belmont (1993) emphasise that sustained behavioural involvement is evidenced when students initiate action and exert concentrated effort in the implementation of learning tasks. Such sustained engagement can indirectly lead to higher learning

outcomes, and can be measured by outlining the active responses that students make to learning tasks (Chapman, 2003) and in the context of this study, the Living Textbook concept map tool. Kahn (1990) highlights that when behaviourally involved, students show evidence of high levels of cognitive awareness, and are emotionally invested in the activity. Thus these two constructs are of critical importance to the present study and are described in more detail below.

### 2.2.2 Cognitive Engagement

Cognitive engagement can be categorized as the focused effort learners give to effectively understand the content conveyed, including self-regulation, deep learning and metacognitive behaviour (Fredericks et al., 2004). Cognitive engagement is a critical construct to explore for those seeking to design and develop digital learning environments as it is central to the student's relationship with the learning design of the tasks and activities in these environments (Wiseman, Kennedy & Lodge, 2016). This construct is evidenced by the way in which students feel about themselves and their work, their skills, and the strategies they employ to master their work (Metallidou & Viachou, 2007) and is consistent with theories proposing the fundamental needs of autonomy and competence (e.g., Connell & Wellborn, 1991). Given the purpose of the Living Textbook concept map tool is to help students see the interconnections between concepts, student's self-perceptions of competence can be evidenced by statements which highlight their cognitive improvement as a result of their use of the tool. Pintrich & De Groot (1990) associated engagement levels of students with their use of metacognitive strategies to monitor and guide their learning process, and thus this sub construct will also be explored in this study. This metacognitive awareness can be measured by how students perceive the concept map tool has helped them to more effectively monitor and strategically manage their own learning. It is also important to understand how students perceive their own level of involvement with the tool, and the degree to which they have been made more cognitively aware by their use of it.

### 2.2.3 Emotional Engagement

Emotional engagement can be defined as the feelings students have about their learning experience (Fredericks et al., 2004). There is an emotional intensity attached to the experience of learning that is often underappreciated (Askham, 2008) and this is important to examine because this can often have an impact on the cognitive and behavioural elements of engagement (Kahu, 2013) already outlined above. Valiente, Swanson & Eisenberg (2012) highlight that the object of attention, in this case a digital learning aid, can prompt emotional responses that vary in motivational intensity. Students who are emotionally engaged in learning activities show positive emotions such as enjoyment and enthusiasm, whereas students who are disaffected show emotions such as anxiety and frustration (Skinner & Belmont, 1993). Negative emotions such as anxiety have the capacity to narrow a student's attentional focus and inhibit their cognitive processing, whereas positive emotions that are lower in emotional intensity such as enthusiasm have the capacity to broaden attentional focus and cognitive processes

(Valiente et. al, 2012). Anxiety can be recognised as a state of worry, concern or unease, and specifically in the context of a digital learning tool can be evidenced by students expressing that they are overwhelmed or intimidated by certain features of the interface. On the other hand, frustration is a less intense emotion and is visible when a student expresses annoyance or irritation with a particular aspect of their learning experience, such as the time it takes for a page to load or being prevented from navigating the interface in a particular way. Enthusiasm refers to interest or excitement the learner expresses in relation to their learning experience and in this case it is an important emotion to explore because it highlights the interest that students have towards the learning experience (Trowler, 2010). Students enthusiasm in relation to a digital learning tool could be a positive expression of interest in a particular feature of the tool or positive comments in relation to the tool's benefit to them. Enjoyment is a slightly different case in that it can be seen by the student taking pleasure in the act of learning, and in the context of a digital learning tool this could be seen by the student having fun interacting with the tool. It is important for the present study to explore the degree of motivational intensity of these emotions users experience as they engage with the concept map, because this can aid in understanding the positive or negative reactions provoked by interacting with digital learning tools.

## 2.3 USABILITY OF WEB BASED EDUCATIONAL SOFTWARE

In order to gain an understanding of students' engagement with such a concept map visualization, it is vital to also explore the usability of such a tool. While studies have emphasized the need to move beyond usability to design for more engaging experiences (Hassenzahl & Tractinsky, 2006), the premise still stands that if a tool is not usable, students will not be able to engage with it effectively. The concept of usability encompasses such attributes as learnability, efficiency, flexibility and user satisfaction (Nielsen, 1994) and explores the degree to which something is fit or ready to be used. Shiratuddin, Hassan & Landoni (2003) compare the web usability factors proposed by Nielsen, IBM and Microsoft and outline screen layout, accessibility, navigation, interactivity and content as key factors to explore. The relevance and operationalization of these factors is outlined in the subsequent sub sections below.

### 2.3.1 Screen Layout

Content should be structured and designed in such a way that users will find information easily and effectively (Shiratuddin et al., 2003). Sometimes referred to as interface layout, students identify well designed layout as a critical factor in determining web based tools that are positive to use (Storey, Phillips, Maczewski & Wang, 2002). The layout of the screen can refer to the way in which information is structured and presented, and Microsoft's web usability guidelines outline that having simple and clear structure would improve users' navigation within a Web site. Effective screen layout is evidenced by reducing clutter and avoiding redundant information, as the fewer items that are on screen, the more that users will notice them and the less overwhelmed they will be (Nielsen & Loranger, 2006).

### 2.3.2 Navigation

Good navigation will help users find what they need easily and quickly especially for large amounts of information (Shiratuddin et al., 2003). Any technology based support needs to be easy to use (Dale & Lane, 2007) and effective navigation plays a critical part in this. Good navigation is evidenced by how easy it is for users to search for information and how smoothly and quickly they are able to transition from one element of the interface to another. Nielsen & Loranger (2006) emphasise that best practice in navigation is to make it as efficient as possible, and to make main topics and icons static and appear at once in order to allow people to skim quickly between their choices.

### 2.3.3 Interactivity

Students should be provided with interactivity elements such as giving response, feedback, and searching for information (Shiratuddin et al., 2003). Providing greater user control is identified by IBM as one of the elements that can enhance usability, and adding interactive features is one way in which website designers are able to do this. While multimedia elements such as animation and interactive features can enhance the user experience, it is important to evaluate whether these are integrated properly so that they do not adversely affect how which users interact with the web based system (Nielsen, 2000). An appropriate level of interactivity will eschew designer controlled action in favour of true user interaction that does not take up too much time or resources (Nielsen & Loranger, 2006). Alongside this, the response time of interactive elements is a critical element to evaluate with any web based application, as slow response time has a direct effect on user satisfaction (Hoxmeier & DiCesare, 2000).

### 2.3.4 Content

In order for students to perceive value in any web based learning tool, the content provided should be useful, relevant, and up-to-date (Shiratuddin, et al., 2003). Web designers should also ensure that they employ appropriate depth and breadth in the content that they provide, and any multimedia content that is used is appropriate to the context (Venkatesh & Ramesh, 2002). Good content design is evidenced by sites that do not overwhelm the reader with too much information, but still provide the key pieces of knowledge required that are relevant for the student in their learning process. Nielsen & Loranger (2006) emphasise that good content design avoids unscannable text and material that is too dense for the reader to quickly grasp at first glance.

### 2.3.5 Accessibility

Having good design and useful content are inadequate without considering the accessibility factor (Shiratuddin et al., 2003) and it has been outlined as a critical sub construct of usability (Brajnik, 2000). This means that designers of web learning tools should take into consideration of whether their information are accessible to all target users who use different technology to access the Internet. This is particularly pertinent for web based tools that aim to provide equal learning opportunities for students

in both the developing and the developed world. The proper use of text, having effective cross platform design and the speed of page loading are good indicators of how accessible a website is to users with different levels of internet connectivity (Nielsen, 2000).

For the purposes of the present study, the above usability factors will be evaluated, given how appropriate they are for an interactive navigational tool such as the Living Textbook concept map. Alongside this, the perceived value of the tool will be explored from both the teacher and the student perspective as much of the literature pertaining to student perceptions on learning in web based environments focuses on the perceived value of the task (Venkatesh et al., 2016). Sánchez & Hueros (2010) define perceived value this as the degree to which people believe a tool can enhance their performance, and they emphasize that this can be an extrinsic motivation to the user. Mayes & Fowler (1999) have also highlighted the importance of adopting the constructivist perspective when specifically discussing usability of educational software, and emphasize that learning is a by-product of understanding rather than an activity that can be supported directly. Thus it is necessary in the course of this research project to also explore how students perceive these tools have impacted their understanding, and how each of the components of the tool may have contributed to or impeded that learning (Storey et al., 2002).

## 2.4 TEACHER PEDAGOGICAL BELIEFS ABOUT VALUE OF CONCEPT MAP TOOLS

Aside from the usability of such tools for students, it is also important to explore their pedagogical value from the perspective of teachers. Moore (2013) highlights that course-wide concept maps have the potential to be useful both as tools for teachers in instructional design as well as in the learning process for students. However, teacher beliefs play a key role in whether educational technologies such as these are adopted (Ertmer, 2005), and thus it is critical to explore the nature of their beliefs in relation to the pedagogical value of the tool for both teachers and students. These beliefs are formed by many years of experience, from life as a pupil in the classroom (Keys, 2007) to the variety of professional context teachers encounter (Prestridge, 2012) and understanding these beliefs is a crucial element in understanding how and why teachers make instructional design decisions regarding technology. Much of the literature regarding pedagogical beliefs focuses on teachers in K-12 education although there is evidence to show that college teacher's educational beliefs are a strong influence on how they enact their professional roles (Stark, 2000).

### 2.4.1 Beliefs about tool's value for teachers

Faculty play a key role in the construction of expert generated concept maps, and there is evidence to show that concept mapping has been positively received by instructors as an aid in the planning process (Martin, 1994). Alongside this, such digital concept map visualizations can provide a compelling interface to better facilitate faculty content creators think about their course structure, and motivate them to create and add new material (Schwab et al., 2017). In the process of mapping all course concepts and

relationships, the course instructor can gain insights not only into the order in which content should be presented in their course and any gaps that may reside there, but also into helping to ensure that each interconnected course flows into the next (Moore, 2012). The teacher's perceptions in relation to a digital concept map tool's value can be evidenced by the different ways that they outline that they would be likely to use the tool, and the added value or concerns they perceive as accruing from its use to them in their teaching. For example, it must be noted that the construction of such complex and interconnected concept maps can be seen as a time-consuming process for teachers (Moore, 2012). This study will explore the beliefs that teachers hold regarding the potential of such a tool in both the planning and instruction process.

### 2.4.2 Beliefs about tool's value for students

Alongside the potential use of these maps as a planning tool for teachers, it is also important to understand the perspective teachers have on their potential benefit for students in the learning process. Teacher beliefs have an impact on the way in which they integrate technology into the classroom (Kim, Kim, Lee, Spector & DeMeester, 2013), and thus can potentially impact on the way in which students adopt new technology. Schwab et al. (2017) highlight numerous ways that teachers could increase the adoption of course wide concept map tools among students, such as referring to the 'big picture' during classroom sessions, or highlighting and digitally annotating certain parts of the map so attention could be drawn to sets of concepts of current importance. Teacher beliefs in relation to the value the tool holds for students can be seen by the different benefits they see in its use and the problems they see it solving. These beliefs may also extend to concerns that teachers have about the problems they believe students may encounter with specific features of the tool in their use of it. These beliefs are important to explore because teachers can play a key role in whether students engage with these concept maps.

### 2.4.3 Institutional influences on teacher beliefs

Despite the potential of interactive concept map tools, other institutional factors could affect the degree to which teachers adopt digital learning aids (Perrotta, 2013) and thus the extent to which students engage with them. The process of teaching itself has been described as an act of negotiation between one's pedagogical beliefs and the institutional factors (students, stated objectives, norms, staff assumptions and beliefs) which serve as enablers or constraints to perpetuating these beliefs (Bennett, Agostinho & Lockyer, 2015). This study will examine these institutional factors further, as Sherry & Gibson (2002) emphasise that institutional influences should be considered when examining ICT adoption and integration in education. Structural factors such as time restraints and course deisgn can shape the beliefs that teachers hold on how to approach teaching, as well as human factors such as relationships with colleagues. Another key factor to explore is the how the cultural diversity of the students attending the institution helps to shape pedagogical beliefs about how to approach teaching and the use of digital learning aids. These institutional influences can be recognised in the perceptions

teachers have on the structural challenges they perceive standing in the way of teaching best practice, and in the opportunities afforded to them by the institution that they believe have impacted the way in which they approach teaching.

## 2.5 RESEARCH QUESTIONS

Overall, research describes the importance of engagement in the higher education context, as well as the potential that resides in expert generated concept maps as instructional and navigational tools. In this study, student engagement will therefore be studied in relation to one prototype of an expert generated concept map visualization tool, alongside exploring the ways in which teachers perceive the pedagogical value of such a concept map. The insights gleaned from the above study will be used to create recommendations specific to the use of digital concept maps as a means of developing interconnected knowledge. To help achieve this aim, the following research question and sub-questions are drawn:

**How do students and teachers in higher education engage with and perceive the web based 'Living Textbook' concept map tool?**

- What is the nature of student engagement when interacting with web based expert generated concept map tools?
- In what ways is the current prototype of the Living Textbook concept map tool usable or not and why?
- What kind of pedagogical beliefs do faculty hold in relation to concept map visualization tools?

# 3. RESEARCH METHODS

*This chapter will outline the research methods designed to meet the goals delineated in the previous section of this document. The research adopted a qualitative case study model, deemed appropriate to gather in depth information regarding the Living Textbook concept map from student and teacher perspectives. Semi-structured interviews were taken with four randomly purposefully sampled MSc students to understand how they engaged with the tool, and a think aloud study was conducted to evaluate the usability of the tool with six voluntarily participating diploma students. Six teachers voluntarily participated in the study also, and their perspectives were gathered using semi structured interviews. All of this information was then transcribed, coded and a thematic analysis was performed to identify recurring patterns in the data.*

## 3.1 RESEARCH DESIGN

Given the central goal of this research was to determine usability of and engagement with the Living Textbook concept map tool, a descriptive single case study design was adopted. Kahu (2013) highlights that engagement is a dynamic and situational construct, and thus in depth qualitative research methods are more useful for understanding its complexity. There are numerous definitions for a case study but Bromley (1990) defines it as a "systematic inquiry into an event or a set of related events which aims to describe and explain the phenomenon of interest" (p.302). Yin (2014) has emphasized the appropriateness of utilizing case studies to conduct evaluation research and also explicitly states that they are most pertinent to use "when the intervention being evaluated has no clear, single set of outcomes" (Yin, 1994, p. 15). Given that another goal of this exploratory research was to glean insights regarding teacher's beliefs and their perceptions of the pedagogical value of this specific tool, this case study involved two sets of respondents (teachers and students). Multiple case methodology has been employed previously to explore how students interact with interactive web based concept maps (Moore, 2015) but there have not been any case studies on interactive concept map technology that focus on both teachers and students. Given that both are key stakeholders in the educative process, it was determined that including both within the scope of the case would provide a more rounded perspective on how users engage with and perceive such concept map tools. While participants also had interactions with the Living Textbook wiki tool as part of their course environment, this was not considered a part of the case explored. Any questions asked in relation to the Living Textbook tool as a whole or the wiki element were included to provide context to the student's use of the concept map tool. To ensure that rich data would be collected that would provide valid feedback on the tools usability and value, only participants studying or teaching Geo-Information Science were selected.

