GIFTED KNOWLEDGE:
WHAT DOES IT LOOK LIKE?

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The University of Melbourne

Giuseppe Franco Santoro
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ORCID ID: 0000-0001-5770-9924

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ABSTRACT

Catering for gifted students in the classroom context is emerging as a priority focus for many schools. Inclusive provision includes protocols for identifying these students and for implementing effective learning opportunities. This research examined options for this provision by using the novice-expert knower model to describe the knowledge characteristics of gifted students. The novice-expert knower model has drawn on previous work utilising the expertise framework. The model describes and interprets the similarities between an expert and gifted understanding. This allows for the identification of giftedness to be based on tasks within the context of the classroom by using the regular student understanding as a reference point.

The identification of giftedness within the context of the classroom targets the issue of teachers being able to see instances of gifted thinking within regular classroom interactions. One of the reasons cited for a lack of differentiation for gifted students in the classroom is that teachers lack professional knowledge of what giftedness looks like in the context of regular classroom interactions. The present study investigated the efficacy of the novice-expert knower model for explaining a gifted learning capacity and learning outcomes in multiple domains in order to describe what the knowledge of gifted students looks like.

Students were classified as verbally gifted, nonverbally gifted, globally gifted (gifted in both domains) or not gifted in order to assess how the knowledge representations differed across domains of giftedness. Using concept mapping procedures, students’ knowledge characteristics were assessed for two different topics taken from the regular school curriculum. Students’ knowledge characteristics were assessed prior to learning in order to assess their learning capacity for the topics and following teaching to assess their learning outcomes.

Results showed that students gifted in both verbal and nonverbal domains (globally gifted students) displayed more expert-type characteristics than those gifted in a single domain and not gifted students prior to teaching (learning capacity) and following teaching (learning outcomes). Students gifted in a single domain varied in their characteristics of knowledge representation both in terms of their learning capacity and their learning outcomes. Overall, the globally gifted
students were most likely to spontaneously extend and infer from the teaching ideas and to form either an inferred pattern or a ‘big picture’ understanding of the topics.

The findings from the present study demonstrated that the novice-expert knower model can be used as a framework to describe the knowledge of gifted students and the knowledge of gifted students varies for students gifted in verbal and nonverbal domains. Concept mapping emerges as a useful tool for identifying gifted learning characteristics. Furthermore the findings provide more evidence to suggest that relying solely measures of intelligence to identify giftedness does not provide enough information to facilitate pedagogical provision for gifted students in the classroom. Finally, teachers could benefit from using the novice-expert knower framework to identify gifted knowledge in its various forms within the classroom.
DECLARATION

This is to certify that:

- the thesis comprises only my original work towards the degree of Doctor of Philosophy
- due acknowledgement has been made in the text to all other material used
- the thesis is fewer than the maximum word limit of 100,000 words in length, exclusive of tables, maps, bibliographies and appendices

Signed: ______________________

Giuseppe Franco Santoro

January 2016
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CHAPTER 1
INTRODUCTION

This chapter outlines current trends and perspectives in gifted education provision. In addition, this chapter discusses the need for a different approach to identification and differentiation for gifted learners within the classroom context. Support for this approach stems from the research that outlines the reasons for teachers’ lack of differentiation for gifted learners and provides a basis to research alternative ways to facilitate this practice. An overview of this research study is also provided with an outline of the focus for each chapter.

1.1 Current Trends and Perspectives in Gifted Education Provision

The traditional approaches to giftedness focused on the early detection of the innate gifts that individuals possessed (Ericsson, Roring, & Nandagopal, 2007). Recent research in gifted education provision has focused on the adequacy of commonly used identification procedures for ‘innate gifts’ such as intelligence quotients (IQ). As stated by Renzulli (2005), the practice of describing intelligence through the use of single scores has and always will be questionable. Researchers such as Ziegler and Stoeger (2008) have argued against the use of these traditional methods such as IQ tests and have argued for identification of giftedness based on the quality of learning outcomes. Similarly, Shavinina (2007, 2010) has suggested that research should focus on understanding the unique cognitive experiences of the gifted individual. Both approaches emphasise the importance of understanding the cognitive capabilities of the gifted learner. Ziegler’s approach in particular would focus on observable learning outcomes rather than focussing on innate talent for describing giftedness.

The shift in gifted education has also provided a framework for acknowledging the multiple ways in which students can be gifted. VanTassel-Baska, Feng, and de Brux (2007) stated that a belief in the field of gifted education was that the new conceptions of giftedness and a new paradigm for identifying students would benefit those students who have previously been
underrepresented in gifted programs. The new paradigm would recognise the multiple ways in which students display giftedness. Following the consensus among researchers in the field of gifted education, Van Tassel-Baska stated that this new paradigm would focus on multiple criteria for identifying giftedness rather than focusing solely on intelligence and achievement test scores. Furthermore, this approach would benefit students who were previously unidentified such as those students from minority or disadvantaged backgrounds and would involve trying to tap into fluid abilities as well as crystallised abilities.

A number of conceptions of giftedness have been proposed in the past decade, which emphasise the changing nature of giftedness research. Models such as the Three-Ring Model (Renzulli, 2005), the WICS model (Wisdom, Intelligence, Creativity, Synthesised) (Sternberg, 2003) and the DMGT (Differentiated Model of Giftedness and Talent) (Gagné, 2004) include an aspect of general intelligence (g) that contributes to the overall conceptualisation of giftedness without being the single contributor. Current conceptions of giftedness such as the Three-Ring, WICS, DMGT, and the actiotope model of giftedness (Ziegler, 2005) describe how giftedness is conceptualised, including a range of cognitive, non-cognitive, environmental, and cultural factors that contribute to the actualisation of gifted (or talented) outcomes. These conceptions of giftedness have emphasised that giftedness is not a unitary construct based solely on intelligence and can be viewed from a more complete and holistic perspective.

