International Journal of Innovation, Creativity and Change. www.ijicc.net
Volume 2, Issue 1, May 2015

Concept mapping: A tool to analyse the development of a Technology teachers' professional identity.

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Abstract:

The advancement of a student's professional identity as a Technology Teacher is essential to grasping Technology education and framing future Technology education research.The aim of this research is to examine the professional identity transition that occurs for students' over the course of a technology teacher education pre-service program and to determine the factors that contribute to a successful transition. It will examine the student's initial identity as a trade worker, trace their identity, knowledge, skill, values and attitudes developed during their first course in a Technology Teacher pre service university program. This study uses concept mapping as a way to examine the professional identity change of Technology students moving from a technical/trade worker to a Technology teacher. This study suggests that a student's tertiary education should be focused on them developing their identity as a professional Technology teacher. The influences on the development of this identity, both positively and negatively, will direct future research in Technology education.

Key Words:
Concept mapping, Professional identity, Technology Teachers, Technology Education

Introduction

In December 1990, the *Journal of Research in Science Teaching* , Novak (1990) outlined the conceivable uses of concept mapping for the enhancement of learning and teaching in the science classroom. Concept mapping also has its application in Technology classrooms.

Novak inferred that concept mapping has the potential to enhance Technology
Education in four categories: (a) as a learning strategy, (b) as an instructional strategy, (c) as a strategy for planning curriculum, and (d) as a means of assessing students' understanding of concepts. This research is concerned with the last of these four categories.

In the same issue Wallace and Mintzes (1990) presented evidence supporting the validity of concept map assessments of students' learning, and concluded that concept mapping is a valuable tool for educational researchers.

Since 1990, concept mapping has been used in diverse ways to study topics in education. Barenholz and Tamir, (1992) and Trowbridge and Wandersee (1994) used concept mapping tasks to examine the effects of instruction. Hegarty-Hazel and Prosser (1991) used concept mapping to evaluate the relationship between conceptual understanding and the use of study strategies by secondary students.

An important purpose of the map is to help make the overall context of the concept explicit. This is particularly important for complex concepts where students display a fragmentary understanding and are unable to incorporate all the constituents to form a meaningful overview. Identifying these fragments of understanding, termed 'anchoring conceptions' by Clement, Zietsman and Brown (1989), is vital as these form the basis for future meaningful learning.

Rationale

Concept mapping grew out of the cognitive learning work of Ausubel in Malone and Dekkers (1984). The use of concept maps as a learning tool compliments the constructivist model of learning, in which students build their own understanding from the material presented in class Von Glasersfeld (1991). In fact, concept maps have been traditionally used by those subscribing to the constructivist model of learning in an attempt to understand and model how students learn Cliburn (1990). It was Ault (1985) who first argued that concept maps capture students' true understanding of concepts.

Concept mapping is frequently linked to the 'constructivist' view of learning. The constructivist view has been summarized by Novak (1993) as being based in the belief that from birth to adolescence or death, individuals construct and reconstruct the meaning of events and ideas they participate in or consider. For the constructivist, understanding is created rather than discovered. Thus, learning is an active process. Learners acquire knowledge and use it to draw their own conclusions and develop their ownbeliefs. As the learner gains more information, it is added to and mixed with previous information and beliefs (Grandy 1997).

The enhancement of such understandings can be characterised graphically using concept maps. The action of mapping also helps the process by enlightening the student to associations that had not been known previously and by acting as a spotlight for communication between student and teacher. This is seen in Novak and Gowin's statement that, 'students and teachers constructing concept maps often remark that they recognise new relationships and hence new meanings or, at least, meanings they did not consciously hold before making the map' (1984, p. 17).

Concept maps may be compared from different instructional levels to determine what types of changes take place. These changes in the structure of the concept maps represent changes in students' conceptual frameworks, as evidenced by the work of Regis *et al.* (1996).