To explore the perspectives of teachers and students using the tool in a DE module, semi-structured interviews were conducted. Semi-structured interviews were deemed to have the most scope for enabling and building a rapport with participants while allowing for improvisation depending on the responses of the interviewee (Myers & Newman, 2007). Alongside this, to capture how students reacted to the tool in the moment and to discern first time use issues, 'think aloud' research was performed with students from the Geo-Informatics Diploma course (GFM), what Nielsen (1994) terms as the single most valuable usability engineering method.

The alignment between the research questions outlined in the previous section and data collection methods proposed is included below in Table 1. The data collection process is further visualised in relation to the key research themes in Figure 3.

Table 1
*Alignment between research questions and data collection methods*

| Research Questions | Data Collection Method | Respondent Information |
|---|---|---|
| RQ1: What is the nature of student engagement when interacting with web based expert generated concept map tools? | • Student engagement interview<br>• Think aloud walkthrough | • 4 DE students, random purposefully selected<br>• 6 GFM students, voluntarily participating |
| RQ2: In what ways is the current prototype of the Living Textbook concept map usable or not and why? | • Think aloud walkthrough<br>• Student engagement interview | • 6 GFM students, voluntarily participating<br>• 4 DE students, random purposefully selected |
| RQ3: What kind of pedagogical beliefs do faculty hold in relation to web based concept map tools? | • Teacher engagement interview | • 6 ITC teachers, voluntarily participating |

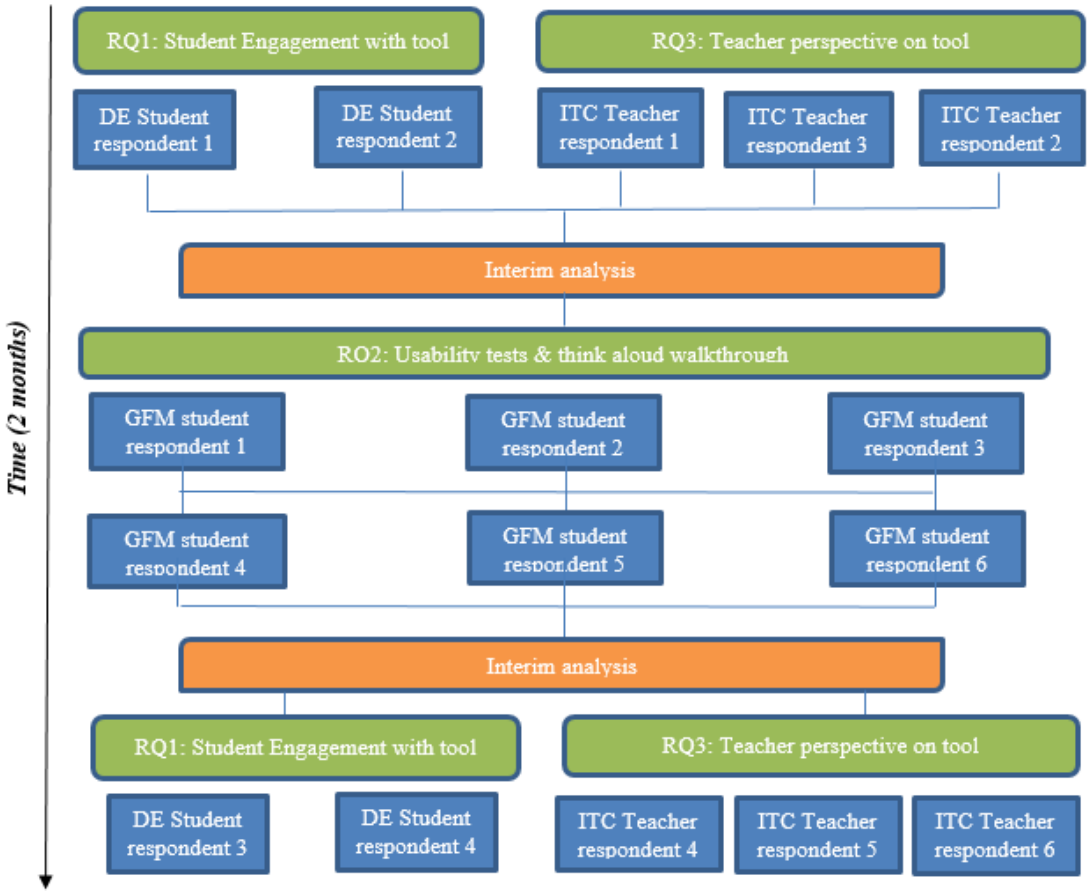


*Figure 3.* Data collection process & key research themes

## 3.2 PARTICIPANTS

Students and teachers from the University of Twente's ITC department were asked to participate in this research. As the focus was on a particular group who are directly involved with the Living Textbook tool, this concerned purposive sampling (Devers & Frankel, 2000). A prototype of the Living Textbook tool had recently been piloted in a DE core MSc module of Geo-Informatics and it has been argued that these kinds of typical cases are often the most likely to have the greatest benefit from the application of purposeful sampling (Miles & Huberman, 1994, p. 34). Four students taking part in the DE core module participated (n=4) with a mixture of educational experience, with some students having attained PHD's and others only Bachelor Degrees, but most students had substantial experience working with GIS software. All the DE students interviewed had high competency in the English language. Alongside this, six faculty members who were teaching part of the DE module (n=6) and had contributed to the content of the concept map were interviewed. These teachers had a range of experience teaching in the ITC faculty, with some teachers having just begun teaching in the department two years previous and others having been involved with the ITC department for the last 15 years.

In addition to these participants, another six students from the face to face Geo-Informatics Diploma Program (GFM) participated in the think aloud usability tests (n=6). These students were a lower educational level than those taking the DE course but were chosen because they have no prior experience using the Living Textbook tool but still enough knowledge of Geo-Information science to navigate the usability test effectively. However, the students interviewed all came from an international background and did not have a high level of competency with English as it was not their first language. As a result, it is still important to note that there was expected to be a significant difference in the subject domain knowledge between the MSc students and those taking part in the Diploma course and any data collected was interpreted keeping this distinction in mind. All teachers and students signed a form of consent prior to participating in this research.

## 3.3 PROCEDURE

As ethical concerns play a role the ethical committee had to first approve the research and as such an ethical form was submitted and approved in advance by the ethical committee of the University of Twente. Due to the researcher's location, the semi-structured interviews with most teachers and all students took place via Skype. The researcher briefed the participant on the nature of the research before recording the audio of the interview, which took approximately 30 minutes.

With regard to the think aloud research, six GFM students were contacted in advance by a lecturer within the ITC department, and this lecturer and the researcher conducted individual usability tests with these students over a two-week period. Students were first briefed by the researcher on the goals of the research and on the eye tracking equipment that would be used throughout and then were given time to read through an overview of the test. Before beginning the set of tasks involving the Living Textbook tool, students were encouraged to think aloud during the test and the researcher highlighted

that no questions were to be asked unless a participant was very unsure about how to proceed. During the tasks, which took participants between 30 and 45 minutes to complete, the researcher observed the participant and took notes on the way in which they used the tool and any difficulties they encountered. At the end of the test, the researcher conducted a retrospective think aloud interview (lasting approximately 15 minutes) focusing on highlighted moments from the individual participants' test. The researcher recorded audio throughout and the computer screen which the participants used was also recorded. These interviews took place when these students were in the second and third week of their GFM course module.

## 3.4 INSTRUMENTATION

In order to explore the ways in which students engaged with the Living Textbook tool, the self-report measure of the semi-structured interview was employed. Alongside this, to collect more authentic data regarding the specific ways in which students utilize the tool and the issues they encounter, a think aloud protocol was developed for the usability tests. A separate semi-structured interview instrument for teachers was developed in order to probe the perspective of faculty within the ITC with regard to the pedagogical value of the Living Textbook tool. The researcher, who did not have any domain specific knowledge of Geo-Information Science, executed all of this. Below, more detailed explanations are given with quotes included to exemplify the different elements of the instruments.

### 3.4.1 Semi-structured interview schema for students

The schema developed for students (Appendix A) focused on eliciting insights regarding how students are engaging with the Living Textbook tool ("*How have you engaged with the Living Textbook so far?")* as well as trying to capture what their initial reactions were to the tool (*When you opened up the concept map for the first time, what was your reaction?")*. Alongside this, a series of probes were developed relating to clarification *("Can you give an example of that, I think I know what you are talking about, but if you could clarify a bit?")* as well as elaboration *("Why do you think that would benefit you so much?").* In order to glean further insights regarding what students need in relation to their learning experience, questions were also added to the schema relating to their perceptions on the learning environment *("How has the experience of doing distance learning been different from the face to face experiences of education you have had?")* and features they would like to see added to the tool *("What suggestions for additional functionality could the WIKI/Concept Map provide? Why would this feature appeal to you?").*

### 3.4.2 Concurrent and retrospective think aloud protocol

The researcher developed a protocol that could be used for both the concurrent think aloud elements of the usability study (Appendix B). This protocol outlined the researcher's role as an observer and a note taker in identifying the participant's tendencies and difficulties encountered during the tasks, as well as

instructions for the students in how to effectively participate *("We would really like you to think aloud, that you say what you are thinking, as otherwise we cannot really use the test usefully").* An additional protocol was developed for the retrospective think aloud interview which consisted of questions triggered by observations of the researcher *("The first thing you did was moving the nodes itself, why do you think that was the first thing that you did?"*) alongside pre-defined questions related to each of the tasks *("How was your experience of moving between the wiki and the concept map in Task 2?")* This retrospective think aloud protocol elements were included to address the likelihood that participants would not feel comfortable thinking aloud while engaging with the task, and this had the additional benefit of freeing participants from the extra cognitive load of being compelled to think aloud during a complex task (Van den Haak, de Jong & jan Schellens, 2003)

### 3.4.3 Semi-structured interview schema for teachers

The interview schema developed for teachers (Appendix C) explored their conceptions of the teaching and learning process *("How would you describe your own philosophy of teaching/education?")* in order to provide insight on the reasons behind their perspective relating to the value of the Living Textbook tool. To help place these conceptions of teaching and learning further in context questions were included that explored some of the institutional factors that influence teachers such as medium, *(what do you think are the additional challenges, constraints or opportunities when you teach in a distance education context?)* and time *("So what would be the advantages or disadvantages as far as you are concerned, having it in such an intensive burst, these modules?").* The schema also focused on directly investigating their perceptions of the pedagogical value of the Living Textbook tool ("*How do you think the Living Textbook could help teachers improve the way in which they teach?")* which was important to explore given the key role teachers play in the creation and maintenance of such expert generated visualizations. Alongside this, the third part of the interview schema explored ways in which teachers believed the tool could be redesigned to better meet the needs of students *("How could the visualizations be made more effective for the next iteration of the tool?") and* teachers *("so from a teacher perspective if you were to add additional features to the concept map, what do you think you would add that could further support you to teach more effectively?").*

## 3.5 DATA PREPARATION

All semi-structured interviews, concurrent think aloud and retrospective think aloud interviews were subsequently transcribed verbatim from the audio recordings. To ensure that immediate impressions were not lost, the researcher transcribed the interviews as soon as possible after the data had been collected. The transcripts created included the utterances of the researcher as well of course as those of the students and teachers who took part in the interviews. In certain think aloud transcripts the researcher had to insert in parentheses what the participant was referring to in order to ensure that the perspective or emotion was adequately and clearly described. This was achieved by watching back the video and

audio recordings of the test to track what was on the participants screen at the time of the utterance. In total 16 interviews, lasting 12 hours in all, were transcribed, covering 85 transcript pages.

## 3.6 DATA ANALYSIS

The final data set consisted of audio recordings of the Skype interviews with teachers and students, as well as the audio recordings of the concurrent think aloud and retrospective think aloud interviews. This data was used to help explore and interpret how students and teachers perceived and engaged with the web based concept map visualization element of the Living Textbook tool. In order to reach conclusions about this, a codebook was developed and then the data was first coded by hand and then interpreted by thematic analysis. The process of data reduction, data display and conclusion was adhered to throughout this process (Miles & Huberman, 1994).

Two separate codebooks were developed for the different datasets, with one focusing on the teacher perspective on the tool, and the other on usability and student engagement with the tool. A set of four categories and 17 codes were developed inductively for the teacher perspective, after reading through the interviews multiple times. On the other hand, the 10 categories and 20 codes for the student interviews were mainly deductive, drawing heavily from Fredericks et al.'s (2004) theory on student engagement as well as from website usability heuristic literature (Nielsen, 1994; Hassan & Li, 2001). Even though the majority of codes were deductive, there were still some emergent codes that were developed during the process of coding the transcripts of this data set. A selection of categories, code definitions and sample data are outlined in Table 2 and Table 3 below.

To first secure reliability, a segment of the data was coded and then a second rater coded the same 5% of the data and Cohen's Kappa was then computed, measuring the inter-rater conformity by two independent coders (Cohen, 1960). At first there was some discrepancy between the coders, with an unreliable Cohen's Kappa rating of .59 but after a discussion with the other independent rater, specific issues were highlighted in relation to three or four codes that had been causing confusion and two that were not mutually exclusive. The researcher then reworked the respective codebooks, merging two codes together, deleting another, and clarifying the definitions of a number of other codes. The researcher then coded another segment of the data, and different interview segments were sent to the independent rater, and there was a much more reliable Cohen's Kappa rating of .81.

After coding both datasets, the coded data was then organized as suggested by Biddle, Markland, Gilboure, Chatzisarantis & Sparkes (2001), whereby the data units were clustered together to form themes. A theme "captures something important about the data in relation to the research question, and represents some level of *patterned* response or meaning within the data set" (Braun & Clarke, 2006). These themes were then analysed in relation to theory related to student engagement with and the usability of web based visualization tools, alongside different facets of teacher's perceptions of such educational tools.

Table 2.