In addition, a recent development in the study of gifted learning has focused on alternative frameworks for describing gifted knowledge and learning such as the novice-expert knower model (Munro, 2012). Drawing on models of expert knowledge and performance (Ericsson & Lehmann, 1996; Ericsson, Nandagopa & Roring, 2005; Ericsson, Patel, & Kintsch, 2000; Ericsson, Roring, & Nandagopa, 2007; Farrington-Darby & Wilson, 2006; Shavinina, 2007; Sternberg, 2005), the novice-expert knower model provides a basis for identifying and interpreting the cognitive characteristics of gifted knowledge within the classroom context. This model describes the thinking that underpins the novice to expert transition, and provides a means for inferring how the knowledge of the gifted learner might develop when exposed to teaching.

1.2 Statement of the Problem

The problem with measures of general intelligence or general cognitive functioning is in terms of classroom and more specifically, curriculum application. These cognitive assessments
provide insight into the aptitude or potential learning (ability) of the student but lack content-specific information. In terms of classroom application, measures that assess students’ learning capacity, including the content knowledge and the attributes of that knowledge in a specific context, offer the teacher richer and potentially more useful information in a specific learning context.

Teachers require some methods of identifying the learning characteristics and the depth and breadth of gifted students’ knowledge. In addition to the depth and breadth of knowledge, teachers require some way of discerning whether some students display thinking that is different – at a level higher than other students in the class. Of course, it would be expected that most students think at different levels. This research proposes a method of identifying and describing the way that ‘gifted’ learners represent conceptual knowledge. This method of identification will focus on specific attributes (knowledge representation) of the gifted learner. A representation of gifted learners’ knowledge will give insight into how gifted learners think and how they encode and manipulate information. This is important from a classroom perspective as it will give teachers insight into how gifted students think and the ways in which they build knowledge – as well as snapshots of knowledge that is specific to the learning context.

The shift away from using measures of intelligence or innate intellectual ability has marked a paradigm shift within the gifted literature. Current conceptions provide in-depth descriptions of the conceptual foundation for giftedness. However, in terms of the use of identification measures from the classroom context, in order to differentiate curriculum for students to nurture their talents within particular domains of study, it is also necessary to know what the knowledge of gifted students looks like within the context of the classroom.

A further issue that requires attention as emphasised by the current conceptions and literature, is what the knowledge of gifted students looks like according to different domains of giftedness. This idea can be interpreted firstly within the context of the ‘Talent Search’ work pioneered by Julian Stanley in the 1970s (Olszewski-Kubilius & Thomson, 2014; Thomson & Olszewski-Kubilius, 2014). Talent search refers to the model of identification and programming of gifted learners through domain-specific assessments (Olszewski-Kubilius & Thomson, 2014). As reported by Olszewski-Kubilius and Thomson (2014) the emphasis of Talent Search has been on capturing the different cognitive profiles of students with relative strengths and weaknesses in mathematical and verbal reasoning in order to develop a comprehensive picture of their abilities
that can facilitate educational placement and advising. This program has been successful in identifying ‘talent’ across different domains of giftedness and in providing accelerated learning opportunities for these students. Furthermore, popular models such as the WICS, Three-Ring, and DMGT provide comprehensive descriptions of giftedness conceptually. However, operationally within the classroom context these models do not provide teachers with enough information in order to make gifted knowledge visible during daily student-teacher interactions for the purpose of differentiating curriculum based materials and content. This could be the reason why differentiation is infrequent and why teachers find it difficult to recognise and differentiate gifted knowledge within the school curriculum. The novice-expert knower model provides a framework for interpreting how the knowledge of gifted students might ‘look different’ to that of not gifted students during regular classroom interactions.

As reported by Wallace (2000) the identification of gifted students within the school curriculum poses a number of difficulties. What underlies these difficulties could be a lack of teacher or professional knowledge on what 'giftedness' or gifted knowledge and thinking looks like within the classroom context. This was identified by Van Tassel-Baska et al. (2007) and further emphasised by Munro (2010, 2012) where a lack of professional knowledge of what constitutes giftedness or gifted thinking within the classroom was one of the key reasons that teachers were unable to employ differentiation strategies for gifted and talented students. Therefore, it is apparent that there is a need to make more visible what gifted thinking and knowledge looks like within the classroom context and within the context of the school curriculum.

Given the shift towards using the expert performance framework to unpack and understand the differences between a gifted and novice understanding, it is necessary to consider the factors that constitute expert thinking. Expert performance framework provides solid grounding in being able to attribute certain knowledge characteristics to ‘gifted knowing’ and a basis for interpreting and seeing this within the classroom.

Thus, two reasons for the identification of what gifted knowledge looks like within the classroom can be extrapolated. Firstly, it will allow teachers to gain more insight into what and how students know about the topics that are being studied within the school curriculum and secondly, this will allow teachers to more easily and effectively differentiate curriculum for these
students. The effective differentiation of curriculum for students is critical for the development of knowledge for these students.

1.3 The Australian Context

The issues raised by eminent gifted researchers such as Van Tassel-Baska and colleagues about the provision of education for gifted students have international relevance. The research for this thesis was conducted in Melbourne, Australia. However, it is the belief of the author that the findings from this research are relevant not only within but beyond the Australian school and education context. That is, evidence from this research can extend beyond the Australian context.

Evidence of the need for a paradigm change in gifted education in Australia is shown in recent state-sponsored evaluations. The most recent was the inquiry into the provision of gifted education in Victoria in 2011. Following a reference from the Victorian state government in February 2011 to conduct this inquiry, a report was compiled and the report outlined current practices and future directions for gifted education in the state. One of the major findings to come out of the inquiry was the extent to which gifted students are neglected by the Victorian school system. It was noted that at a system level, the assumption was that all students learn not only at the same rate but also in the same way (Parliament of Victoria, 2012). Furthermore, another finding to come out of the inquiry was the extent to which current identification procedures for gifted students were unsatisfactory. The report stated that the current system not only failed to recognise and identify these students, but as a result of this also failed to provide adequate pedagogical provision for these students. It was stated that gifted students who remain ‘unidentified’ can often become frustrated and disengaged and a failure to identify and nurture their potential could be attributed to this. As the future visionaries and innovators in a time when skills such as creativity and innovation are critically important, the report outlined the importance of providing these students with appropriate educational opportunities in order to develop their potential.