In the Regis et al (1996) study, secondary school students were first trained on how to use concept maps. These students were then asked to generate concept maps of their understanding once at the beginning of the unit and one at the end. In 75% of the cases, students had dramatic change in conceptual understanding, as evidenced by their concept maps. Conclusions about the conceptual change of the students with instruction were drawn.

Concept mapping differs from traditional methods of textual coding by making underlying formations clear and giving a focus to the schema by which individuals construct meaning. Kinchen et al (2010). Concept map structure correlates with the richness of anecdotal data. They provide quick summaries of qualitative data. In this study rich information provides complex concept map structures.
Concept mapping provides a tool to support reflection, helping to convert implicit associations to make explicit linkages (Fisher, 2000). Kinchin, Hay, and Adams (2000) have shown how a concept map can be used to gauge the cognitive structures that the researcher uses to describe a particular topic.

The analysis of concept maps can reveal structures indicative of different patterns of understanding (Hay & Kinchin, 2006).Through this approach we will measure change.

It is suggested that the most appropriate time for introducing mapping is early in the students' educational pathway, before preferred study habits are established (Santhanam, Leach and Dawson, 1998). This is the reason that concept mapping, in this study, was included at the beginning of semester.

In particular, concept mapping is a helpful metacognitive tool, promoting understanding when new concepts interact with the students' existing cognitive structure. The interaction of new and existing knowledge is made easier if the existing knowledge is made explicit to both teacher and student. This is described as 'meaningful learning'.(Kinchin 2001)

The construction of a concept map will reveal the perceptions of its author, rather than a reproduction of memorized facts (Jonassen *et al*., 1997). The structure of a map is therefore, unique to its author, reselecting his/her experiences, beliefs and biases in addition to his/her understanding of a topic, in this instance the developing identity of a pre service Technology teacher.

International Journal of Innovation, Creativity and Change. www.ijicc.net
Volume 2, Issue 1, May 2015

Concept Mapping
Concept maps are graphical tools for arranging and demonstrating knowledge. They are made up of concepts, grouped into propositions linked by statements of relationships. The concepts are first identified and used to build a structure in which to arrange the concepts. In this way the map grows and the overall configuration emerges.

Concept maps are built by placing terms, which represent the concepts to be mapped, in structures Following Novak and Cañas (2006), a *concept* is a perceived regularity in events. The nodes are then linked together into propositions to show how students connect or link the concepts. P*ropositions* are statements about some event. Propositions contain two or more concepts, usually connected using linking words or phrases to form a meaningful statement.

Concept maps are illustrative instruments s for arranging and demonstrating information. They include concepts, usually enclosed in boxes and relationships between concepts indicated by a connecting line linking the two concepts. Words on the line, called linking words, define the association between the two concepts.

A concept can be defined as an idea or notion designated by a label. Propositions are statements about an experience. Propositions contain two or more concepts connected using linking words to form a meaningful statement. Individual concepts are connected together with propositions, which are represented by arrows. The arrow indicates the direction of the link. The direction and the connecting propositions indicate how the student conceptualized the knowledge. The propositions illustrate the relationship of the concepts to each other. The words over the arrow represent how the student connects concepts together. The approach to constructing the concept maps followed the guidelines put forward by Novak (1998) and Novak and Cañas (2008).

Within a concept map, the concepts are shown in an ordered manner with the most important and/or general concepts at the top of the map and the more specific, less important concepts arranged in order below. The hierarchical structure will depend on the context in which the knowledge is being considered. Therefore, concept maps need to be constructed with a focus question that we seek to answer. It is important that a question be given and not just a topic as answering the question helps the students focus on their maps. In this study the focus question is What is involved in teaching Technology Education?

The concept map in this study relates to the development of a pre-service technology teacher's professional identity through their understanding of Technology Education. They are trying to demonstrate their understanding of this through the organization of knowledge in the concept map, thus providing the context for the concept map.