*Sample inductive codes and data on teacher perceptions of the pedagogical value of the Living Textbook tool*

| Category | Code | Definition | Example |
|---|---|---|---|
| Promoting Student Engagement | Relevant & Challenging Course Structure (1) | Teacher emphasizes the importance of integrating into the fabric of the course urgent real world problems and hands on exercises that push students | "they really need this because otherwise, because they will come with their own real life problems and if a lecturer like me stays somewhere on top and doesn't give any examples then they will feel like lost because they need to be practical as well" |
| | Medium of communication (3) | Teacher focuses on the importance of the way in which content is delivered to students as a key factor in engaging them | " I explain something and then say ' but what if we had this situation, what do you think would happen' and then if the group is dynamic you can even have a mini debate for one or two minutes and then you can continue." |
| Institutional Influences | Course Structure & Medium (6) | Teacher mentions the format of the course/module as a factor to be considered in how they can successfully educate students | "And it also has to do with the time that we have and the way that we teach in three week intensive modules and after three weeks they have to do the assessment and with only one weekend in between they have to go on to the next module and so there is no way to digest things over a longer time." |
| | Student Demographic (8) | Teacher draws attention to the cultural make up of the institutions student body as a factor in how they approach teaching | "there are cultural differences, definitely differences, there are more cultures where it is allowed and stimulated to have discussion even with your professor lets say, and then there are cultures where it is not allowed at all and you are not supposed to interfere or put a question to what the professor says" |
| For students | Perceived value (13) | The teacher highlights that the tool provides additional benefit for the student in the learning process | "the added value of this concept map is that you have a visual that makes relationships clear between concepts that are not maybe so close in the text so where you would normally have to do several clicks before you find that certain concepts are related, you see them quite easily in this diagram |
| | Concerns (14) | The teacher expresses apprehension about the usefulness of the tool as a whole for students or a particular aspect or feature of the tool | "What I am afraid of, is if that we continue like this the ontology will grow and grow and grow and grow and there will be no way to find by visual exploration anything in this map." |
| For teachers | Use as in - classroom tool (17) | The teacher highlights how the Living Textbook could be applied by teachers within the context of the lecture hall | "lets say the lecture today is going to be about a certain topic so we go straight to the ontology, talking about what are the major concepts directly connected to this one and then say more or less putting a boundary line around the subject matter of that lecture" |
| | Use to clarify & connect course content (19) | The teacher emphasizes the benefit the tool would bring in helping the teaching faculty to revise, update and agree upon content to be covered in the curriculum | "what I liked about the exercise that we went through is that if you are teaching a subject it triggers you indeed to think about well do I bring these concepts forward lets say in a good structure with the proper relationships" |

Table 3.

*Sample deductive codes and data on usability and engagement from student interviews*

| Categories | Codes | Definition | Examples |
|---|---|---|---|
| Behavioural Engagement | Use likelihood (1) | Student highlights a situation when or when they would not use the concept map or wiki and/or how frequently they use these tools in general | "I use it to just kind of sanity check to ground myself with my thoughts and how I think the things I am learning about are related" |
| Cognitive Engagement | Metacognitive awareness (3) | Student explicitly mentions strategies related to the use of the concept map or Living Textbook that reflect planning, goal setting, and monitoring | "I go through the tasks and when it says look up this and this and I have no idea what that should be, I do two things, I copy and paste and google it and then I go to the link to go to the Living Textbook" |
| Emotional Engagement | Frustration (5) | The student expresses annoyance with a particular feature of the concept map/Living Textbook or highlights that they were prevented from taking a desired learning action as a result of the tool | "I felt it was a bit cluttered, like a lot of information in one place" |
| Screen Layout | Organization (10) | Student comments on the layout of the concept map or the way in which information is organized (e.g. hierarchy, order etc) or on how clear information is on the screen | "Things were not necessarily in a chronological order, so you had to put in extra effort to understand how you move from point A to point B" |
| Navigation | Ease of Use (11) | Students comment on specific difficulties they faced in relation to how they were able to move between different parts of the concept map (e.g. search functions, zoom, animation etc) or on how intuitive or straightforward this movement was | "You zoom it and it comes all the way down or all the way up and you can't get right in the middle, you can't get just that one size you're looking for" |
| Interactivity | Response (12) | Student comments on how quickly or effectively the system reacts when the user engages with it or highlights how it could be improved | "I'm not quite sure but I was obviously looking for those nodes that are related to the concept that I am searching, so I thought that I could go to the other node by dragging this somewhere, but it didn't work so I just tried to move the whole screen" |
| Content | Depth (13) | Student highlights issue regarding the quality or type of information included in the concept map/wiki (e.g. depth, variety etc.) | "But what I noticed with the Living Textbook is that the quality of the depth that is provided varies a lot, some entries are very repetitive" |
| Access | Accessibility (15) | Student makes a comment highlighting the difficulty of using the concept map as a result of internet connectivity/not being able to find the tool | "The whole of my first week I could neither access the textbook or the concept map because I did not have the proper credentials" |
| Improvements | Screen Layout (16) | Students makes suggestion for improvement in terms of clarity or organization of information on screen | "But if you only show me the whole tree the main branches the letters should be bigger, not all of them but the main concepts on the homepage" |
| | Navigation (17) | Students suggests improvement in relation to the ease of use of the map/wiki interface | "So even within the concept map, a button that makes the background fade totally, that cuts it out so you only have it as a standalone" |

# 4. FINDINGS

*In this chapter, the combined findings from the think aloud walkthrough and the semi structured teacher and student interviews will be discussed in relation to the research question. The three sub-questions focus on student engagement with the tool and its usability, and on teacher perspectives on the pedagogical value of the tool. DE students claim to use the tool frequently in their study and believe that the map has aided their competence with regard to conceptual clarity. Both sets of students also appear to be emotionally engaged with the tool, with most students expressing enthusiasm for the tool as a whole and frustration with specific features of the concept map they believe do not function in the most effective manner. These findings are echoed in the usability test, where students indicate that they perceive the tool as useful as a navigational aid and in its capacity to show a contextual overview. The areas that students experience most usability issues are in relation to the cluttered and intimidating nature of the screen layout, the difficulty in accessing the concept map, and problems in transitioning from the map to the wiki text. Teachers indicate that they perceive the concept map as a useful tool for helping students see connections between concepts that wouldn't be seen from a textbook, as well as for helping teachers more effectively connect content within and between courses.*

## 4.1 STUDENT ENGAGEMENT

### 4.1.1 Behavioural engagement

The majority of the DE students interviewed report using the concept map frequently, with some students using the map as a precursor to looking up information on the wiki, and others using it only once they had gained some initial conceptual understanding of the information. These users cite the fact that the map is able to provide them with an overview of the content and a quick way to see the relations between concepts as the primary reason for their continued usage of it. One student also highlights another reason for their continued use of the map, in that it enables them to review and reflect on their learning as they progress through the text:

> "I'm really just using it like I said when I'm just reading through the text and just kind of a little back and forth, I think just kind of a sanity check to ground myself with my thoughts and how I think the things that I am learning about are related."

Only one student reports relatively infrequent use of the concept map, saying they use the map only 50% of the time, and explain that they would prefer a physical textbook. The reasons they cite for this usage pattern are that they find that the information contained within the map is not that detailed, and also that the digital format of the map does not engage the senses sufficiently.

Alongside this, three GFM students involved in the usability tests report being likely to use the concept map as compared to text if it were available to them as a tool, as it would enable them to find information quicker. One student emphasises that they would use it primarily as a navigational tool:

> "The functions which the wiki has, the concept map all covers, the search function and every concept and I can just double click and just enter the page, so maybe it is better to use the concept map first in every situation."

Overall, Table 4 below highlights that the majority of DE students interviewed report strong patterns of behavioural engagement with the tool, and that 50% of the GFM students emphasize they would be likely to make use of the tool were it available to them.

Table 4.
*Summary of DE & GFM data collected on student engagement with concept map*

| Concept | Sub-concept | DE students | Users | GFM students | Users |
|---|---|---|---|---|---|
| Behavioural Engagement | Use likelihood | Uses the map frequently to get an overview | 3/4 | Likely to use the concept map if it were available | 3/6 |
| | | More likely to use a physical textbook | 1/4 | | |
| Cognitive Engagement | Competence | Helps to gel concepts together and aid understanding | 4/4 | | |
| | | Arrows trigger confusion about concept relationships | 1/4 | Arrows trigger confusion about concept relationships | 2/6 |
| | Meta-cognitive Awareness | Enables students to keep in mind the bigger picture | 4/4 | | |
| | | Enables more self-directed learning | 1/4 | | |
| Emotional Engagement | Anxiety | | | Freaks out and is overwhelmed by too much data | 1/4 |
| | Frustration | Clutter and lack of hierarchy in the map | 4/4 | Wiki text being blocked by map | 3/6 |
| | | Wiki text being blocked by map | 2/4 | | |
| | | Unable to access concept map through PDF links | 2/4 | | |
| | | Unable to control the screen/nodes | 1/4 | | |
| | Enjoyment | Fun moving around nodes and interacting with map | 1/4 | | |
| | Enthusiasm | Very positive about the tool's added value as a whole | 3/4 | Stresses the convenience and speed of finding info. | 5/6 |
| | | Being able to click on node in map and go to wiki page | 1/4 | Intuitiveness of the search feature of the concept map | 2/6 |
| | | Happy with the consistency of information provided | 1/4 | | |

### 4.1.2 Cognitive engagement

*Competency.* For students to fully benefit from a learning aid such as the Living Textbook concept map, they would need to be developing increased cognitive competence as a result of their use of it. Students interviewed who are taking part in the DE masters course have been using the map for a number of weeks, and as a whole report that the map enables them to develop increased competency in terms of the relationship between concepts and building a conceptual overview of the subject. Students comment that the map helps them gel concepts together and enables them to understand the other concepts that are associated with the one they were searching for, as shown in Table 4 above. One particular student comments on the role of the map in helping to situate new knowledge, highlighting:

> "you find out whatever topic you just studied, how it is embedded in the rest of the stuff."

On the other hand, students claim that some features are having a potentially adverse effect on their competence, in that they prompt more confusion than conceptual clarity. Two students cite the size of the arrows and the difficulty in reading relationships as the primary causes of such confusion:

> "But also, the other thing was you know the little arrow heads, I was looking into if that gives me an idea of direction, of directional information, and again it seemed like no."

Two GFM diploma students participating in the usability study also highlight this same confusion brought about by the arrows regarding the direction of relationships. One of those students in particular emphasized that she did not even see the arrows and this was partly what prompted the misunderstanding of the conceptual content:

> "So I will always read on the direction of the text, that is my reading habit, and I haven't noticed the arrows, I haven't noticed it because if it was bigger I could see it"

*Metacognitive awareness.* One of the potential benefits of expert based concept map visualizations is that they can make students more mindful of their learning process, and of where the concept they are exploring fits in their learning journey. All the DE students who report consistent use of the concept map emphasise that the tool had better enabled them to keep sight of the bigger picture as they progress through content. One student stresses the importance of the tool in helping to strategize about what content to prioritize:

> "so it gives me ideas for things high level things to focus on, or I guess critical things for me to know about this particular concept."

Digital concept maps can also be used as navigational tools, and it has been theorised that they could aid students in engaging more in self-directed learning. Only one of the DE students interviewed makes reference to this, highlighting that the tool gives her more control over the direction of her learning:

> "that's why I like the concept map a lot, I can navigate myself, I can direct my learning myself, not just my pace but also which area I prioritise."

### 4.1.3 Emotional engagement

Students' emotional engagement with educational software can be both negative and positive, depending on whether students feel the tool is enabling or inhibiting their learning. When the student's experience of a particular negative emotion leads to the student focusing on the object of the negative emotion, it can drain cognitive resources away from the educational task at hand. Conversely, the positive emotions of students in relation to an educational tool can promote broader cognitive awareness of potential solutions to problems.

*Anxiety.* This feeling can be brought about when the student feels overwhelmed, lost or confused by a particular aspect of the educational tool they are utilizing in their learning journey. This is not an emotion visible among the DE students interviewed, but there is one very specific of a GFM student expressing this emotion in the think aloud study. The student in question is opening the concept map for the first time during the usability test, and reacts strongly to the way in which the information is presented:

> "Okay, what's this? I think if I click this it is better to show me the topics or the related bars/fields I am looking at, I think it is better to highlight the topological relationship and it will be more useful for me, if you just show me this actually I can't see, I freak out, I'm lost, I don't know where I should go."

*Frustration.* This emotional reaction is much more evident among both DE and GFM participants, with almost all students expressing frustration in some shape or form. In the vast majority of cases, the frustration the student highlights is in relation to a specific feature of the concept map tool, rather than with the tool as a whole. These are often usability issues which prevent students from being able to interact with the tool in the manner in which they want to. The most common gripe students have in relation to the tool is with respect to the messy and cluttered layout of the concept map. While the GFM student in the section above reports 'freaking out' in an anxious manner, most DE students express their annoyance about this feature in a much milder manner:

> "Well I thought it was a lot of information that we need to learn and it got a little bit messy, but apart from that when you go down into a concept it actually tells you what concepts are connected and a little bit how."

However, these emotional responses still represent a significant distraction from the task at hand, and are thus of interest in the context of this study. Another common source of irritation among both sets of participants is in relation to the navigation between the concept map and the wiki. Participants do not like that they are not able to have the wiki and the concept map open side by side. They express frustration that the concept map covers the wiki text so they are unable to read about a concept in detail as they try to simultaneously look at its relationship with other concepts. One DE student remarks that this could result in them utilizing the concept map less frequently:

> "Well I mean just another simple practical display thing, the concept map covers up the text to a certain extent so when that happens and you want to go over and read and the concept map is minimized and then maybe you are not as encouraged to open it up again."

Given that one of the main functions of the tool is to serve as a navigational conduit, this is not an ideal scenario. Not all students want to be able to view both pages at the same time, but still express frustration about the fact that text content becomes obscured after they interact with the concept map. One GFM student in particular pinpoints the fact that the map should not remain open after clicking a node.

*Enthusiasm.* Almost all of the participants express some degree of enthusiasm, although often the enthusiasm is for the Living Textbook as a whole, rather than for the concept map tool specifically. Some students do comment specifically on the concept map as a feature that they find "very convenient", with one student highlighting that they find the tool "phenomenal, it helps a lot". The specific feature that most captures the imagination of the participants in the usability test is the search functionality:

> "When I type a word or several letters it will match the available concepts it will match and I just click and find it so it is very convenient"

Among the DE students interviewed, on the other hand, the specific feature that garners the most positive comments is the ability to navigate directly from the concept map to a wiki page:

> "The thing that I liked on the concept map is the ability on clicking on a node of information on the title and it takes you right back to the textbook and this is where it is"

*Enjoyment.* The more that students enjoy interacting with educational software, the more likely they will be to make continued use of it. There was very little evidence of students expressing enjoyment in either the usability test or the DE interviews. While students are content with the overall convenience of the tool, only one DE student expressly mentions that they had fun with the tool:

> "I just had fun following the connections and moving it around to get the right view that I thought for me makes more sense, by just moving it around, I like that very much"

Overall, students appear to be quite engaged with the concept map tool on an emotional level, although the majority of their responses are not high in motivational intensity. Many of the features that cause the most negative reactions are usability issues with the concept map, and these are explored in greater detail in the following section.

## 4.2 USABILITY

Students will engage with a web based concept map if they perceive it as a valuable aid in their learning process. At the same time, students may be less likely to engage with the concept map if specific issues are inhibiting their use of it.

### 4.2.1 Perceived value

The perceived value of the concept map is examined according to four usability factors, as well as ascertaining whether or not students find the tool useful overall as a learning aid. The frequency of the main findings are outlined in Table 5 below and then further elaborated in the rest of the section.