The report also outlined a notable trend in recent times with regard to the decline in Australia’s scores on international assessment data. Achievement at the top levels in particular for both reading literacy and mathematical literacy have declined between the PISA (Programme for International Student Assessment) assessments in 2000 and 2009. One hypothesis has attributed the decline in literacy and numeracy scores to the lack of identification, extension and
neglecting of high ability students within Australian classrooms (Parliament of Victoria, 2012). Professor Geoff Masters, Chief Executive Officer of the Australian Council for Educational Research, reported that:

Nobody knows exactly what is responsible for the decline ... what we do know is that over the past decade there has been a decline at the top end in reading and mathematics. One of the hypotheses is that, because we are now so focused on making sure that all students achieve at least minimally acceptable levels, schools have taken their eyes off extending very high-achieving students (Parliament of Victoria, 2012, p. 8).

Thus, one of the issues to come out of this report focused on the potential impact of failing to extend or nurture giftedness within the classroom. Furthermore, the failure to extend or nurture giftedness within the classroom could also be attributed to the failure or lack of identification of giftedness in the first instance.

The findings from this inquiry provided a snapshot of the current picture of gifted education provision within the school system in Victoria and coincide with issues and challenges that have been identified in the literature on gifted education more broadly. In addition, the decline in scores for students at the higher end of international assessments pointed to a broader issue across Australia in the provision of education for gifted students. The issues raised in this inquiry can be interpreted as involving multiple connected challenges. These challenges include the identification of giftedness within the classroom and the subsequent nurturing of these gifts to provide students with the opportunities to develop and reach their potential. Thus, in order to provide these students with the opportunities to develop and reach their potential, teachers and schools must be able to recognise instances when these students display this potential. The current trends and perspectives in gifted education provide a framework to begin unpacking how these issues can be further understood and addressed.

1.4 Outline of the Present Study

According to Van Tassel-Baska and Johnsen (2007) the key for providing gifted students with the opportunities to adequately flourish in the 21st century context rely on teachers’ education in relevant theory, research, pedagogy, and management techniques. Thus, a model for identifying gifted learning in the 21st century classroom is needed in order to provide opportunities for gifted students to develop and to reach their potential within the classroom
The present study investigates a possible model (novice-expert knower model) that is referenced in how gifted students learn. This approach will aim to provide teachers and educational professionals with a model that can facilitate the identification of advanced cognitive abilities within the classroom context in order to facilitate differentiation for these students. The gifted learning characteristics will be assessed both in terms of students’ learning capacity, that is, what students already know about a topic prior to teaching, and their subsequent learning outcomes following teaching. In order for teachers to identify gifted learning capacity and gifted learning outcomes in the classroom, the characteristics of the novice to expert knower model must be examined within the context of regular classroom interactions. Thus, the current study has multiple purposes; firstly, to examine whether the cognitive characteristics of gifted students differ to the cognitive characteristics of not gifted learners, and secondly, whether the novice to expert knower model is appropriate in its description of these characteristics in order to facilitate the identification of gifted learning capacity and gifted learning outcomes within the classroom context. The cognitive characteristic assessed as part of the novice to expert knower model will provide an insight into the cognitive profiles of students gifted in different domains.

Chapter 2 outlines current conceptions of giftedness and also provides a background to the use of the expert performance approach as a guiding framework for understanding giftedness. These conceptions of giftedness provide a basis to describe the cognitive aspects of knowledge that comprise an expert type understanding and provide a background to the expert performance approach in giftedness that has been established in the field of gifted research. Furthermore, these conceptions provide a rationale for the identification of the gifted learning capacity that will facilitate the identification of gifted learning characteristics within the classroom context.

Chapter 3 outlines and discusses methods for identifying these cognitive aspects of knowledge based on the expert performance approach with a focus on concept mapping.

Chapter 4 describes the conceptual framework for the present study. This conceptual framework is based on the expert performance approach using a model known as the novice-expert knower model (Munro, 2012) to describe the transition from a novice to expert type understanding. This chapter also outlines the different knowledge representations that might be attributed to students gifted in different cognitive domains, Furthermore; the rationale for the present study is made explicit in outlining how the aims of the project can inform current concerns that stem from the literature and from the Australian school context. In addition, this
chapter draws attention to the ‘gap’ in the literature around what constitutes a gifted learning capacity within the context of the classroom and the school curriculum. Research is cited that demonstrates a need for the identification of giftedness based on advanced cognitive abilities within the context of the school curriculum and regular student-teacher interactions. At present, the identification of giftedness based on advanced cognitive abilities through standardised tests does not provide teachers with discipline specific and task specific information that can facilitate differentiation of topics within the school curriculum.

The study methods used to conduct the research for the present study are outlined in Chapter 5, and the findings from the present study are described in Chapter 6. In Chapter 6, the findings are presented in two sections. First, the results are presented for the science topic, and second, the results are presented for the humanities topic.