A significant feature of concept maps is the inclusion of *cross-links*. These are interactions between concepts in different sections of the concept map. Cross-links demonstrate how a concept in one area on the map is related to a concept in another area on the map. In the creation of new awareness, cross-links often represent creative leaps on the part of the author of the map.

An additional feature of concept maps is specific examples that clarify the meaning of a concept. These are not included in boxes, as they do not represent but clarify concepts.

Concept mapping is a powerful way for students to organize their own conceptual understanding (Regis *et al.* 1996). It can be used to display individual knowledge structures for comparison at different stages in the learning process as it is in this study at the entry and exit points of the course.

Reliability

Reliability is an expression of the proportion of the variation among scores that are due to object of measure. McLure et al (1999) suggest that factors that may serve as sources of error in a concept map include: (a) variations in students' concept mapping proficiency, (b) variations in the expertise of those evaluating the concept maps, and (c) the consistency with which the concept maps are evaluated. This third factor depends in large part on the selection of a method by which concept maps are scored. The effect of the selection of a scoring method on the assessments score reliability is of primary concern in this study. These factors are assumed to contribute little to the variation of map scores.

Validity

"Validity is an overall evaluative judgment. It is founded on evidence and rationales, of the adequacy and appropriateness of inferences and actions based on test scores" (Messick, 1988, p. 33). In this study the concerns with validity have to do with the quality of the inferences they make about students' grasp of concepts and their schema as Technology teachers as well the strength of their initial professional identity.

The validity of decisions made using information from a concept map assessment is influenced by the nature of both the concept mapping task and the concept map evaluation. For optimal validity, the concept mapping task must result in a concept map that accurately reflects the content and organization of students' knowledge. If the procedures of a concept mapping task are overly complex, there is a chance that students' focus on the mapping procedures may degrade the quality of their representation. For this reason the concept mapping will be a simple task. The concept mapping task should not be so complex as to distract the mappers, nor to simple as to loose clarity.

Limitations

Some of the circumstances in which the use of concept mapping is limited are:

1. When the participant do not link concepts and relationships clearly
2. When the concepts and relationships have been deliberately misrepresented by the participant,
3. If the person analysing the concept maps has insufficient understanding of the world of the participant or of the topic.

Some of these limitations could be addressed by ensuring that the concept maps produced are shared with other participants as a stimulus to clarification.

Method

Map Production

Participants received 90 min of training in concept mapping techniques on two occasions, one week apart before commencement of semester. This is because the students' skill with concept mapping techniques will have an effect on the quality of their products, and therefore affect the score reliability and validity of the assessment McClure (1999). Immediately after completion of the training, the participants were given a set of 30 concepts and asked to create a concept map that demonstrated their understanding of what Technology Education entails.

The concepts listed include the following: authentic, experiential, reflect, values, justify, situation, evaluate, solution, manufacture, technology, design, research, create, ideate, communicate, skills, tools, innovate, safety, sketch, plan, manage, quality, techniques, experiment, apply, sustainable, materials, synthesize and reflect.

These concepts were taken from the unit being taught on Technology Education, which is completed as part of the Technology Education program in which the participants were enrolled. Although told they had 40 min to complete this map, participants who had not completed their map in the 40 min were allowed to finish. The result of this portion of the study was the generation of a set of 49 concept maps.

Concept maps rely on the context in which they will be used, so it is best to identify a question that one is trying to understand. This question creates a *context* that will help to determine the hierarchical structure of the concept map. Every concept map responds to a focus question, and a good focus question can lead to a much richer concept map. The focus question used here is What is involved in teaching Technology Education?

Novak (1998) explains that when constructing concept maps, learners tend to deviate from the focus question and build a concept map that may be related to the domain, but which does not answer the question, to overcome this it is suggested that the key concepts that apply to this domain be identified.