Table 5
*Perceived value of concept map tool according to students*

| **Category** | **Perceived value** | Users (10) |
|---|---|---|
| **Overall** | Likely to use concept map first as it is more convenient & useful | 7 |
| | Increased ability to self-direct learning | 1 |
| **Screen Layout** | Digital presentation of the map | 1 |
| **Navigation** | Speed of finding information on the concept map | 4 |
| | Search functionality on the concept map is very useful | 2 |
| **Interactivity** | Being able to move nodes to reorganize information | 4 |
| | Map feature intuitively suggests matches after typing a few letters | 2 |
| | Instant switching to wiki page after clicking on a node in map | 1 |
| | Being able to move the screen of the concept map to navigate | 1 |
| **Content** | Concept map is very helpful for seeing how concepts interconnect | 9 |
| | Arrow function and the clarity of direction of relationships | 1 |
| | Assurance of consistency the concept map gives to the content | 1 |

Overall, 70% of students perceive the concept map as more valuable to them than the wiki, and cite the fun and convenience of the concept map as the primary reason for this. One student in particular highlights that the ability to see an overview is one of the most useful aspects of the tool:

> "I would always go first to the concept map, also simply because it is also more fun, I like to get an overview first, I don't like to read into detail one by one, so I like that very much."

The predominant areas which the students deem the concept map beneficial are in its capacity as a navigational tool and the speed of finding information. Alongside this, students see value in its interactive features and the content contained in the map, particularly in relation to how concepts connect with one another.

*Navigation.* The most common benefit of the concept map participants highlight is the speed with which it enables them to find information, and how this sense of getting an overview contributes to being more quickly able to place a concept in the broader scheme of information. One DE student specifically comments:

> "You can get your answers much quicker, you get a better overview of what is going on, you can get the information, you can pinpoint things much quicker and you know where things lie within the system"

Participants often cite the search functionality of the concept map as a key mechanism for obtaining information so quickly. A number of the GFM students in the think aloud walkthrough comment on the intuitive nature of the search feature, and how this aids them in their navigation of the map:

> "I found the search function in the concept map is very good. When I type a word or several letters it will match the available concepts it will match and I just click and find it so it is very convenient"

Some students make direct comparisons between how long it would have taken them to find similar information in a traditional or digital textbook, with one GFM student again emphasizing this convenience of navigation as the key selling point of the map:

> "Much more convenient...I can see the whole map as a relationship very directly and when I refer to a book maybe it is not that convenient, I must refer to each concept and find the relationship, so it can save time."

*Interactivity.* Another element of the concept map that some participants perceive as useful is the interactive nature of the concept map. The fact that the concept map allows students to manipulate both the screen, the zoom and the positioning of the nodes is cited by two DE students as helpful in visualization of the content that is most of interest. One particular student notes the interactive features as key in helping focus on different content areas:

> "I thought that was useful, because you can concentrate on different things, visualize things differently, it makes it easier, you can move them in a direction where you can read this bit better or that bit better"

*Content.* As a whole, both DE & GFM students perceive the content within the concept map as being of value in their learning journey. Students consistently highlight the way in which relationships were shown on the map as key in helping them understand more easily the way in which different concepts within their course interconnect. In particular, one GFM student emphasizes how relevant such content would be when looking back at concepts after a lecture:

> "That map gives me a clear structure of the relationships of the concepts, which is quite useful, especially when you are reviewing this concept after the class, or after you have this and know this concept to get them related"

The same student also comments on how simple and clear the language of the concept map is compared to the more complicated language of a wiki or textbook, and this is of particular relevance to the ITC department in the University of Twente. The student emphasizes that longer texts represent significant challenges for people whose "English is not so good like us" and given that a large proportion of students in this department come from abroad, this challenge could be lessened by the simplicity of the concept map.

4.2.2 Usability issues & suggested improvements

Four of the same factors addressed in relation to perceived value were also explored with regard to usability issues that students experience, with the addition of the accessibility factor. The frequency of the main findings are summarized below in Table 6 and then further elaborated in the rest of the section.

Table 6
*Usability issues of concept map tool according to students*

| **Category** | **Usability issues** | Users (10) |
|---|---|---|
| **Screen Layout** | Map is lacking structure in terms of hierarchy of information | 8 |
| | Too much information and clutter is on the concept map | 7 |
| | Being unable to see concept map & wiki screen at same time | 4 |
| | Words are too small to see on the concept map | 2 |
| | Arrows too small which prompts misunderstanding of relationships | 2 |
| | Not being given a full view of the map at first glance | 1 |
| **Navigation** | Takes time to understand how the relationship logic works | 2 |
| | Map not opening on the concept of the wiki page you are on | 2 |
| | Map moving by itself is uncontrollable and distracting | 2 |
| **Interactivity** | Map doesn't automatically close once you click a concept node | 1 |
| | Not seeing info, snippets or definitions when you hover over a node | 1 |
| **Content** | Relationships on concept map are little more than common sense | 1 |
| | The label 'is used by' seems more an excuse than a relationship | 1 |
| | ReadME is too boring and should have audio/visual instead | 1 |
| **Accessibility** | Unsure about how to access concept map from wiki, missed button | 5 |
| | Living Textbook not easy to find in the online course environment | 2 |
| | Not being able to access the map offline is a problem | 2 |
| | Map needs a fast internet connection to run smoothly | 1 |

*Screen Layout.* By far the most persistent issue among both DE & GFM students is the fact that the concept map interface is cluttered and difficult to read, and lacking in a sense of hierarchy. Almost all students mention this as something which they feel could be improved, and which makes it more difficult for them to navigate and engage with the map. The sheer volume of information participants are faced with when they first click on the concept map button is something which participants consistently

comment on in the GFM think aloud walkthrough. One student in particular highlights that she feels a sense of cognitive overload due to too much information:

> "If you just show me this actually I can't see, I freak out, I'm lost, I don't know where I should go."

Some participants note that what is missing is primarily a sense of importance or hierarchy, and as a result they don't "know where to start". A recurring comment is that participants want guidance towards some particular concepts when they open the map first, rather than being presented with the whole structure, and all concepts looking the same as one another. One DE student described the map as "busy!" and highlights prioritization as the most noticeably absent element when first opening the map:

> "The first other thing that I noticed is what is obviously missing is the importance, prioritizing in terms of importance, something you would get in a mind map, there is no sense of what is more important than others."

Participants suggest a number of different ideas about how this could be addressed, but there is agreement among the majority that introducing some element of hierarchy is necessary to better facilitate navigation of the map. Suggestions range from changing the colours of the more important nodes, to increasing the size of the more important concepts. Participants feel that these amendments to the screen layout would enable them to explore the map more intuitively, or in the words of one participant, "search without using the bar". One novel idea a DE participant suggests is to introduce an element of chronological order into the map via a flow chart mode that helps to guide users.

*Navigation.* Students overall express satisfaction with the navigation functionality of the map, but they do encounter some issues that prevent them from doing so in the most effective fashion. One of the most persistent of these issues is in relation to the transition between the map and the wiki page. Two students highlight that they have some difficulty when moving from the concept map to the wiki, in that the concept map would remain open after clicking a node, thus blocking their view of the wiki text. One GFM student highlights that they would prefer the map to close instantly after clicking on a concept node, whereas another emphasizes that the issue is that they are not able to adjust the size of the map:

> "I can see the concept structure and I can see the contents of the wiki and I want to see it at the same time but now it is blocked and I can't change the size of the concept map, and the only thing I can do is close, not very friendly for the users"

Alongside this, some students also feel there is a misalignment between the concept map and the wiki, when they open the concept map button from a particular concept page of the wiki. One GFM student specifically highlights that the purpose of going to the concept map from a specific wiki page is to see that concept's connections in more detail and that this is not achieved by the current iteration of the concept map:

> "No, I have told you that when I search a topic from wiki and why I open this map I want to highlight the concept I am searching for and zooming in this place, and zooming in on the relative topics is much better."

Another issue that one GFM and one DE student face that hinders their navigation of the map is in relation to the movement of the nodes, an animation feature of the concept map. These students emphasize that the movement of the nodes is at times a distraction, and that it is not conducive to helping them understand the concepts in question.

Students suggest a number of different ways for how the navigation of the map could be further improved, with the most focusing on how you could make the exploration of the map easier to allow students to find connections between concepts more effectively. One DE student suggests the idea of a road map feature based on Google Maps, that would help lay out a learning path of sorts between two distinct concepts:

> "For example you are in Managua, you want to go to Ireland and you go to Google and it will give you the address…so then the road will be highlighted, so if you could do that with the concepts, so you are let's say in vector and you want to be in database management, so you could put two concepts and then it would be highlighted how it would be connected, using other nodes which are concepts."

*Interactivity.* Any web based educational software should respond quickly to the users attempts to manipulate it, to facilitate ease of use. While some students find the moving animation of the nodes useful, others highlight the issue that the map interface becomes difficult to control at times because of the manner in which nodes move and rearrange of their own accord. In particular, there are challenges for students when trying to drag the nodes to a particular place, or to zoom and arrange the map view in exactly the position they want. One DE student highlights the specific difficulty of trying to take a screengrab of a particular section of the map as a result of this:

> "Useful but uncontrollable, in some instances I couldn't control it, for example, one of the assignments was to submit the concept map, so I had to zoom it and you know when you release the mouse it has like an animation so it drags it slowly and then it adjusts itself, so I think I did this like three or four times to try to capture it"

While students generally speak very positively about how quickly the wiki would open after clicking a node on the map, three students express disappointment that interaction was not "two-way". The specific need is that when students encounter a specific term or concept on a wiki page they are able to click this and instantly transition to the node in the concept map. One DE student emphasizes that this would serve the overall purpose of the concept map, helping students place a concept in the broad scheme of knowledge:

> "When I'm in the text and I've got all these kind of terms and ideas in my head, I could just say okay I'm going to click into this sentence that I'm reading about and see visually how it relates to some of these other things that are floating around in my head, I think that would be helpful."

Students from both the DE and GFM groups highlight a very specific way in which the map could be made more interactive in its own right, so that it is not always necessary to exit the map to go to find more information in the wiki. One of these students proposes a feature whereby definitions or small nuggets of information pop up if you hover over a concept node:

> "So if you are in the map, if you could…sort of drill down into it and expand it to see maybe some examples…I guess you can already click it and it can take you to the corresponding text, but maybe just like a little summary, something that is almost just like a snippet of an example or definition that just kind of pops up."

Another way to improve the interactivity of the map, according to one DE student, is to link exercises or challenges to the map interface. The purpose of this function is to allow the student in question to test their knowledge of the concepts and their relationship to one another through a quiz "fill in the blanks" version version of the map. The student highlights that this type of heightened interaction would help him retain the material better.

*Content.* The above suggestions aim to tackle the issue of depth of content, and this is something which two other students make reference to. While students overall perceive the content within the map as useful, there is a concern among a minority of students about the relevance and value added by some of the semantic labelling being utilized to clarify relationships between concepts. In particular, one student sees the 'used by' label as a "bit of an excuse" that is only utilized when no other label seems to fit. One GFM student emphasizes that some labels are little more than common sense, while some require much more explanation to be understood properly:

> "Someone who havn't learned this before, who just knows yes, is 'a kind of' yes, so if you don't show me that I know from common sense...and this one is just you showed us 'is based on' ellipsoid, but how? How is it based on ellipsoid, but why ellipsoid, someone who didn't learn this before doesn't know what this means."

The main issue that students have as regards content is not in relation to the concept map though, but rather the depth and consistency of the wiki entries. This study is focused specifically on the concept map functionality, but this finding seemed prudent to include, given how critical the content on the wiki is in encouraging students to make use of the concept map as a navigational tool. One DE student cites this lack of depth in the wiki as a reason for needing to often leave the Living Textbook environment in order to find the information that was required.

*Accessibility.* Regardless of how relevant and useful the content is for users, this will be rendered null and void if students are not able to easily access the web based educational software in question. In the case of the concept map, accessibility is the second most persistent issue, after screen layout & organization. For the majority of students, this is the case because the concept map is not always clearly accessible through the wiki of the Living Textbook. Students cite that the button for the concept map is not easy to see, is not given enough importance, and is at an angle that made students unlikely to notice the map on first glance. This was most vividly highlighted during the think aloud walkthrough, where students sometimes struggle to find the concept button even after being instructed to look for it:

> "Is this the concept map? Okay, I should say this is a little small for me, it is not so obvious, and maybe there are the little images to show this is much better and then I know what this is."

Sometimes, the concept map is not accessible through the Living Textbook at all. This was the first time that the concept map has been trialled with distance education students, and one of these students shared that the concept map button is not accessible through certain PDF links the course provides:

> "These downloadable PDF's have links and the first downloadable PDF has links and we click on it we come to the page of the Living Textbook, and the little button to go to the concept map is there, it hovers on the right, but any other PDF's after that, you cannot access the concept map, you follow the links, you arrive at the Living Textbook, there is no concept map button, there is no way in, nothing".

The student in question emphasizes the critical nature of this issue, and cites this as a reason why many colleagues who are also taking the course are unlikely to have made use of the concept map. Alongside this, two other students also highlight the fact that the concept map animation requires a fast internet connection to run effectively, something that is not ideal for students undertaking distance learning in countries which experience more connectivity challenges.

## 4.3 TEACHER PEDAGOGICAL BELIEFS

### 4.3.1 Beliefs about how to promote student engagement

The teachers interviewed overall have similar beliefs about the most important factors in promoting student engagement in the MsC program. The factors which all but one teacher highlight is the medium of communication, and the degree to which students and teachers have direct interaction with one another. With regard to communication, teachers mention that challenging students within the classroom with relevant questions is one of the primary mechanisms they use to ensure that students remain engaged. One teacher in particular stresses the power of active questioning over a static PowerPoint:

> "I usually do a lot of questioning during the class, for example I try to avoid just dumping one slide after the other, I think that is awful…every 2 or 3 minutes I launch a question to the audience, and I try not to give the answer myself, it is not a rhetoric question, I really expect something."

Other teachers mention the importance of stimulating the audience with visuals, by integrating YouTube videos into the class, or beginning the lecture with a diagram or a visual example that acts as the hook to catch the student's attention and refer back to later in the session. Some lecturers highlight that one way to really promote and assess student engagement is to consciously provide misinformation:

> "I tickle them and I trigger them by telling them something opposite or wrong and then waiting for a response."

The examples highlighted above are also examples of the direct interaction that is cited as one of the primary mechanisms for ensuring that students remain involved in the session. However, two teachers specifically highlight the social or informal interactions between teachers and students as critical for helping students really feel they are being listened to and understood. Another teacher stresses this as a key difference between how engaged students are likely to be in distance and face to face education:

"All the people that were actually there, they needed help, not help with content, not at all, but help with their careers. And all needed different things…these social aspects are absolutely also important, not that I can help all of them, but at least I can listen and provide some feedback"

Alongside these two interrelated factors, 50% of the teachers interviewed also emphasize the importance of continuous learning as key for ensuring that students remain engaged. The teachers express this both as keeping up to date with the latest developments in one's academic field, but also learning from the way in which students engage with a topic, or do not engage. One teacher highlights that they learn most when students pose difficult questions they have not considered, and that this also has the auxiliary benefit of making the students feel that they can have a voice that is valued and respected. Another lecturer highlights that they gauge students' reaction to the way in which they deliver content to assess if they need to take a different approach:

"What you do is you watch what you see in the student group and if they look blank you need to find another way of explaining…maybe it's like a learning process on my side…I'm also sensing what I see in the student group, and when I sense blank faces I have to trace back and find another route."