The findings for the present study are discussed in Chapter 7 and the implications of the research along with concluding remarks are presented in the final chapter.
CHAPTER 2
REVIEW OF THE LITERATURE ON GIFTEDNESS AND EXPERTISE

This chapter outlines the current conceptions of giftedness and provides a brief historical background to the field of giftedness research. The current conceptions are discussed in terms of their theoretical frameworks for describing giftedness and the characteristics of gifted knowledge. The chapter also details the transition from novice to expert as a framework for identifying and describing giftedness. In doing so, the cognitive characteristics of expertise are discussed and unpacked in terms of how they might reflect the cognitive characteristics of gifted learners. The multiple domains of giftedness are also outlined in this chapter with a particular focus on the verbal and nonverbal domains. This is discussed with respect to fluid and crystallised intelligence and models such as dual coding theory, which provide a basis for interpreting differences in verbal and nonverbal abilities. It is noted by the author that a number of references predating 2005 are used frequently in the present chapter. The conceptions of giftedness that are used to justify the examination of both the capacity to display giftedness and subsequent gifted learning outcomes were established in the early to mid 2000s. These conceptions are the basis for the establishment of the characteristics that are later explored in the chapter. Furthermore, the exploration of cognitive characteristics that stem from research in the domain of expert performance is cited as a description of the expertise framework that is utilized in the present study. A number of key ideas were presented in the ‘expertise’ literature during the 1980s and 1990s and these ideas are presented in this chapter. Therefore, the review of the literature draws on the earlier ‘expert performance’ work that was conducted during these decades in order to establish the rationale for the present study.

2.1 Brief History of the Conceptions of Giftedness

Conceptions of giftedness have evolved over the decades. At the beginning of the twentieth century, psychologist Charles Spearman (1904) posited a factor called ‘g’, or general
intelligence following the positive correlation of a number of cognitive tests. He viewed this general intelligence as innate and proposed that this general factor was a result of “mental energy” (Spearman, 1927). During this time, Alfred Binet and Theodore Simon (1916) were developing a scale to assess and identify students who required alternative education. This scale was one of the first to include measures of higher-level cognitive abilities. Lewis Terman (1916) adapted Binet’s scale and created the Stanford-Binet Intelligence Scale, one of the first intelligence tests used to identify gifted students. Terman viewed giftedness as a single entity and equated this with high general intelligence or high IQ. This work laid the foundation for identifying and measuring giftedness.

In more recent times, several researchers (Borland, 2005; Walberg & Paik, 2005; Ziegler, 2005) have raised concerns about the validity and the usefulness of concepts of giftedness that focused on innate ‘gifts’. Monks and Katzko (2005) reported that giftedness could not be described in its entirety by mental aptitude alone. They reported that giftedness stems from the development of mental aptitude, personality, and behavioural characteristics and the development of these factors needed consideration when identifying gifted children. Borland (2005) went as far as suggesting no conception for giftedness. His reasoning focused on the question of whether or not the outcomes stemming from the construct of giftedness were beneficial in the educational context; does the label of ‘gifted’ contribute anything to the educational needs and pedagogical provision for the individual student?

However, following the early conceptions of giftedness that did focus solely on general intelligence, subsequent conceptions of giftedness became multi-dimensional. Although these conceptions still focused largely on intelligence, they also considered other traits such as motivation, creativity, or wisdom, and the talent development process (Kaufman & Sternberg, 2008).

The passage of time has not been the only factor that has shaped different conceptions of giftedness. These have varied widely among different cultures (Shavinina, 2009), particularly American and European standpoints (Phillipson & McCann, 2007). Researchers in the United States such as Joseph Renzulli and Robert Sternberg proposed system models of giftedness such as the Three Ring Model (Renzulli, 1978, 2005) and the WICS model (Sternberg, 2003, 2005), which describe giftedness in terms of a system with psychological processes operating together. According to Sternberg and colleagues (Sternberg & Lubart, 1995; Sternberg & O’Hara, 1999),
intelligence is just one of six forces that generate creative thought and behaviour. It is the confluence of intelligence, knowledge, thinking styles, personality, motivation, and the environment that forms gifted behaviour as viewed from a creative–productive perspective.

In Europe, the developmental models of giftedness such as the Munich model of Giftedness (MMG) (Heller et al., 2005) and Differentiated Model of Gifted and Talented (DMGT) were introduced (Gagne, 2005), which emphasised the talent development process. These models differed from the models proposed by Renzulli and Sternberg by emphasizing the environmental and non-cognitive variables that transform “gifts” into “talents” in a talent development process. Other researchers such as Albert Ziegler also emphasised the systemic approach to giftedness with the Actiotope Model of Giftedness (2005). The systemic approach built on the ideas presented in the MMG and DMGT but emphasised the notion of system with the environmental factors not just inhibiting or catalyzing talent development, but a co-evolution of the environment along with the development of gifted performance or excellence. This chapter will review these conceptions of giftedness and will outline the cognitive characteristics of gifted learners.

2.2 Current Conceptions of Giftedness

2.2.1 WICS model of giftedness. In his WICS model, Sternberg (2003) provided a common basis for identifying gifted individuals. WICS is an acronym standing for Wisdom, Intelligence, Creativity, Synthesised. According to the model, the synthesis of wisdom, intelligence, and creativity provides the basis for giftedness. The basic idea of the WICS model is that, people require creative skills and attitudes to produce new and original ideas; analytical skills and attitudes (academic intelligence) to evaluate the quality of these ideas; practical skills and attitudes (practical intelligence) to execute ideas and to persuade others of their value; and wisdom related skills and attitudes in order to ensure that one’s ideas help to foster a common good, rather than only the good of oneself and those closely associated with oneself (Kaufman & Sternberg, 2008). Gifted people, in this view, are not necessarily extremely strong in all of these aspects, however, without a synthesis of these three attributes, someone can be a decent contributor to society, and perhaps even a good one, but never a great one (Sternberg, 2003). Furthermore, according to Sternberg, one is not born ‘gifted’ but rather giftedness in wisdom,
intelligence, and creativity is a form of developing competency or ‘expertise’ in each of these respective areas.