The 30 key concepts identified in this study include:
authentic, experiential, reflect, values, justify, situation, evaluate, solution, manufacture, technology, design, research, create, ideate, communicate, skills, tools, innovate, safety, sketch, plan, manage, quality, techniques, experiment, apply, sustainable, materials, synthesize and reflect

Figure One**:**

What is Technology Education?

authentic project experiential reflect values

justify situation evaluate solution

manufacture technology design research

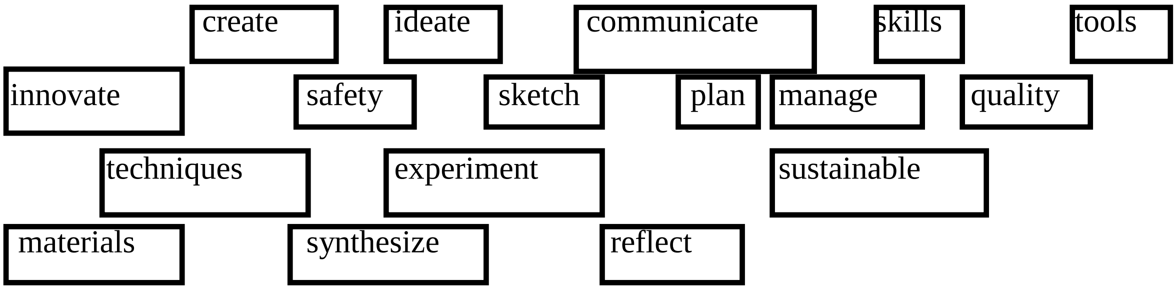


Figure 1. The Focus Question and parking lot: an initial set of concepts for the concept map
It is then suggested that from this list, a ranked list should be determined from the most general concept, for this question, at the top of the list, to the most specific concept at the bottom of the list. This rank order may be approximate but it will help the process of map construction.

Figure Two:
What is Technology Education?

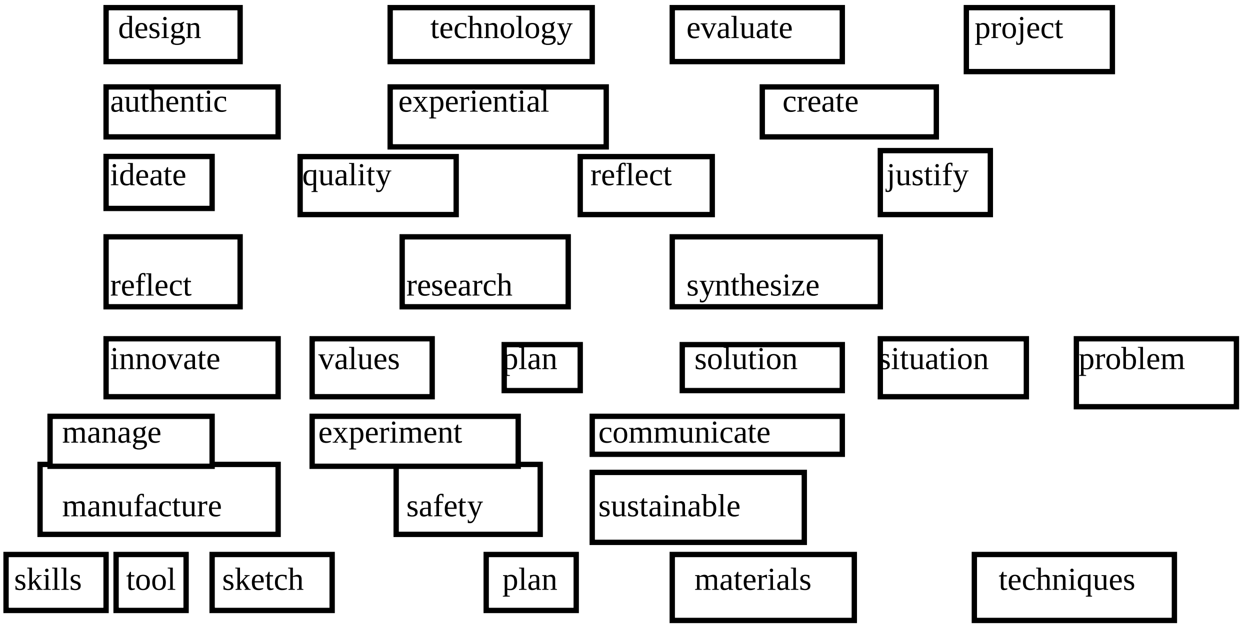


Figure 2. Concepts are now placed in an approximate ranking of most general to most specific from top to bottom, and may be moved around to start forming the map.