Finally, three teachers also underline the importance of the very structure of the course in ensuring that students engage with it. Teachers highlight that if the course structure is relevant and challenging then students respond positively to that. One lecturer makes reference to the fact that ITC has a lot of possibilities to put theory into practice in real world projects, such as in work with the Red Cross, and that these possibilities are what really motivate and engage students.

### 4.3.2 Institutional influences on teacher beliefs

The findings from the interviews with the ITC faculty interviewed reveal two major influences on the way in which they approach education that are specific to the ITC department. There are an extremely high number of foreign students who study at the ITC in proportion to the University of Twente as a whole, and this unique student demographic clearly comes across as a strong influencer on the way in which ITC teachers express their educational beliefs. Alongside this, the ITC has an unusual intensive three-week course structure that again differs from the traditional semester system in Dutch education, and this could also be a potential influence on the way in which the faculty of ITC approach teaching.

With regard to student demographics, the teaching staff interviewed highlight the linguistic and cultural differences in the student body as key factors in altering their approach towards education. One lecturer specifically emphasizes the differences that exist in how students from different cultures interact with teaching staff in class:

"I am already working here a long time, there are cultural differences, definitely differences, there are more cultures where it is allowed and stimulated to have discussion even with your professor let's say, and then there are cultures where it is not allowed at all and you are not supposed to interfere or put a question"

Lecturers highlight these differences as things they need to address, and this is something that very clearly plays on their minds in how they approach preparation for upcoming modules. One lecturer highlights that they would aim to get students out of modes of learning that are "not productive", whereas another stresses the pace of learning as the biggest challenge they need to help the student body adapt to:

> "Initially a lot of people struggle with study load, some of them are mid-career professionals and they have to readjust to being a student and the speed that we expect them to go through materials. Also people come from different continents with let's say different speeds of living"

A recurring theme in the data was also that the three-week nature of the course to a large degree governs the way in which lecturer's relay content, and what expectations teachers have of their students. Some lecturers highlight that it is more challenging for students because of the intensive nature, whereas one lecturer also emphasizes the challenge this poses for the lecturers themselves in making connections between different courses that would normally be happening in parallel in the semester system. The lecturers also emphasize that in ITC there is more of a focus on practical exercises and more interaction with students than with the educational system that they were a part of as students, and this also influences the way in which they teach. They feel this interaction is lacking in the distance courses they teach in and this significantly impacts the amount of time they invest in disengaged students. One teacher emphasizes that the structure of these mediums simply does not allow teachers to reach out to students in the same way:

> "In a distance course, yeah it is the attention and presence and the structural participation of the participants that is difficult…I have taken a position now that you cannot now persist with dragging them along, you have to accept that there will be dropouts, and also you should not spend too much energy on those"

Three different lecturers make reference to the time restraints both they and the students face as a result of this intensive course module structure. One lecturer in particular highlights that this makes it difficult for students to see how different concepts connected:

> "They just get too many concepts to learn and they don't see the interrelationships and they just learn all these things but they don't see the context anymore and that is also because there is not a lot of time to practice"

Another lecturer brings attention to the fact that this intensive course structure also makes it difficult for them to find time to integrate continuous learning into their daily practice, highlighting that they need to be taken out of their current environment to be able to learn effectively.

### 4.3.3 Beliefs about tool's value for students

The pedagogical beliefs that teachers express also extend to the perspective they offer on the value they perceive in the concept map tool. Teachers are very positive overall about the tool's potential for students, yet also express some concerns in relation to issues they believe currently could inhibit students from using the tool. The main findings in relation to this are summarized below in Table 7 and elaborated further in the rest of this section.

Table 7
*Teacher perspectives on pedagogical value of tool for students*

| Theme | Summarization | Frequency |
|---|---|---|
| Perceived value | Will help them see the connections between different concepts that wouldn't be obvious from wiki text | 6/6 |
| | Will aid in placing individual concepts in overall context | 2/6 |
| | Help students to plan their study and learning more effectively | 1/6 |
| | Can help students develop logical reasoning skills | 1/6 |
| Concerns and reservations | Map is messy so students may get overwhelmed & intimidated | 6/6 |
| | Lack of hierarchy in map does not aid high level understanding | 3/6 |
| | Misunderstanding relationships because of vague semantic labels | 2/6 |
| | Ontology does not update according to the wiki page you are on | 1/6 |
| Suggested Improvements | Introduce hierarchy by emphasizing some concepts over others | 4/6 |
| | Expand the options available for semantic labels to add nuance | 1/6 |
| | Provide links to other resources on map (exercises/video etc.) | 1/6 |
| | Introduce comment layer so students can bookmark concepts | 1/6 |

*Perceived usefulness.* All teachers express the opinion that the map is useful to students to some extent, but there is quite a range in the degree of enthusiasm they express in this regard. The one aspect that all teachers agree upon as useful for students is the fact that the concept map would enable students to pinpoint linkages between concepts that otherwise would not be visible in the textbook or the wiki. However, one teacher highlights that the map is "sort of pointing to linkages" whereas another teacher claims to be "very confident" that the map would much easier allow students to see how knowledge interconnects. Alongside this, two teachers emphasize the belief that the map would enable students to see the bigger picture, and help them understand that all knowledge is part of a network:

> "It will allow them to see that concepts are not just mushrooms that have popped out of the earth and just live there, they are part of a network of information that is interrelated."

Another teacher brings attention to the fact that the concept map could function as an advance organizer that could better facilitate students to plan their learning and decide what to study, while another feels the navigation of the map itself and the way in which relationships are read could help students develop logical reasoning skills.

*Concerns.* Even though teachers in the main perceive the map as useful to students, some teachers express concerns about the potential negative impact of the map on students. These concerns relate in the majority to usability issues that teachers feel could adversely affect the student's interaction with the tool in its current iteration, but one teacher expresses reservation about the purpose of the tool in general. Every single teacher interviewed highlights the messy and cluttered nature of the screen layout as their biggest worry for students, as they feel that if not provided proper guidance students would be intimidated and overwhelmed and just not interact with the tool. One lecturer specifically feels there would be a "shock effect" when opening the map for the first time and that this would discourage use:

> "The way of visualization is not very well developed yet, it looks way way way too complex, it is likely to be quite daunting to some people when they see it for the first time, as they think oh, I can't handle that!"

A related problem which three teachers highlight is that the map does not show any sense of hierarchy, and that this would inhibit students from being able to explore the map on a high level. Another concern raised by two teachers is that the semantic labels used to describe the relationships between concepts are often too vague and could potentially lead to misunderstandings for students. One lecturer highlights that this is in part due to the fact that there are limited labels available to choose from, and thus in some cases there is no appropriate label for a relationship:

> "The semantics that are describing the relationships are sometimes not the most meaningful ones"

One other teacher feels that the map's inability to update automatically to focus on a concept when a student is moving through the wiki devalues the tool's functionality as a navigational aid.

*Suggested improvements.* The recommendations that teachers make for how the tool could improve mainly focus on introducing some degree of hierarchy into the concept map. Some teachers make reference to the fact that different ways of representing certain relationships through circles or through different size or colour arrows could be one way of addressing this issue. One teacher makes specific reference to how the tool could model itself in the same way as Google Earth:

> "You have different levels where you zoom in, where you have on a global scale where you see global patterns where you have maybe few text and major boxes and then when you zoom in you see more and more detail"

There is also reference made by one teacher to how expanding slightly the number of potential semantic labels to teachers constructing the maps would help make the tool more meaningful for students. Alongside this, one teacher raises the idea of making the map more interactive by allowing students to

bookmark concepts they found difficult, and that teachers could then be made aware of this so more specific help could be given to that student. To help facilitate more self-directed learning, one teacher recommends that the map provide links to other types of media, particularly exercises so that students could instantly move beyond the abstract view of the concept.

### 4.3.4 Beliefs about tool's value for teachers

Alongside their perception of the benefit and challenges to students, teachers also proffer their perspective on the value of the tool to them as faculty. The main findings are summarized on Table 8 below, but overall teachers seem more enthusiastic about the potential of the tool as an aid to them in planning and delivery of instruction, and management of content.

Table 8
*Teacher perspectives on pedagogical value of tool for teachers*

| Theme | Summarization | Frequency |
|---|---|---|
| Perceived value | Helps faculty connect content within and between courses | 6/6 |
| | As in classroom tool for introducing and assigning content | 3/6 |
| | To gain feedback from students on concepts that pose problems | 3/6 |
| | Helps to spot gaps and inconsistencies among module content | 2/6 |
| | As a flexible content management system that updates easily | 2/6 |
| Challenges posed | The time commitment required from teachers to construct map is substantial and adding hierarchy will place further time pressure | 2/6 |
| | Granularity of modelling differs according to teacher style | 1/6 |
| Suggested Improvements | Allow teachers to highlight a specific set of concepts on the map | 2/6 |
| | Track the concepts that students select most frequently and chart the most common learning trajectory through the concept map | 2/6 |
| | Have a base unit per hour taught of the number of concepts lecturers use in their map to help ensure consistency in the map | 1/6 |

*Perceived usefulness.* The primary benefit of the tool identified by teachers is something that took place during the construction of their maps and the discussion that took place around this with colleagues. Teachers developed the ontology for their individual subject area before aligning with colleagues and they are unanimously effusive about the value of this exercise in identifying and clarifying the main concepts of their modules, and the connections between them. Teachers highlight that there was often some level of disagreement between faculty when consolidating their different maps together, and that the map facilitates discussions about what content should and should not be connected. Two teachers

also cite the importance of the ontology construction process and discussion in helping them to identify the gaps and inconsistencies between the textbook and the content that they plan to teach in their modules. One teacher highlights that this made teachers recognize areas for textbook revision:

> "Those relationships were also pointing to gaps in the official textbook which is very interesting, like for example what do you mean this concept is not in the book, no this concept is not in the book and them some of them realized okay, maybe the text is in need of a serious update and a serious revision."

Two teachers suggest that the map itself could function as a flexible content management system, which would be easier and more cost effective to update than a printed textbook. It is also highlighted by three teachers that the map could be a mechanism for teachers to gain feedback from students about the concepts that were most challenging to them.

Half of the teachers interviewed also believe that the tool has potential to be used as an instructional aid in the classroom. Two teachers say they could see the value of the tool in highlighting to students a set or cluster of concepts to be studied at the end of a lecture or to prepare for an exam, and that this would be a less artificial means of clustering concepts than a chapter in a textbook. Alongside this, one teacher stresses that the tool could even be used as a means for bringing students attention to the 'bigger picture' in class:

> "The lecture today is going to be about a certain topic so we go straight to the ontology, talking about what are the major concepts directly connected to this one and then…putting a boundary line around the subject matter of that lecture and if possible connect it to something that has happened before, and at the end of the lecture you could say now we have looked at this and the next subject is over here and it is related in this way"

*Challenges posed.* The majority of teachers do not highlight challenges in their use of the tool as teachers, but two teachers do make reference to the time commitment involved in the construction of the map as an issue. The creation of ontologies and the merging of them with different teachers is described as a time intensive process that required numerous meetings over a sustained period of time, and some teachers think this is unsustainable:

> "It was a bit too much for me and quite some of the others as it was too much time pressure."

Some teachers are worried about whether this level of time commitment would be required moving forward and are especially concerned that adding additional functionality such as hierarchy to the concept map would require a substantial amount of time and effort for lecturers to agree on how to go about this. Another challenge one teacher thinks they have to deal with was that there was a large difference in the level of detail in lecturers' concept map ontologies.

*Suggested improvements.* Teachers suggest some additional functionality to be added to the map so they could implement some of the ways in which they would prefer to use the tool as an instructional aid in the classroom and as a means to understand student's challenges better. Two teachers mention that they would like to be able to highlight a specific set of concepts on the map to pinpoint to students the

concepts being studied in class or those that were going to be important to revise for an upcoming exam. Teachers also recognize that it could be technically challenging to track student's movement through the map to better understand which concepts were posing difficulties, but two teachers reiterate that this would be of benefit to them if it were possible. One teacher in particular highlights that this could offer insights on the typical learning journey of students:

> "It would create interesting visualizations if you could show in a concept graph…which relationships are frequently visited one after the other, or which concepts are frequently visited one after the other."

In order to combat the inconsistency in the granularity of modelling in the construction of the ontologies, one lecturer proposes introducing a base unit that would equate a certain number of concepts to the teaching load in hours. He explains that this would pose its own challenges, but at least it would ensure a more uniform approach to modelling for teachers.

# 5. DISCUSSION

*While students are currently engaging with the concept map as a navigational aid and teachers do perceive value in the tool, more effective visualizations and screen layout are needed to enable its optimal use. The study has theoretical implications for research in that the level of clutter of the screen layout is causing map shock and preventing students from engaging with the map, and also that students with lower verbal ability may benefit more from its use. It is recommended that a greater sample size and a more controlled longitudinal experiment is carried out in future research, to tackle the limitations of the current study and to provide more empirical evidence on whether the map increases conceptual understanding. Design recommendations (p. 55) are provided to help the next iteration of the tool to better support students and teachers, and it is recommended that the updated tool be integrated into the classroom as an instructional aid to increase student engagement and enable students see the bigger picture and contextualize learning.*

## 5.1 CONCLUSIONS

This research focused on the following question: *How do students and teachers in higher education engage with and perceive the web based 'Living Textbook' visualization tool?* To answer the above question, the three sub-questions below will first be answered, and then discussed in more detail in the subsequent sections:

### 5.1.1 RQ1: What is the nature of student engagement when interacting with web based expert generated concept map tools?

The findings in the previous section suggest that not all students engage with and interact with web based expert generated visualization tools in the same way. The majority of students engage with these tools to more quickly navigate to the information they need, but not all students are behaviourally involved with such a tool. Students cognitive engagement takes the form of an increasing sense of competence in understanding concept connections and a greater metacognitive awareness of where their learning fits into the bigger picture of course content. The majority of students are also emotionally engaged with the tool, with this taking the form of enthusiasm for the tool as a whole and frustration relating to specific usability issues they experienced in their interactions with it.

### 5.1.2 RQ2: In what ways is the current prototype of the Living Textbook concept map tool usable or not and why?

The current prototype of the Living Textbook concept map tool is usable and adds value in some ways, but needs significant refinement in others in order to enhance the user experience. Students in the main perceive substantial value in the tool's overall functionality, and particularly with regard to its ability to enable them to better understand the connections between concepts. However, there are issues with the screen layout of the tool, as students feel it is too cluttered and there is a lack of hierarchy which leads to a feeling of intimidation. Alongside this, students see the need for significant improvement in making the tool easier to access and in navigating seamlessly between the concept map and the wiki interfaces. While students do perceive value in the tool as a navigational aid to the wiki,

these findings suggest that with more effective visualizations and structure, the concept map would be used more as an independent means to build conceptual understanding.