2.2.2 Three-Ring Model. Joseph Renzulli’s Three-Ring Model (1978, 2005) describes giftedness as the interaction of three characteristics including well-above average ability, creativity, and task commitment or motivation. Well-above average ability refers to both general ability that can be applied across all domains and/or specific ability, which consists of the ability to perform at a high level within a specific domain. Renzulli made a distinction between two types of giftedness: “schoolhouse giftedness” and “creative-productive giftedness”. Schoolhouse giftedness can be viewed as test taking or lesson learning giftedness. It is the kind of giftedness most easily measured by IQ type tests. For this reason, the concept of schoolhouse giftedness is described as the type most often used for selecting students for entrance into special programs. Creative-productive giftedness differs from schoolhouse giftedness. According to Renzulli, students who display creative-productive giftedness are excellent producers of knowledge whereas schoolhouse gifted are excellent consumers of knowledge. However, as stated by Renzulli (2005), it is important to mention that the breadth and depth of one’s declarative knowledge base plays an important role in the creative-productive process and is the foundation upon which this type of giftedness is based.

The Three-Ring Model of giftedness is a system model of giftedness, which emphasises the interaction of the three psychological variables: motivation, creativity, and exceptional abilities. The WICS model and the Three-Ring Model provide examples of gifted being assigned to an ensemble or interaction of a number of psychological variables. According to these models, the presence of the psychological variables would result in gifted outcomes or gifted performance. Renzulli makes the distinction between potential and gifted performance. In describing this distinction Renzulli (2005) stated:

I also make a distinction between potential and performance. Persons can have remarkable potentials for mathematics, swimming, or piano playing, but until that potential is manifested in some type of superior performance I am reluctant to say they have displayed gifted behaviors. And, of course, our main challenge as educators is to create the conditions that convert potential into performance. (p. 248)

Developmental models of giftedness however, were formulated in response to models such as the Three-Ring and WICS model to emphasise the changing nature of innate ‘gifts’ and
to broaden the net to include external factors that along with internal factors might interact to produce gifted or ‘talented’ outcomes (Kaufman & Sternberg, 2008).

2.2.3 The Differentiated Model of Giftedness and Talent. Gagné (2004) proposed a developmental model of giftedness that emphasised the talent development process. This model was called The Differentiated Model of Giftedness and Talent (DMGT). According to the model, giftedness is the potential or aptitude within an individual, and this can be developed into talent (developed abilities or high performance) if environmental and other catalysts are present to facilitate the process. This model explores what an individual needs to do in order to transform an aptitude into a developed skill. Gagné clearly defines giftedness as ‘natural’ abilities that may be made apparent through the ease and rate at which individuals acquire new skills – learning appears to be easier and faster in individuals whose natural abilities are high, but these aptitudes must pass through a developmental process before they can be demonstrated as ‘talents’ (systematically developed skills). Talent development requires systematic learning and practising, and the more intensive these activities are, the greater the demonstrated skills will be. In the DMGT, while one cannot be talented without first being gifted, it is possible for natural abilities not to be translated into talents, so that academic underachievement of some intellectually gifted pupils may be linked to a failure to engage fully in the developmental process. The DMGT describes natural abilities in six domains, one of which is the intellectual domain. Within the intellectual domain exists general intelligence, including both fluid and crystallised reasoning.

2.2.4 The Munich Model of Giftedness. The Munich Model of Giftedness (MMG) is another developmental model of giftedness, which was developed in Germany in the 1980s by Kurt Heller, Christopher Perleth, and Ernst Hany as part of the Munich longitudinal study of giftedness. The MMG is based on four interdependent dimensions; talent factors (predictors of giftedness), non-cognitive personality characteristics (moderators of giftedness), environmental conditions (moderators of giftedness), and performance areas (criterion for giftedness). Across both the MMG and the DMGT models of giftedness, similar components can be found. In both models, giftedness is conceptualised as a multifactorised ability construct within a network of non-cognitive (e.g. motivation, interests, self-concept, control expectations) and social moderators, which are related to the giftedness factors (predictors) and the exceptional performance areas (criterion variables).
According to Ziegler and Phillipson (2012), gifted persons are individuals who are able to
tain excellence in at least one domain. However, conceptions of giftedness differ markedly in
their explanation of precisely what enables these individuals to attain such extraordinary
achievement levels to be considered gifted. As described in models such as the DMGT and
MMG, there has been a focus on incorporating environmental variables the talent development
process and a focus on how different levels of ability lead to talents of different quality (Stoeger
& Gruber, 2014). Similarly, multifactorial conceptions of giftedness such as the Munich Model
of Giftedness (Heller, et al., 2005) or Gagné’s DMGT model (Gagné, 2009, 2013) explicitly
include external moderators (people, educational institutions, etc.) that, along with internal
cognitive factors (moderators), transform innate dispositions into high achievements. Thus, the
environmental or external factors facilitate the talent development process. Csikszentmihalyi
(1996) pointed to this when stating that excellence could no longer be localised in the individual
alone, but rather in the system consisting of the individual and its environment. Thus, it can be
said that excellence is achieved not only due to internal cognitive factors alone but it is those
individuals who make exceptional use of their exceptionally stimulating environment can
achieve exceptional learning outcomes.

2.2.5 The Actiotope Model of Giftedness. Ziegler (2005) in his Actiotope Model of
Giftedness (AMG) proposed that the environmental catalysts co-evolve during the learning
process and these catalysts are not merely stimulating or inhibiting processes in the talent
development process as the DMGT model suggests. Giftedness or gifted performance, according
to the AMG, is attributed to the individuals who successfully negotiate interactions with their
environment in building action repertoires. The focus of the AMG is on actions and the
development of these actions within a complex environment. Action repertoires are the
possibilities for action that people are capable of performing (Ziegler, 2004). Thus, Ziegler
(2005) describes the path to excellence as the execution of more and more complex actions in
increasingly complex environments. The AMG is a model that describes excellence as the
accumulation of many actions. Furthermore excellence is displayed when a person has the desire
to do something, the ability to do it, and the awareness that it can be done (Ziegler, 2005). The
environment or culture must also consider this behaviour as ‘gifted’. According to the AMG,
excellence depends on the ability to expand one’s own ‘action repertoire’. Some people might
refer to this as a student’s learning capacity. The term ‘action repertoire’ refers to all of the
actions that a person is capable of performing. The theory suggests that the people who are capable of excellent achievements are those who are better able to steer their action repertoire. The steering of one’s action repertoire requires the individual to successfully negotiate interactions with their environment by selecting an effective action at the right moment in pursuit of a goal or objective. This ‘steering’ could effectively be interpreted as metacognition. This idea is consistent with the research in the 1990s which demonstrated that metacognitive skills are integral to the successful performance of gifted students (Carr, Alexander, & Schwanenflugel, 1996). Ziegler and Phillipson (2012) described the development towards attaining excellence as “a long-term learning process during which an individual acquires the repertoire which will eventually allow for excellence” (p. 27). Thus, according to the AMG, gifted individuals are those who are better able to steer and expand their action repertoires. These students are better able to accumulate knowledge within a talent domain and better able to master tasks within that domain.