This list of concepts are referred to as a *parking lot*, as they are moved around the concept map as the students determine where they fit. Some concepts remain unused, as the map is completed if the student has no connection for these

After a preliminary map is formed, *cross-links* or propositions should be considered. These are links between concepts in different areas of understanding on the map that help to

illustrate how these areas are related to one another. Cross-links are necessary to show that the learner understands the relationships between the areas in the map.
Students must understand that all concepts are related to one another. They must be judicious in identifying and naming cross-links. Researchers (Novak and Canas 2008: McClure et al. 1999) agree that the most challenging part of formulating a concept map is constructing the propositions; that is, determining what linking words will clearly show the relationship between concepts.

Students who find it difficult to add linking may poorly understand the relationship between the concepts. They must identify the most useful cross-links to evaluate and synthesize their knowledge.

Finally, the map should be revised, concepts re-positioned to lend to clarity and better over-all structure, and a "final" map prepared.

Concept map scoring
The two sets of 49 and 41 concept maps were scored using holistic and relational scoring methods.

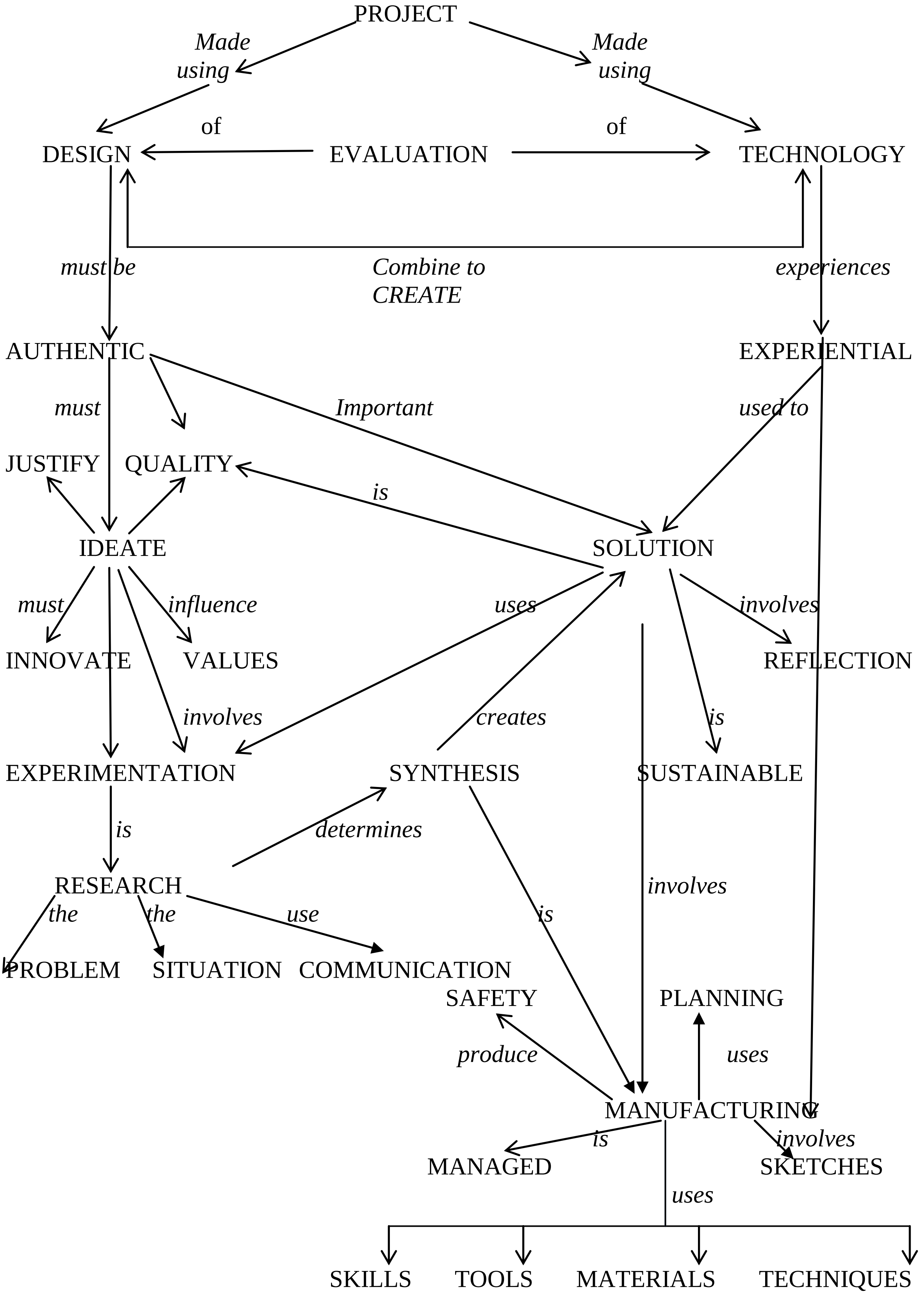
The holistic scoring method was based upon the examination of each concept map and assesses the mapper's overall understanding of the concepts represented by the map. Each map was evaluated with a scale from 1 to 10 (McClure et al., 1999).