### 5.1.3 RQ3: What kind of pedagogical beliefs do faculty hold in relation to concept map visualization tools?

Overall, faculty believe that concept map visualization tools offer value to both teachers and students, but they believe that more effective visualization techniques and may layout need to be implemented in order for students to gain the full benefit of the tool. The findings emphasise that teachers believe that the most important way to engage students is through choosing the most appropriate medium of communication, and this points to the importance of developing such tools in a way that allows more effective use as an instructional aid for teachers. Teachers believe that such tools could help students refer to the big picture and contextualize classroom learning as well as providing a medium for less outspoken students to highlight concepts they are struggling with. All teachers believe that the tool in its current guise already has benefit for teachers in helping to organize content within and between courses, but concerns exist in relation to the time commitment involved in its maintenance and improvement.

### 5.1.4 Main RQ: How do students and teachers in higher education engage with and perceive the web based 'Living Textbook' concept map tool**?**

The answers to the sub questions above highlight that teachers and students engage with and perceive concept map visualization tools in different ways. With respect to the Living Textbook tool specifically, it is clear that the concept map is perceived by students as a valuable aid in the learning process, and most students seem emotionally and cognitively engaged with it. However, this positive perception is clouded by usability issues relating to screen layout and navigation, and this could affect how likely students will be to engage with such a tool in the long run. Teachers perceive the Living Textbook concept map as primarily beneficial in the planning and organizing of course content, in that it aids them in connecting concepts and identifying inconsistencies between and within courses. While teachers do perceive potential value in the map as an instructional aid in helping students to better see interconnections between concepts, they see need for more effective visualizations to enable this.

## 5.2. DISCUSSION OF FINDINGS

The findings of this study show a number of significant themes emerging in relation to how teachers and students engage with and perceive the Living Textbook concept map tool. First of all, students see the concept map as beneficial primarily as a means to finding information about connected concepts quicker. Students also highlight that they perceive an improvement in their competency and metacognitive awareness through their use of the tool. However, the central issue preventing students using the concept map more as advance organizer, is the fact that there is no hierarchy in the concepts

shown and as a result the students perceive the layout as messy and cluttered. This same theme is echoed in the teacher's responses to the tool, who do see potential use in the concept map in an instructional context, but believe that more effective visualizations and greater ability to manipulate the concept map would be necessary for the tool to fulfil this function. As a result, students are primarily using the tool as a navigational aid to the wiki and teachers are primarily using the tool in the planning and organization of course content. The similarity in the perspective of students and teachers on this theme of clutter and lack of hierarchy is striking, and it would seem from the findings that students are not exploring the concept map to see the relationships between concepts and to gain an understanding of the overall body of knowledge as a result of this. Another theme emerging about teacher beliefs is that teachers see the medium of communication as the most important aspect in engaging students in the classroom and the findings point to be the potential for the students to engage much more with tool if it were integrated by teachers into the classroom as a way to help them see the bigger picture in each individual lecture. Teacher's current perception of the tool highlights that if hierarchy and more effective layout were integrated into the concept map then teachers would make more use of the tool as a medium in the classroom and students would therefore engage more with it in their learning process. These themes in relation to the way in which students engage with and use the tool and how teachers perceive the tool will be explored in the sections below.

### 5.2.1 Student engagement with the concept map

Most students in the present study who have the Living Textbook available to them as part of their online course environment highlight that they frequently engage with the concept map to enable them find information more quickly in the wiki environment. This aligns with existing findings which outline the positive relationship between web based learning technology and student engagement (Chen et al., 2010). However, one student does highlight that despite the presence of the concept map, they would still prefer to use a traditional printed textbook because it engages more of their senses. This is consistent with research that emphasizes eye strain and difficulty of navigation as reasons why students disavow electronic texts in favour of printed textbooks (Woody, Daniel & Baker, 2010). Some of the teachers interviewed also emphasized these factors as reasons why they would still prefer printed textbooks over digital learning aids.

The DE students interviewed overall perceive an improvement in their conceptual understanding as a result of the concept map, and this points to a degree of cognitive engagement. Students highlight that the map enables them to be more aware of the way in which they are learning and the strategies they are employing in the process, and this corroborates the findings that asynchronous instructional technology allows learners more time to think critically and reflectively (Robinson & Hullinger, 2008). DE Students emphasize that the concept map helps them develop increased competence with the subject matter in their course, due to their ability to see conceptual connections through it. This association between student's efficacy beliefs and the use of the concept map has

positive implications for the claim that DE students were engaging with the concept map, as students with high self-efficacy beliefs have been shown to be more likely to be behaviourally, emotionally and cognitively engaged in the learning process (Linnenbrink & Pintrich, 2003). Alongside this, students report a heightened sense of metacognitive awareness as a result of their engagement with the map, emphasizing that it enables them to reflect on their learning, and identify new strategies for how to approach learning the body of knowledge.

Students in both the DE course and the GFM usability test seem to be emotionally engaging with the concept map tool, although there was a mix of positive and negative affect associated with the tool. The majority of students express frustration with some aspect of the concept map and. negative states of emotion such as these have been shown to have harmful effects on learning and cause students to disengage from learning activities (Baker, D'Mello, Rodrigo, & Graesser, 2010). However, there was only one student who highlighted a sense of anxiety in their use of the concept map, and Baker et al. (2010) emphasize that frustration is less likely than anxiety to cause disengagement from the learning task. While the frustrations students express are a distraction from the task at hand, they are primarily in relation to usability issues for specific features that they feel need to be improved, rather than frustrations with the tool as a whole. The same students who expressed frustration about specific features of the tool also highlighted their enthusiasm for the concept map overall, particularly as an aid in guiding and facilitating the search for information. While enthusiasm is an emotion which is lower in emotional intensity than joy or delight, emotional responses of this intensity can actually have the capacity to broaden students' attentional focus and cognitive processes (Valiente, et al., 2012).

### 5.2.2 Usability of the tool

The majority of GFM and DE students perceive the concept map tool as a useful aid in their learning. The primary reason students outline for this is that the map enables them to find relevant information more easily, and this is consistent with research which highlights that individuals find it more straightforward to access relevant information when presented with a concept map-based interface as opposed to a web-based interface (Carnot, Dunn, Cañas, Graham & Muldoon, 2001). The majority of students emphasize that they are more likely to use the concept map than the wiki, and the primary reasons for this is the speed with which they are able to find information using the concept map. This continued emphasis throughout student responses on the primary navigational benefit of the concept map is in some ways surprising, as very few students make reference to the capacity of the concept map to act as an advance organizer, contrary to research on similar adaptive concept maps (Moore, 2015). However, almost all students perceive the concept map as useful in seeing the connections between concepts, and the convenience offered by the map's interactive features is cited as a key reason for this. This aligns with claims that concept maps can help students build a conceptual understanding of the content studied (Moore, 2013). One student highlights the maps usefulness in solving the challenges posed by the English language, by simplifying complex content into simple to digest relationships. This

points to research which emphasizes that knowledge maps can be most useful for students with low verbal ability (O'Donnell et al., 2002).

However, despite finding utility in the concept map's functionality, students identify substantial usability issues with the screen layout of the tool. Students universally emphasise that the biggest gripe they have is that the concept map layout is messy and cluttered. This lack of order led to many students expressing symptoms of 'map shock' (Blankenship & Dansereau, 2000), something which can lead to students feeling disorientated and not processing content effectively (Moore, 2013). Students highlight the fact that too much information is presented at once on the concept map, and research has shown that this limited visual and cognitive processing capacity of the map reader is the biggest challenge to creating effective animated maps (Harrower, 2007). A recurring theme in student responses is that they would favour a more structured or hierarchical approach to the layout of the concept map, and Novak & Cañas (2008) emphasize the importance of hierarchical structures in concept mapping, with progressively reducing generality at the lower levels. Interestingly, this preference among students for hierarchy in the map could point to the fact that students may not have seen the potential use of the concept map as an advance organizer due to the messy and cluttered screen layout. Teachers interviews also corroborated these findings, as the majority believe that introducing a sense of hierarchy will increase the usefulness of the concept map to students. Any inclusion of hierarchy into the concept maps will represent scalability trade-offs (Schwab et al., 2017), and thus this is a challenge that will need to be addressed by effective knowledge visualization techniques.

Students interviewed highlight navigation, interactivity and accessibility as issues that negatively impact the ease with which they could use the concept map and research hihglights that perceived ease of use can be said to directly affect perceived usefulness (Pituch & Lee, 2006). Students are unable to easily switch from the concept map to the wiki, often being prevented from reading the text and viewing the map at the same time. Students also feel it takes significant time to understand the logic of relationships and the direction of arrows on the concept map, and these issues highlight that the concept map is not currently as intuitive for students as it could be. The more intuitively that web based systems are designed, the more they will encourage further use by students (Cook & Dupras, 2004). Another critical issue many students face is that they often experience difficulty in accessing the concept map, either through online PDF links in the DE course, or through the wiki homepage during the think aloud walkthrough. Many students highlight that they would prefer the concept map to be made much more prominent on the wiki homepage screen and in the online course environment, as they feel this would encourage more consistent use and indeed research emphasizes that if students are not able to access the web based software in question, it makes good content and interface design irrelevant (Shiratuddin et al., 2003).

Students offer numerous suggestions on ways in which the concept map could be made more useful to them in their learning process. Students highlight that the map could be made more interactive by introducing a quiz version of the map, but research highlights that 'fill-in-the-gap' uses of concept

maps such as this do not necessarily lead to meaningful learning (Cañas, Novak & Reiska, 2012). Other students in both the DE and GFM interviews emphasize the utility of definitions popping up as the user navigates the concepts on the map, and Moore (2015) highlights that this could be a way to help students avoid clutter in their use of adaptive concept maps. Another student emphasizes that the concept map could be made easier to navigate if a road map feature was included that helped identify suggested non-linear learning paths, similar to the structure outlined in Harvard's booc.io research (Schwab et al., 2017).

### 5.2.3 Teacher's pedagogical beliefs

The ITC teachers interviewed as part of this study believe that student engagement can be fostered by primarily ensuring opportunities for direct interaction between teachers and students, and communicating with students in an interactive and non-prescriptive manner. Most teachers emphasized the use of active learning techniques such as asking students to respond to video, debating topics in class and questioning students in class as critical in developing analytical capacity, while also ensuring that attention is maintained. Teachers highlight distinct institutional influences on their beliefs at ITC, particularly that students come from extremely diverse cultural backgrounds and often have very different capabilities with regard to English language and the role of authority. The teachers at ITC are very aware of these cultural differences, and believe that through the process of challenging students to discuss in class and providing hands on exercises, they can help to ensure that all students become independent learners and practical problem solvers. Alongside this, the teachers emphasize that students learn in intensive three-week course modules at ITC, as opposed to the traditional semester system. Teachers at ITC highlight that this intensive course structure can make it difficult for them to help students see the interconnections between different course subjects because of the time constraint and because diverse courses are not taking place simultaneously as they would in a semester system. Bennett et al. (2015) highlight that such institutional factors can be constraints to teachers putting their beliefs into practice.

ITC teachers emphasize the increased ability to spot gaps between courses and see how they interconnect with one another as one of the biggest pedagogical benefits of their involvement with the concept map tool and this aligns with research highlighting this as a benefit of constructing expert generated concept maps (Moore, 2012). Teachers highlight that they normally do not have time for professional development activity, but that this process forced them to think about their course structure and the content within it. This is consistent with the findings of Schwab et al. (2017) regarding the reactions that teachers experience in the process of constructing course wide concept maps. Alongside this, teachers also see value in the tool as an instructional aid in the classroom, corroborating the claim that such tools can better enable teachers to help students contextualize class content and see the bigger picture (Schwab et al., 2017). Teachers also emphasize the potentially insightful visualizations that could be created by tracking students' interactions through the concept map, as this would help them identify

which concepts students were finding the most challenging. Gaining formative feedback from students has been seen as a vital way for teachers to learn what concepts students find most difficult (Juwah et al., 2004), and other research goes further to highlight the benefits of tracking student's interactions with online resources to identify favourable learning paths (Schwab et al., 2017). While teachers are optimistic about the opportunities such technical possibilities could bring about, they are apprehensive at the time commitment involved. One very substantial concern some teachers express is that as hierarchy is integrated into the concept map, the time constraints that this would place on teachers could become unsustainable, and this echoes previous research on similar expert generated concept map tools (Moore, 2012).

The concerns teachers have in relation to the map's utility and value for students are very similar to those the students themselves express. Teachers believe that the map has the potential to enable students to see connections between concepts that would not be easily visible through the textbook, but that the current cluttered layout of the map would intimidate and confuse students. Teachers were adamant that this needs to be addressed if students are to use the map effectively as a navigational tool and this is in line with research which highlights the danger of the overload scenario existing when a map and text are presented on screen together (Mayer & Moreno, 2003). Teachers specifically highlight the split attention effect (Mayer & Moreno, 2003) that students may experience as a result of the moving animation, and some students themselves also identify this as a distraction. Teachers do see the potential of the tool as an advance organizer of sorts for students (Moore, 2015), in that they perceive it could provide a less arbitrary way of helping students contextualize knowledge if used at the beginning of a lecture. This is a particularly interesting finding in light of the fact that students do not perceive the potential use of the map as an advance organizer, and points to the importance of teachers integrating the map into their pedagogy to enable students see its full benefit. There is also a large degree of similarity between teacher and student suggestions for ways to introduce hierarchy into the concept map, with colours and the size of the nodes being the most common suggestions for how to do this.

## 5.2 THEORETICAL IMPLICATIONS

The findings from this research indicate that such concept map visualizations are positively perceived by students as a navigational tool, and this offers some additional insight into previous research exploring their potential use as interactive digital tools linked to repositories of information (Moore, 2012; Moore et al. 2013; Moore 2015). However, although the study highlights that students perceive the concept map tool as having an impact upon their competence in seeing connections between concepts, this is still solely a perception as the instruments used in the study were self-report measures. This highlights the need for more empirical research to explore whether a tool such as this can have a tangible and directly measurable impact on a student's conceptual understanding.

The findings of the present study also provide evidence to support the theory of map shock outlined in the first chapter of this thesis (Blankenship & Dansereau, 2000) as students report symptoms

of cognitive overload they experience while interacting with the concept map. The cognitive overload students experience emerges due to the cluttered nature of the screen layout, with too much happening in terms of both animation and text. This overload of information emphasises the importance of introducing hierarchy into the concept map and greater user control of view into such concept map tools, so that users can access more information on demand rather than being presented with it all at once. This points to the need for future research to explore if the introduction of more hierarchical visualizations reduces map shock, and that if this in turn has an effect on increasing the degree to which students use the tool and improve their conceptual understanding of the course content.

Alongside this, an emerging finding of this study which could have implications for existing theory is that students who struggle with the English language perceive the concept map as more useful specifically for them as an alternative to reading large chunks of text in a book or wiki page. This lends credence to previous research claims outlined in the introduction which highlight that concept map tools could be of greater benefit to students of low verbal ability (O'Donnell et al., 2002) and this should be investigated further in future research. Students could be identified by their English language competency in advance of a controlled experiment involving a similar concept map tool, and then the differences in usage patterns and improvement rates among students of high and low verbal ability could be analysed over the course of a term. This could provide valuable input to theory on the benefit of concept maps tools to students with different language competency.