Ziegler’s use of the terms ‘gifted’ and ‘talented’ (and excellent) differ from that of ‘gifted’ and ‘talented’ in Gagné’s DMGT. According to Ziegler, the assessment of whether someone is in the talented, gifted, or excellence phase can be understood in terms of whether the assessment of that person states that they can possibly realise excellence (talented), will probably realise excellence (gifted), or has already realised excellence (excellent). In Gagné’s model, giftedness is attributed to the potential to achieve excellence or ‘talented’ outcomes.

Ziegler and Phillipson (2012) reported that the evidence is clear in demonstrating the variance in individual pathways for achieving exceptionality and the unique interactions that each individual has with the environment results in different outcomes. Excellence is attributed to those individuals who negotiate these interactions successfully. Part of these unique interactions that individuals have with the environment could be the ways in which gifted students ‘see the world’. This notion is consistent with the idea stated by Shavinina (2007), who proposed that gifted individuals have a unique ‘intellectual’ picture of the world, which manifests from the unique cognitive experience that is the basis for their giftedness. This unique cognitive experience is developed through the individual’s conceptual structures, knowledge base and as part of this, their subjective mental space, or thinking space. Furthermore, this unique experience results in the gifted individual seeing, understanding, and interpreting information differently from their peers who are not gifted. Their ‘giftedness’ stems from
characteristics of their learning and their ability to learn. This description of ‘giftedness’ reflects the notion that the gifted student will develop knowledge that is unique and distinct to the knowledge of their not gifted peers, shaped not only by their innate abilities, but also by the environment in which they learn. This provides a basis for the notion of the ‘gifted learning capacity’ in which these students have a unique capacity to interpret teaching information and develop talented learning outcomes.

**2.2.6 Summarising current conceptions of giftedness.** The system models view giftedness as the culmination of a number of factors (Sternberg, 2003; Subotnik & Jarvin, 2005; Renzulli, 1978, 2005). Gagné (2004), on the other hand, proposed that gifts develop into talents if catalysts such as environmental factors allow the process or transition to talented outcomes. This view in the DMGT emphasised the talent development process, which built on the system models by noting the importance of non-cognitive factors. According to the DMGT, non-cognitive factors such as the environment, along with cognitive factors, can catalyse the process from gifted to talented. Ziegler (2005) in his Actiotope Model of Giftedness proposed that the environmental catalysts co-evolve during the learning process and these catalysts are not merely stimulating or inhibiting processes in the talent development process as the DMGT model suggests. Thus, giftedness is attributed to the individuals who successfully negotiate interactions with their environment in building action repertoires.

As described earlier in this chapter, different terms to describe giftedness and the talent development process have been used across different conceptions of giftedness. Effectively, all of the models presented in this chapter describe in some part a gifted learning capacity and the subsequent learning outcomes. Gagné describes this process from gifted to talented outcomes whereas Ziegler describes ‘talented outcomes’ as the achievement of ‘excellence’. Furthermore, without explicitly describing this in a talent development process, both Renzulli and Sternberg agree that giftedness is ‘potential’ and until that potential is converted into performance, it is not demonstrated giftedness. The notion of the gifted learning capacity is inherent within each of these conceptions of giftedness and important to consider within the context of the classroom. These models show that students have the capacity to achieve giftedness or gifted outcomes if certain other psychological or environmental factors are present. However, what these models fail to do is describe how prior knowledge can be interpreted as part of the ‘capacity’ or ‘potential’ to display giftedness. Thus, the current study proposes a similar conception of
giftedness as these models, however, the current study proposes that students’ learning capacity or potential to display giftedness can be described in terms of their knowledge within the context of the classroom.

These conceptions of giftedness propose that gifted students display high learning ability in one or more domains. Abilities are attributed to a variety of psychological variables and a process of talent development. Furthermore, in each model, the existence of high ability is either inherent in the notion of giftedness or part of the talent development process. However, according to Von Kárólyi and Winner (2005) there is a need for a systematic investigation into describing the qualitative differences that exist in the thinking of gifted individuals. They suggest that much of the previous research that has focused on the qualitative differences between the thinking of gifted and not gifted children is anecdotal. Thus, although current conceptions of giftedness describe the psychological variables that facilitate the development of gifted performance and describe the talent development process, there needs to be a clear understanding about what gifted performance ‘looks like’. For example, what does the knowledge of a gifted student look like in a classroom setting? How can teachers recognise a ‘gifted learning capacity’ in their daily interactions with students?

2.3 Giftedness as Expert Performance

One way of interpreting the gifted performance or talented outcomes that are part of the conceptions of giftedness described is through the lens of expert performance. This has provided a substantial shift in the thinking and research around giftedness and gifted education with a focus on observable achievements based on the model of expert performance (Ericsson, Roring, and Nandagopal, 2007). Through the analysis of observable performance of individuals such as the reproduction of superior performance on domain-specific tasks, the expert performance approach avoids the problems of focusing solely on innate talents and abilities. The expert performance approach is commensurate with the ideas of researchers such as Ziegler and Stoeger (2008), who consider learning outcomes to be more important than personal traits for attaining high levels of achievement. Ziegler and Stoeger (2008) argued that it is impossible to predict expertise exclusively on the basis of cognitive variables and a focus on learning needs to be considered when assessing expert performance. Similarly, Sternberg (2001) used the term ‘developing expertise’ to describe the path from low-level accomplishment (novice) to
outstanding accomplishment (expert), suggesting that all abilities are forms of developing expertise. Sternberg (2001) defines gifted individuals as those who “develop expertise at a more rapid rate, or to a higher level, or to a qualitatively different kind of level than do not gifted individuals” (p. 3).