The relational scoring method was developed by McClure and Bell (1990) Because the method is simple as is the scoring technique. Second, because of the mechanical simplicity of the technique, the scores for maps are easily defended as reported in this study and the relational scoring method combined with a master map yielded the most reliable scores. In this technique, individual maps are rated by evaluating the separate propositions identified on the map. A proposition was defined as two concepts connected by a labelled arrow indicating the relationship between them. Each proposition was scored from zero to three in accordance with a scoring protocol depending on the correctness of the proposition. The final score was found by addition of the scores of all the separate propositions (McClure et al., 1999).

Results
The data collected and analysed included examples of a concept map, scores for concept maps rated by each of the three scoring methods. The holistic, relational and structural scoring method was calculated for each concept map.
The maps were separated into two groups- before and after completion of the university course work and total scores were calculated by adding the individual concept map scores together and converting to a percentage by dividing the total score by the possible total score and them multiplying by 100.

Males and female results were compared.

Figure 3:Concept map: What is Technology Education?



The before and after groups were then reassembled and divided into groups that demonstrated the students length of industry experience. 0-5 years, 5-10 years, 10-15 years and 15-20 years. The before and after groups were then divided into a further six groups according to their industry background.

The industry background groups were labelled:
1.Food group consisting of chefs, hospitality workers and caterers,
2.Textile group consisting of fashion designers, textile and clothing manufacturers and fashion industry workers.
3.Timber group consisting of carpenters, builders and construction managers
4. Metal group consisting of fitters and turners, plumbers and automotive specialists.
5. Graphics group consisting of those who worked in industry in the areas of computing and graphic design.
6. Forces group consisting of people from the Australian air force, the Australian army and the Australian navy

Holistic Score Totals

Holistic	Before %	After %	% Difference
ToTAL	36	70	34
Male	26	73	47
Female	27	71	44
Years in Industry			
0-5	27	68	41
5-10	24	84	60
10-15	23	79	56
15-20	18	59	41
Common trade background			
1=Food	35	75	40
2=Textiles	23	68	45
3=Timber	40	66	26
4=Metal	30	53	23
5=Graphics	41	87	46
6=Forces	45	93	53