Finally, the teachers interviewed unanimously highlight the value they see in the concept map construction process in helping them spot gaps and inconsistencies within course content, which lends further evidence to claims previously outlined in this research which highlight that teachers believe that tools such as these offer value in organizing and structuring course content (Schwab et al, 2017; Moore, 2015). However, the findings from this research also highlight that teachers are optimistic that such a tool could be used as an instructional aid in the classroom to help students be more aware of the bigger picture if more effective visualizations and greater user control were added to the tool. This points to the need for future research to explore whether such an updated tool would be used by teachers as a classroom aid over the course of an academic term, and the impact that this may have upon students use of it as an advance organizer.

## 5.3 LIMITATIONS OF STUDY AND RECOMMENDATIONS FOR FUTURE RESEARCH

As with any study, this research has a number of limitations. The first of these is in relation to the sampling strategy employed. Purposeful sampling was used to identify students who were currently being exposed to the concept map as part of their DE course, and the students that took part in the study were contacted by the researcher and provided qualitative feedback on the concept map of their own volition. However, more than fifteen students were taking the DE course, and only four responded and took part in the study. The concern which this raises is that the students who responded and agreed to the interview were those that were anyway more naturally interested and engaged with the concept map,

thus raising concerns about the reliability of the findings. These same concerns regarding self-selecting bias (Hernán, Hernández-Díaz & Robins, 2004) also applies to the teachers who responded to requests for interview, and the GFM students who volunteered to participate in the think aloud study. The sample size is also a limitation of this study, as in each dataset there were no more than six participants who took part, despite the researcher aiming for a higher response rate. However, Creswell (2011) highlights that it is typical in qualitative research to study a few individuals or cases and Chapman (2003) emphasizes that understanding engagement effectively is often better served by a small number of detailed descriptive accounts. It is recommended that the next prototype of the Living Textbook tool be trialled in a real-life classroom setting, with a control group in one term who use the Living Textbook wiki only, and an experimental group in the next term who have access to both the concept map and wiki. This would help to combat the self-selection bias as whole classes of students would participate in the research and this would also help extend the sample size.

Another key limitation of this study is that all the data collected was collected using self-report instruments, which can cause common method bias. The views that students and teachers share with regard to their engagement with and perceptions of the concept map tool are not corroborated by any other qualitative or quantitative data so this raises questions about its reliability. Assor & Connell (1992) also emphasize that the validity of the data yielded by self-report measures such as these will vary considerably with students' abilities to accurately assess their own cognitions, behaviours, and affective responses. Alongside this, due to the self-report instruments used, the participants are always speaking to or in the presence of the researcher and thus the data collected runs the risk of social desirability bias (Fisher, 1993). However, the think aloud study was included to provide somewhat of an antidote to this, as the fact that students are speaking their thoughts in the moment can make them less likely to tailor their answers to what they think the researcher wants to hear. One way in which the reliability of the findings in relation to engagement could be improved would be to statistically track the student's usage patterns of the concept map and then compare this with their anecdotal reflections on levels of engagement. This could help researchers understand if students use such tools primarily as a navigational entry point to explore more detailed content on the wiki, or whether students spend significant time exploring the map in and of itself. Students could then be assessed by a pre and post test to see if there are any significant differences in the rate of improvement with regard to conceptual understanding. and how their patterns of engagement influence conceptual understanding.

Finally, another limitation of the study is the fact that teachers and students were only interviewed on a single occasion, and after having had limited interaction with the tool in the teaching and learning process. Griffin (2004) highlights that longitudinal studies can offer particular value in qualitative studies by highlighting contradictions in and progression of participants views over a series of interviews or observations. However, this research was an evaluation of an early stage prototype of a concept map tool, and thus a single snapshot perspective on the tool was deemed sufficient to provide recommendations for future iterations and evaluative studies. The above concern could be addressed by

future evaluative research of a further iteration of the concept map tool, whereby the student group engaging with the concept map over an entire term could be interviewed at intervals throughout to see how their perception of the tool develops over time. Moore (2015) highlights the need for understanding how and why students develop these behaviours in relation to concept map tools, and this approach could address this need.

## 5.4 DESIGN RECOMMENDATIONS FOR TOOL

The findings discussed above highlight that the majority of students engage with the concept map tool in its current iteration and see it as a useful learning aid, and that the majority of teachers perceive it to be of value to both themselves and students. However, substantial usability issues are at present increasing the extraneous cognitive load students are facing, and preventing both faculty and staff from extracting maximum value from the tool. As a result, this study proposes the below design guidelines in Table 9 as a means of tackling the issues outlined above, and ensuring that the tool provides optimum support to both teachers and students in the teaching and learning process. Each of the key issues has emerged directly from the data obtained from the student and teacher interviews, and the sections listed alongside that issue (e.g. 4.1.3/4.2.1 Cognitive overload) highlight the specific sections of the findings the issue originates from.

Table 9

*Design recommendations for the Living Textbook concept map tool*

| Key Issues | Recommendations | Example |
|---|---|---|
| **Providing support for students** | | |
| *4.1.3/4.2.1 Cognitive overload*<br><br>Why: Students intimidated and overwhelmed by the large amounts of information they are confronted with when they open the concept map for the first time | Introduce content in the concept map on an incremental basis to help students manage cognitive load<br><br>Enable students to have more autonomy over what content they choose to see on the concept map<br><br>Provide students with more control over the size of the concept map | *Only show relevant cluster of concepts when students navigate from wiki to concept map and have button which allows students to 'see full map' if they want to explore more generally. Also allow students to manipulate the size of the concept map screen so they can have more control over their learning experience.* |
| *4.2.2/4.3.3 Prioritizing content can be a challenge for students*<br><br>Why: Students not able to prioritize or structure use of the concept map because every data point is represented in the same way | Introduce an element of hierarchy to help students discern between concepts that are of greater importance<br><br>Create super concepts that tie different courses together and which are visible as the first layer of the concept map | *Have more important concepts be denoted by a bigger node or larger text, or have different coloured lines or different size lines to denote the strength of relationships* |
| *4.2.2 Tool difficult to notice and access*<br><br>Why: Students not always able to access map through course environment and feel map is not given enough prominence | Ensure that the design of the online course environment and the Living Textbook wiki encourage students to open and make use of the concept map | *Have the concept map button as a more prominent feature at the top of the wiki homepage and/or have the map open in a small window when students first open the wiki homepage* |
| *4.2.2/4.3.3 Lack of depth*<br><br>Why: Students and teachers see certain relationship labels as less meaningful than others.<br><br>Wiki entries that lie behind concept nodes vary in terms of depth and quality of content | Ensure that content included on the tool provides students with sufficient nuance and meaning<br><br>Have teachers cross check one another's expert generated content to ensure consistency of content depth is provided to students<br><br>Include links on the concept map to resources outside the LTB | *Increase the number of semantic labels that teachers have to choose from in order to enable them to ensure each relationship delineated on the concept map adds value to students understanding. Also include the option for students to see exercise and video content on the web linked to concepts that can provide more depth if needed.* |

| | | |
|---|---|---|
| *4.1.2/4.2.2 Reading of map not intuitive*<br><br>Why: Students are not used to reading from a right to left direction and the size of arrowheads are too small for some students to identify relationships<br><br>There is insufficient guidance given to students to help them understanding how the map functions | Include more detail on demand in the concept map to enable students to contextualize information more effectively<br><br>Provide students with adequate introduction and guidance with regard to how to use and acquire meaning from the concept map | *Have definitions of concepts pop up as a side box when students hover over them. Also, place arrowheads in the centre of relationship lines, so that they are more visible to viewers on first glance. Finally, replace the ReadME button with the option of a video tutorial that pops up when you first open the concept map, and that narrates how to read and use the concept map.* |
| **Providing support for teachers** | | |
| *4.3.2/4.3.4 Time intensive to update*<br><br>Why: The more complexity and nuance that is added to the concept map, the more time consuming a process this becomes for teachers. | Ensure that the back end of the tool is easy to maintain for teachers.<br><br>Integrate the maintenance of the tool into existing evaluation activities. | *Identify a set of super concepts that connect courses so that individual teachers do not need to rewrite their entire ontology. Conduct yearly reviews at faculty meetings so teachers do not need to work on their concept maps individually.* |
| *4.3.4 Track learning paths*<br><br>Why: Teachers want to understand more about the way in which students learn to better enable them to adjust and structure course content | Track student use of the Living Textbook and concept map tool. | *Integrate functionality that gathers data on the most common routes that students take through the concept map, and the order in which they look at concepts, to help create an elephant trail that can show how students learn.* |
| *4.3.3/4.3.4 Facilitate use of the tool as an instructional aid*<br><br>Why: Teachers can benefit from having the concept map as an interactive tool in the classroom to contextualize course/lecture content. | Create a separate version of the concept map that allows teachers greater control in manipulating content. | *Include the capacity for teachers to highlight a specific set of concepts or cluster of concepts that they can identify as study material or to use to show the bigger picture in class* |
| *4.3.2/4.3.4 Facilitate interaction between teachers and students*<br><br>Why: Some students are less likely to raise doubts in class because of cultural or other differences.<br><br>Teachers benefit from having a sense of how different students are progressing. | Integrate functionality into map that allows students to highlight content that they are struggling with so that teachers are able to use this as formative feedback on individual student and class progress with regard to conceptual understanding. | *Include a comment layer on the map that students can add to with queries regarding concepts and teachers can choose to view this comment layer and view the issues students have. Another solution would be for students to be able to flag concepts they are struggling with by pressing a button and teachers can then see concepts causing most doubt.* |

Based on the findings of the present study, the following recommendations can be made for both the design and implementation of web based concept map tools in higher education. It is important that designers recognise and tackle the challenge of 'map shock' that students may face when confronted

with large amounts of information on a map screen. Designers should endeavour to introduce some element of hierarchy or layering that enables students to discern between concepts of greater and lesser importance, and ensures that students are not overwhelmed by the data displayed. Findings from the study highlight that students would engage more consistently with the concept map if they had more control over the layout and view of the concept map. It is thus recommended that designers include features that allow students autonomy with regard to the way in which they visualize the map, as a greater level of control can allow students to utilize the map for different purposes. Designers should also ensure that any element of hierarchy introduced to such a tool is sustainable in terms of the time required from expert teachers to create the content required, as this is a concern that teachers interviewed express.

It is also suggested that as different functionality is added to the map, designers conduct formative pilot studies with Masters teachers and students in ITC to gain quick feedback with regard to whether the user need is being addressed by the proposed innovation. The design guidelines proposed in this study could form the basis of the incremental improvements that are made in the concept map, and it could be evaluated to what extent further iterations meet the guidelines proposed. The present study has shown that both teachers and students have very firm opinions on the way in which they believe the tool should look and function, and also have numerous ideas about how this could be implemented in practice. The benefit of involving teachers in every stage of the design process of such a tool, would have the auxiliary benefit of making teachers more invested in the final version of the tool that they are encouraged to use in their practice.

In order for tools such as the Living Textbook concept map to be integrated effectively into the teaching and learning process, there should be efforts made to ensure that all teachers and students are trained in the use of it. It is recommended that a workshop be conducted with teachers in advance of the introduction of such a tool as to the pedagogical benefits of the concept map, and the way in which it could be used as an instructional aid within the classroom. The present study highlighted that the type of visualizations facilitated by the map are not common to students, but that these tools can offer value to students who engage with them in a sustained manner. If teachers were also comfortable in advance with the functionality of a digital concept map, they would then be all able to introduce the tool in the same way in their classrooms and model its use in order to ensure that students are aware of what functionality it offers. Further, designers should also attempt to integrate multimedia tutorials into the tool so that students can receive an explanation in its functionality at the point of use.

## 5.5 CLOSING REMARKS

The present study set out to explore the way in which students and teachers engage with and perceive the web based ‘Living Textbook’ visualization tool, and to provide recommendations for how such a tool could be improved to better support students and teachers. The goal was to provide insight on the different ways that student engagement is triggered by visualizations such as these, and to understand

which elements of the tool students and teachers perceived as useful and less useful. The findings show the value that teachers and students at ITC perceive in the navigational capacity of such concept map tools and their ability to facilitate conceptual understanding, and highlight that students are emotionally and cognitively engaged in their use of such tools. Alongside this, both students and teachers have concerns that exist with regard to the cluttered nature of the screen layout and the limited functionality of the tool. The data that was collected from teachers and student interviews was used to create a set of recommendations to improve the design of the Living Textbook, and these recommendations have the potential to increase student engagement with the tool and enable teachers to perceive them as more valuable instructional aids.

There is clear potential in the capacity of such tools to enable students to see connections between concepts that wouldn't be as easily seen in traditional educational approaches, but visualization challenges will need to be addressed and explored in future research in order to ensure that students do not become lost or intimidated by the sheer volume of data presented to them in course wide concept maps. Teachers can play a vital role in guiding students in seeing the bigger picture of course content through the maps use in an instructional context, and also can benefit from the tool in the organization and structuring of course content. In order to ensure that stakeholders adopt such tools and integrate them into their teaching and learning process, it is crucial that both students and faculty are involved in the design process of such innovative alternatives to traditional textbooks.

The findings of this research study highlight that this tool has many potential applications in the teaching and learning process, particularly if more effective visualizations and hierarchical structures are implemented. Teachers in both face to face and distance education could utilize such tools as a fulcrum around which they plan and deliver their instruction, if they had greater ability to manipulate the content on screen, and this research suggests that teachers are open to this as a possibility. Teachers could introduce the tool as they are introducing the module as a whole, and in this way can highlight to students the specific body of knowledge they will be encountering over the course of the semester and the ways in which these different concepts interconnect. Teachers could then return to this map at the beginning and end of every lecture which would serve to orient students to how what they are learning fits into the overall body of knowledge and their existing knowledge structures. Students would then be more likely to utilize this tool as an independent resource to situate the knowledge they are learning, and teachers could then gain feedback through student use of it with regard to the concepts that students find the most challenging. The findings from this study highlight that expert generated concept map visualization tools thus have the potential to combat the difficulty teachers have in helping students visualize the interconnections between concepts, and can offer a fresh medium to engage students both in and outside the classroom.

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# 7. APPENDICES

## 7.1 APPENDIX A: SEMI STRUCTURED INTERVIEW SCHEMA FOR STUDENTS

**Part One – Understanding student perceptions of learning**

What comes to your mind when you hear the words 'to learn'?

How do you prefer to learn? What mediums do you like to learn through and why?

What do you think is the role of the teacher in the learning process?

How has the experience of doing distance learning been different from the face to face experiences of education you have had?

What are the aspects of this specific distance education course you have liked the most so far? What are the aspects you have found challenging/frustrating? For both, why?

**Part Two – Understanding the student experience of using the concept map tool**

How have you engaged with the Living Textbook so far?

When do you use it, as in just for specific tasks or more generally for expanding your information base?

How was your experience of using the Living Textbook different or similar to a traditional textbook?

When you opened up the concept map for the first time, what was your reaction?

How do you think the visualizations are impacting how you are learning in this year's DE GIS module?

How do you think your experience would have be different with just the WIKI and no concept map?

How was using the search function on the wiki and the concept map similar or different?

How did the concept map change how you thought about the relationships between concepts?

With the semantic labelling that was used, can you describe how that influenced your understanding?

How was your experience of navigating the concept map visually to look for concepts you might already know?