Shore (2009) drew comparisons between the characteristics of the thinking of gifted students and experts consistent with previous links between gifted knowledge and expertise (i.e. Ericsson, Nandagopal, & Roring, 2005; Sternberg, 1998; Subotnik & Jarvin, 2005; Ziegler, 2005). Shore described the differences in the thinking of gifted children in comparison to not gifted children in terms of the nature of their knowledge. It was suggested that the differences lay within the ability to link pieces of learned information into categories, which makes the knowledge more efficiently retrievable. On a descriptive level this is consistent with the idea that the knowledge of gifted learners is different to the knowledge of not gifted learners. Furthermore, according to Ziegler, Vialle, and Wimmer (2013), the characteristics that comprise the effectiveness of the expert’s action repertoire include more successful actions, more extensive actions, rich information storage, access to effective actions, analysis of problems, physical adaptions, introspection, and cognitive effort.

Shore (2009) also reported that gifted children, like adult experts, acquire extensive networks of knowledge about facts and procedures. Gifted children have an ability to understand relationships and make connections between ideas (Clark, 2002; Pfeiffer, 2012) and have an intuitive understanding of concepts (Pfeiffer, 2012). Furthermore, some of the key components of a gifted understanding include the ability to make spontaneous links between concepts, the ability to differentiate between and elaborate on concepts and the ability to make higher-level inferences (Munro, 2012). From this we start to narrow down into the factors that define gifted knowledge in order to understand how the ‘actions’ of a gifted learner can be better understood both in terms of their learning capacity and their learning outcomes following teaching.

What becomes prominent in the literature is a shift towards focusing on learning and knowledge acquisition for gifted learners. Various researchers (Ericsson, Nandagopa, & Roring, 2005, 2007; Shavanina, 2007; Shore, 2009; Sternberg, 2001, 2005) have proposed that the framework for expert performance be applied as a conceptual model for describing gifted knowledge. In viewing giftedness from the expert performance perspective, the similarities in the cognitive characteristics that exist between gifted and expert understanding are identified. The
views from the aforementioned researchers have been the driving force behind the move to view
giftedness in terms of expert performance and to focus on models such as the novice-expert
knower model (Munro, 2012).

In moving away from the traditional measures of assessment for identifying giftedness, it
is essential to identify the purpose for the assessment. As suggested by Borland (2005), the label
of giftedness may not provide any benefit to the student or their educational development. The
fact that the expertise approach focuses on the student learning outcomes enables assessment of
the learning capabilities in an educational context, as opposed to the assessment of intelligence
or cognitive abilities which provide only general learning or aptitude measures. The goal that is
central to all conceptions of giftedness is the identification and nurturance of specific gifts. The
current shift is moving toward explaining the talent development process as opposed to merely
listing traits or characteristics that are important to achieve giftedness. For both the system and
developmental models of giftedness, intelligence and expertise are one piece of a larger network
of interconnected elements.

2.4 The Novice-Expert Knower Model as Guiding Framework

2.4.1 The novice-expert knower model. Drawing on models of expert knowledge and
performance (Ericsson & Lehmann, 1996; Ericsson, Nandagopa, & Roring, 2005, 2007;
Ericsson, Patel, & Kintsch, 2000; Farrington-Darby & Wilson, 2006; Shavinina, 2007;
Sternberg, 2005), the novice-expert knower provides a basis for identifying and interpreting the
characteristics of gifted knowledge that can be understood for practical classroom use. The
notion of understanding how the gifted learner thinks differently to the not gifted learner is
summarised in the novice-expert knower model of giftedness proposed by Munro (2012). This
model describes the thinking that underpins the novice to expert transition, and provides a means
for inferring how the knowledge of the gifted learner might develop when exposed to teaching.
This model can also be used to describe the learning capacity of students; that is, their unique
cognitive representations that allow them to frame up ideas and theories about a topic prior to
teaching. This is consistent with ideas such as the subjective action space proposed by Ziegler
and Stoeger (2008), the unique interactions that gifted students have with their environments
(Shavinina, 2007; Ziegler & Phillipson, 2013) and the intuitive understanding of ideas and
concepts of gifted students (Munro, 2012; Pfeiffer, 2012).
2.4.2 Cognitive characteristics of expertise. In order to interpret the expert performance approach and its application to models of giftedness it is important to firstly unpack the notion of ‘expertise’. This provides the basis for understanding how the models of giftedness integrate this framework to view the gifted learner as the expert-knower.

The view from a cognitive science perspective proposes that experts within their specific domains think in qualitatively different ways from novices (Farrington-Darby & Wilson, 2006; Anderson, 2000; Chi, Glaser, & Far, 1988). In order to understand the qualitative difference that has been reported, the characteristics that describe the differences between an expert and a novice are explored.

The knowledge structure of experts is characterised by elaborate, highly integrated frameworks of related concepts (Chi et al., 1988). According to Glaser and Chi (1988) experts mainly excel in their own domain, perceive large and meaningful patterns in their domain, perform skills fast and quickly solve problems with little error, have superior short-term memory and long-term memory, represent problems at a deeper level, qualitatively analyse problems, and have strong self-monitoring skills. This extensive list of characteristics provides an insight into the workings of an individual who would be described as an expert.