Relational Score Totals

Relational	Before %	After %	% Difference
ToTAL	43	78	35
Male	32	81	49
Female	34	80	47
Years in Industry			
0-5	45	85	40
5-10	39	88	49
10-15	49	90	41
15-20	45	73	28
Common trade background			
1=Food	42	78	36
2=Textiles	36	72	36
3=Timber	37	82	45
4=Metal	30	62	32
5=Graphics	37	85	48
6=Forces	40	96	56

Discussion

Distinction between concept maps has often been undertaken quantitatively, based on the scoring protocol devised by Novak and Gowin (1984). Subsequent researchers have made slight adjustments, such as the relative weightings of the scoring components, but all tend towards an aggregate score of factors including concept maps and conceptual development, the number of valid links presented; the degree of cross-linkage indicated; the amount of branching; and the hierarchical structure (Dorough and Rye, 1997).

In this study it was found that whether the concept maps were graded using a holistic or a relational approach the results were the same.

The results revealed that pre-service technology teachers could not successfully place the provided concepts on the concept maps. It is also clear that although the pre-service teachers have knowledge on the topic, they have difficulty establishing relationships among the concepts.

When the concept maps produced by the experts and initial pre course concept maps produced by the participants' are compared, it is found that the maps produced by the experts are far more comprehensive.
It is assumed that one reason for the participants' having difficulty producing concept maps and for the fact that the resulting maps are narrow in scope is their inability to establish relationships between the concepts; that is, their knowledge is not at conceptual level and they are inexperienced in producing concept maps that demonstrate their thinking.

The second group of concept maps produced at the end of the semester one coursework shows that there is a distinct change in the conceptual understanding of the question. These concept maps show a much closer similarity to the expert maps that demonstrates a change in their professional identity. The results demonstrated that every student moved from an identity that was quite narrow with a focus on skill building and manufacturing to one that toward one that places greater emphasis on creativity and design based thinking. Some students made greater leaps in understanding than others.

There were not significant differences between the males and females in the course. It was noted that students who had between 5-15 years industry experience made greater changes than those with over 15 years industry experience. The resistance to change shown by the students with over 15 years industry experience could be attributed to their professional identity and value system being firmly embedded in their being and their understanding or who they are and what they need to do.

When examining the students according to their industry background, it was found that the students from the Australian armed forces, the air force, the army and the navy, obtained the highest scores in relation to their second concept maps demonstrating their willingness and ability to take on board new concepts that contribute to the development of their new professional identity. One must consider that being able to adapt to new situations, to solve problems and to take on new concepts is an integral part of the training that received in the armed forced and this will assist in the change in professional identity. The students from a metal background were the least likely to demonstrate a deep understanding of what Technology Education entails on the concept map. It is important to note that the majority of these students also fell into the over 15 years industry experience category and were least likely, according to this concept map to demonstrate a changing identity and take on board new ideas.

In conclusion, the concept map is a powerful tool used to evaluate the conceptual knowledge of students and the maps produced by students provide a rich source of information about their conceptual understanding.

It is observed that although the students have knowledge on Technology education and teaching and also on concept maps, they have difficulty producing concept maps. This may be because they are not used to establishing relationships among the concepts and organising these relationships as a map, in their first years of their tertiary education. It is assumed that this result stems from the fact that the concepts in technology education are complex and studied in a sequential manner. In the first semester course work, the topics are advanced but may not establish clear relationships among the concepts. These concept maps can be used to identify and correct this deficiency.

Students' acquisition of knowledge is a common objective of technology teachers as it is essential in building their professional identity. As emphasised by McClure et al. (1999), concept mapping tasks for students may provide teachers with a unique and valuable source of information. In education, concept mapping has been widely recommended and used in a variety of ways to observe change in students' understanding of concepts. Concept mapping in this study has been a valuable source of information about both the content and organisation of students' knowledge.

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