How could the visualizations be made more effective for the next iteration of the tool?

In terms of the visual appeal or design of the concept map, would you have any comments on that?

What suggestions for additional functionality could the WIKI/Concept Map provide? Why would this feature appeal to you?

Is the wiki/concept map similar to how you currently search for information yourself? If so, how? If not, how is it different?

**Probes:**

Can you give an example of that, I think I know what you are talking about, but if you could clarify?

Why do you think that would benefit you so much?

Can you explain why you found that aspect so challenging?

## 7.2 APPENDIX B: CONCURRENT AND RETROSPECTIVE THINK ALOUD PROTOCOL

**Notes for the researcher:**

Record written observations of participant actions and reactions during the usability test, and use these as touch points to guide the questions asked during the retrospective think aloud walkthrough. Provide encouragement for the respondent to think aloud during the test, but do not force the respondent to talk during the test if it is something that they are uncomfortable or struggle with. Only provide guidance to the respondent in the test if they are unable to proceed and specifically ask for help.

**Concurrent think aloud introduction and prompts:**

Now you see the webcam is also on, and you can see it is recording. You can see instructions are there although it should be self-explanatory, we don't really need to instruct you with other things, unless things go really wrong and we are here to help but you should be able to do this on your own. Please think aloud, you don't need to literally read this, not word by word but what you read and think. Just say I'm reading this now, and I'm now looking at this figure and I like it, I don't like it or I don't understand it, just mention what you are doing and what you are thinking. And please mention also the task number that you are doing so that we can also when we look back at the video so we know where you are, as you have said you are working on task so and so.

Now you can start from here, we will be around and we should not interfere with what you are doing but if you have really a question that blocks the test then you can ask it, otherwise you are on your own although we are present here. At the end of the test we will have a short interview on the software that you used but for now, imagine we are not here. The whole test should be about 30 minutes so you know a bit about the timing.

*Prompts:*

We would really like you to think aloud, that you say what you are thinking, as otherwise we cannot really use the test usefully.

Do you remember to think aloud as you proceed through the tasks.

**Retrospective think aloud:**

**I just had a few questions based on how you were interacting with the concept map during each of the different tasks on the test.**

Task 1:

How was using the search function on the concept map and the wiki different?

When you opened up the concept map for the first time, what was your reaction?

When you started to navigate it for the first time why did you focus on what you did?

You often dragged the nodes, why did you do this? What did you think was the benefit of this function and how would you use it?

Task 2:

When you first saw this question, was your idea to use the concept map or the wiki first? Can you explain your thought process behind this decision?

The first thing you did on the concept map was X, why do you think that was the first thing you did?

How was your experience of navigating the concept map using pan, zoom and search?

How was your experience of moving between the concept map and the wiki?

After you went through both the concept map, and the wiki to answer this question, which one did you find most useful for this task? Why did you find that?

Task 3:

When using both the wiki and the concept map, what difficulties did you encounter when attempting to solve this task? How did the experience of using the concept map for this task differ from using the wiki?

When using the concept map, you often had difficulty with X – can you explain your thought process as you attempted to use the concept map to solve your answer?

Task 4:

What was your experience of navigating the concept map visually to look for concepts you might already know? What were difficulties you encountered in this task or what made this easy for you?

Which improvements do you suggest to make to the wiki and the concept map? What additional features would you as a student find useful in such a tool?

This ends the test.

Thanks for your cooperation!

## 7.3 APPENDIX C: SEMI STRUCTURED INTERVIEW SCHEMA FOR TEACHERS

What the interview is going to focus on today is two parts. The first will focus on trying to understand your conception of teaching and learning and how you see those things, and the role you see visualizations playing in that. The second will focus more specifically on the ontology and the experience of creating and adding to the ontology and what could be improved in that area.

**First part – faculty conceptions of teaching and learning**

How do you prefer to learn? How do you think this influences the way in which you teach?

How would you describe your own philosophy of teaching/education?

Can you explain how your own educational philosophy has been influenced by colleagues at the University of Twente or the years you have spent at ITC?

How do most of the students you have taught like to learn?

What do you want students to have at the end of their Master's program?

What are the most useful ways to represent content in your subject to aid student learning?

How do colleagues at ITC learn from one another with regard to their teaching practice?

What are the aspects of these concepts you teach that make them easy or difficult to learn for students?

What are some common pre-conceived ideas or misconceptions students in the Master's program have regarding the content you teach?

How do the practical constraints of teaching in a DE course make it more difficult to track these difficulties? How do you find out about these difficulties in such a context?

**Second half – Faculty perspectives on the Living Textbook concept map**

When it was titled 'The Living Textbook' project, what in your understanding are the elements that make it 'living'? What elements would make it more so, and why would you choose this to be the case?

How do you think the Living Textbook could help teachers improve the way in which they teach?

How do you think the concept map (particularly in the context of a DE module) could further help teachers learn about how their students learn?

What was the purpose of creating the concept map? How was it supposed to help students learn?

Can you talk me through the process of how you personally constructed your parts of the visualization?

How did creating the concepts for the concept map influence how you thought about the relationships between concepts?

How did working on the concept map with other teachers impact the way in which you would teach any of your content in this year's module?

What was difficult/challenging about the process of merging the different concept maps together?

How could the visualizations be made more effective for the next iteration of the tool

## 7.4 APPENDIX D: CODEBOOKS FOR STUDENT AND TEACHER DATA

Table 2

*Complete set of inductive codes and sample data from teacher interviews*

| Category | Code | Definition | Example |
|---|---|---|---|
| Promoting student engagement | Relevant & Challenging course structure (1) | Teacher emphasizes the importance of integrating into the fabric of the course urgent real world problems and hands on exercises that push students | "they really need this because otherwise, because they will come with their own real life problems and if a lecturer like me stays somewhere on top and doesn't give any examples then they will feel like lost because they need to be practical as well" |
| | Continuous teacher learning (2) | Teacher highlights that a key way to foster student engagement is for teachers to develop themselves professionally | "So you have to think about it, you can't just repeat the methodology and say that they did not study or whatever, there was something was not working. That construction process has to start from the assessment results" |
| | Medium of communication (3) | Teacher focuses on the importance of the way in which content is delivered to students as a key factor in engaging them | "Usually what I do is for example explain something and then say ' but what if we had this situation, what do you think would happen' and then if the group is dynamic you can even have a mini debate for one or two minutes and then you can continue." |
| | Opportunity for student teacher interaction (4) | Teacher makes reference to the critical importance of time and space being allotted for students and teachers to ask questions of one another | "but these social aspects are absolutely also important, not that I can help all of them, but at least I can listen and provide some feedback and why don't you try this or that." |
| Institutional Influences | Time restraints (5) | Teacher highlights that there is a constraint on the amount of time available to them to teach and implement their educational vision | " I think that this is also part of the busy schedule that I am in, is that learning for me should be condensed, in depth, so someone would really have to grab me out of my current situation like what we had yesterday" |
| | Course structure & medium (6) | Teacher mentions the format of the course/module as a factor to be considered in how they can successfully educate students | "And it also has to do with the time that we have and the way that we teach in three week intensive modules and after three weeks they have to do the assessment and with only one weekend in between they have to go on to the next module and so there is no way to digest things over a longer time." |
| | Planning & Evaluation culture (7) | Teacher makes reference to the approach in the institution towards preparing and reviewing modules as an influence | "Basically we have this in our department we have this every three four years we have our curriculum review, where we as a group… go through the whole curriculum and we look at what are new developments in the field and how does it fit what we teach to this new development so what has to be changed" |
| | Student Demographic (8) | Teacher draws attention to the cultural make up of the institutions student body as a factor in how they approach teaching | "there are cultural differences, definitely differences, there are more cultures where it is allowed and stimulated to have discussion even with your professor lets say, and then there are cultures where it is not allowed at all and you are not supposed to interfere or put a question to what the professor says" |

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| For students | Perceived Usefulness (9) | The teacher highlights that the tool provides additional benefit for the student in the learning process | "the added value of this concept map is that you have a visual that makes relationships clear between concepts that are not maybe so close in the text so where you would normally have to do several clicks before you find that certain concepts are related, you see them quite easily in this diagram |
| | Concerns (10) | The teacher expresses apprehension about the usefulness of the tool as a whole for students or a particular aspect or feature of the tool | "What I am afraid of, is if that we continue like this the ontology will grow and grow and grow and grow and there will be no way to find by visual exploration anything in this map." |
| | Potential Uses (11) | The teacher mentions a specific application for the tool that would provide additional utility for the student | "what it would also be very good for, for lecturers to indicate particular clusters of concepts for instance for homework, so they could say okay for next week study this particular part" |
| | Suggested improvements (12) | The teacher makes recommendations for how the tool could be improved to better improve the student learning experience | "I think it might be a good idea that the concept map not only be linked to the text resources, but to all types of media…also to exercises" |
| For teachers | Use as in - classroom tool (13) | The teacher highlights how the Living Textbook could be applied by teachers within the context of the lecture hall | "lets say the lecture today is going to be about a certain topic so we go straight to the ontology, talking about what are the major concepts directly connected to this one and then say more or less putting a boundary line around the subject matter of that lecture" |
| | Use to gain feedback from students (14) | The teacher brings attention to the fact that the tool could help teachers gain additional knowledge about how students are faring with course material | "if it also included the ability to track what students were doing so like how many people are visiting specific nodes in the ontology or links in the ontology and tracking their paths through the ontology, how their use of the ontology changes over time as the course develops, are they really exploring it or if they just put it to one side" |
| | Use to clarify & connect course content (15) | The teacher emphasizes the benefit the tool would bring in helping the teaching faculty to revise, update and agree upon content to be covered in the curriculum | "what I liked about the exercise that we went through is that if you are teaching a subject it triggers you indeed to think about well do I bring these concepts forward lets say in a good structure with the proper relationships" |
| | Challenges posed (16) | The teacher draws attention to the additional problems that the tool may cause teachers or the difficulties it may pose in continued implementation | "It was a bit too much for me and quite some of the others as it was too much time pressure" |
| | Suggested improvements (17) | The teacher makes recommendations for how the tool could be enhanced to further benefit its application as a tool in the planning and instruction process for teachers | "it would create interesting visualizations if you could show in a concept graph for a tutor indeed which concepts are selected most frequently, which relationships" |

Table 3.

*Complete set of deductive codes and example data on usability and engagement from student interviews*

| Categories | Codes | Definition | Examples |
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| Behavioural Engagement | Use likelihood (1) | Student highlights a situation when or when they would not use the concept map or wiki and/or how frequently they use these tools in general | "I use it to just kind of sanity check to ground myself with my thoughts and how I think the things I am learning about are related" |
| Cognitive Engagement | Competency (2) | Student outlines how the map had influenced their understanding of or comfort with course content | "Once I know something then the map becomes more meaningful and helps it to gel how the concepts are related" |
| | Metacognitive awareness (3) | Student explicitly mentions strategies related to the use of the concept map or Living Textbook that reflect planning, goal setting, and monitoring | "I go through the tasks and when it says look up this and this and I have no idea what that should be, I do two things, I copy and paste and google it and then I go to the link to go to the Living Textbook" |
| Emotional Engagement | Anxiety (4) | Students expresses concern or unease about a particular feature or function of the concept map or about the Living Textbook as a whole | "Useful but uncontrollable, in some instances I couldn't control it" |
| | Frustration (5) | The student expresses annoyance with a particular feature of the concept map/Living Textbook or highlights that they were prevented from taking a desired learning action as a result of the tool | "I felt it was a bit cluttered, like a lot of information in one place" |
| | Enjoyment (6) | Student makes it clear that they had fun exploring the concept map or derived pleasure and entertainment in using it | "I like to just look at the concept map and switch the Living Textbook off and not look at that too much, I just had fun following the connections and moving it around to get the right view" |
| | Enthusiasm (7) | Student expresses interest or excitement about a feature of the map or the concept map as a whole | "Yeah it was phenomenal, it helps a lot" |
| Student perceptions | Of the learning environment (8) | Student makes clear their opinion on what they believe the course setting (physical or distance) should provide them with and focus on | "I know that you use participation to gauge if somebody is motivated, but considering that we took this course as our own choice, I find that a bit, it's not important to us, not important to me" |
| | Of the role of the teacher (9) | Student mentions what they believe the purpose of the instructor to be/not be in the context of education, and explains why | "The role of the teacher is to give assistance when needed, or to introduce the material, give the vision or even draw the path and let you walk towards the path" |

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| Screen Layout & Appearance | Organization (10) | Student comments on the layout of the concept map or the way in which information is organized (e.g. hierarchy, order etc) or on how clear information is on the screen | "Things were not necessarily in a chronological order, so you had to put in extra effort to understand how you move from point A to point B" |
| Navigation | Ease of Use (11) | Students comment on specific difficulties they faced in relation to how they were able to move between different parts of the concept map (e.g. search functions, zoom, animation etc) or on how intuitive or straightforward this movement was | "You zoom it and it comes all the way down or all the way up and you can't get right in the middle, you can't get just that one size you're looking for" |
| Interactivity | Response (12) | Student comments on how quickly or effectively the system reacts when the user engages with it or highlights how it could be improved | "I'm not quite sure but I was obviously looking for those nodes that are related to the concept that I am searching, so I thought that I could go to the other node by dragging this somewhere, but it didn't work so I just tried to move the whole screen" |
| Content | Depth (13) | Student highlights issue regarding the quality or type of information included in the concept map/wiki (e.g. depth, variety etc.) | "But what I noticed with the Living Textbook is that the quality of the depth that is provided varies a lot, some entries are very repetitive" |
| | Perceived usefulness (14) | Student makes reference to the content within the wiki/concept map being useful or of benefit to them | "I think this is what the current concept map we're using in class has a great job in doing it, you can get one concept and then you see all other concepts around it, what other ideas are associated with that" |
| Access | Accessibility (15) | Student makes a comment highlighting the difficulty of using the concept map as a result of internet connectivity/not being able to find the tool | "The whole of my first week I could neither access the textbook or the concept map because I did not have the proper credentials" |
| Improvements | Screen Layout & Appearance (16) | Students makes suggestion for improvement in terms of clarity or organization of information on screen | "But if you only show me the whole tree the main branches the letters should be bigger, not all of them but the main concepts on the homepage" |
| | Navigation (17) | Students suggests improvement in relation to the ease of use of the map/wiki interface | "So even within the concept map, a button that makes the background fade totally, that cuts it out so you only have it as a standalone" |
| | Interactivity (18) | Student suggests feature or improvement to increase the speed/quality of systems' response or search of the map/wiki | "this should be better, it should swiftly switch to the page of the topological relationship, sure there is a close button but maybe if it can switch to the new page it would be better, I think so" |
| | Content (19) | Student suggests additional content to improve type, variety or medium of the information included in the map/wiki | "but as I have said on the concept map you cannot see every detailed explanation about the concept, you have to go to the wiki right, but if for example when I'm hovering on the node if some description could be displayed on the side, that would be nice" |
| | Access (20) | Student suggests ways that the map/wiki could be made easier to find or use without high speed internet | "an additional point that could make the map or even the textbooks useful would be to be able to cache it offline" |