The characteristics described by Glaser and Chi (1988) provide a sound and broad description of expert performance. However, more specifically, the knowledge base of experts has been an area of focus in the literature. The knowledge base of experts has been described as being large (Sternberg, 1998), consisting of complete representations (Cellier, Eyrolle, & Marine, 1997; Pollert, Feldhusen, Van Mondfrans, & Treffinger, 1969) and being well organised (Pollert et al., 1969; Sternberg, 1998). When considering the characteristics that describe expertise, our goal is to find a working solution to describe the knowledge of children who develop an understanding of a topic that can be described as gifted. This would provide opportunities for the descriptions of expertise to facilitate classroom teaching.

Thus, we select and focus on the characteristics of expertise, which can potentially facilitate this endeavour. In doing so, we select and focus on two broad characteristics of expert knowledge which feature prominently in the literature. The focus of the next part of the present study is on the description and enhancement of knowledge in the classroom. Two aspects of expert knowledge are seen as relevant and appropriate for the study. The amount of domain-specific knowledge held by an individual, and the organisation of that knowledge. Furthermore,
the processing capabilities that manifest from a combination of highly organised and structured domain-specific knowledge.

2.4.2.1 Amount of domain-specific knowledge. Salthouse (1991) suggested that superior performance demonstrated by experts could be attributed to the larger body of knowledge for their domain of expertise. Put simply, experts have more knowledge about a topic than novices (Shore, 2009). However, in describing expert knowledge more specifically, Sternberg (1998) reported that the experts acquired a large knowledge base and their knowledge base contains rich schemata and great amounts of declarative knowledge (knowledge of facts) about a given topic or domain of study. Furthermore, Van Merrienboer and Sweller (2005) reported that human expertise develops from knowledge stored in schemata.

Thus the idea of schema development and domain-specific knowledge becomes pertinent when describing the knowledge base of experts. In looking at how schemata are involved in the development of expertise, we look at the pioneering work of Dutch Psychologist, De Groot (1946-1965) that began by examining the reasons why chess masters defeated weekend players. It was found that chess masters were able to accurately re-create the configuration of the chessboard taken from a (real) game 70% of the time compared to 30% for weekend players. The conclusions drawn from this finding was that the chess masters had highly developed schemata stored in their long-term memory. These highly developed schemata were activated when chess masters were presented with chessboard configurations. Weekend players lacked the highly developed schemata which impacted on their ability to problem solve during the game.

Similarly, Reingold, Charness, Schultetus, and Stampe (2001) found that skilled chess players build up structures in long term memory of pieces that are frequently encountered together, along with information on how they are related to one another on the board and to the position as a whole. Expert players are then able to use their stored knowledge that is readily available in long-term memory to encode and manipulate more chess-related information in a given mental operation. This provides further evidence for the idea that domain-specific expert performance stems from a highly developed network of schemata in which one is able to manipulate information with access to chunks of knowledge in long-term memory and provides evidence for the importance of knowledge base in expert performance.

2.4.2.2 Organisation of knowledge. In addition to the abovementioned differences in the amount of knowledge that experts acquire compared with novices, another aspect worthy of
consideration is the organisation of that knowledge. Ericsson and Staszewski (1989) stated that the fundamental problem is to describe what experts know and how they use their knowledge to achieve performance that most people assume requires extraordinary ability. Thus, in describing expertise, it is not only important to know what experts know but how they know. Ericsson and Staszewski (1989) reported that experts develop skills that enable them to efficiently apply their knowledge. The expert is able to efficiently apply knowledge because of the efficiency in the organisation of that knowledge in long-term memory.

The organisation and representation of knowledge in long-term memory is important to consider in addition to the greater body of knowledge that experts possess when compared to novices (Sternberg, 1998; Tashman, 2013). Glaser (1987) proposed that expert knowledge is structured more effectively, qualitatively different, organised into deeper and richer representations, and more adaptable to varying situations than is novice knowledge. But what is meant by effective structure? Curter et al. (2011) emphasised the importance of acknowledging and understanding the ways in which experts organise and structure knowledge. Experts demonstrate more well-structured and coherent knowledge (Feltovich 1981; Chi et al. 1988; Bordage & Lemieux 1991; Bordage 1994), which is a point of critical importance due to the dramatic impact of knowledge organization on the “efficiency and effectiveness of recall and problem solving within a domain” (Schmidt, 2006, p. 69).

In a study that looked at expert and novice students’ knowledge of dinosaurs, Gobbo and Chi (1986) found differences between expert and novice children in the ways that they organised and structure their knowledge. The expert children tended to focus on deeper level features such as the category of dinosaurs whereas novice children were more likely to focus on surface level features such as the size of dinosaur. They also found that the knowledge of expert children was more cohesive and structured and the superior organisation of the knowledge structure helped students derive implicit information about unknown dinosaurs. Differences between novice and expert knowledge organisation were also reported by Mayfield, Kardash, and Kivlighan (1999). In their study, novice counsellors exhibited less interrelated and organised schemata, tended to order the information based on the time of presentation in the case, and generated more concept categories (Mayfield, et al., 1999). The expert counsellors however, categorised and mapped client statements faster than novices and exhibited more highly integrated and domain-relevant knowledge structures.
Kalyuga, Ayres, Chandler, and Sweller (2003) also reported differences in the way experts organise knowledge. In addition to the large number of domain-specific knowledge that experts possess, their knowledge is hierarchically organised. This organisation allows experts to categorise multiple elements of related information in single higher-level elements. The highly organised nature of the knowledge of experts also has implications for processing and the development of automatic processing. Experts are better able to link new information to pre-existing knowledge than novice learners (Berliner, 1994). This knowledge is more easily retrieved in appropriate situations and more transferable to new situations. The benefits of a hierarchical knowledge structure in terms of facilitating further learning was also stressed by Reif, 1984; Reif & Heller, 1982 and others (Camacho & Good, 1989; Elio & Scharf, 1990; Prawat, 1989). According to Reif (1984) a hierarchical knowledge structure allows for the retention of knowledge, for quick and efficient search processes, and for fitting new elements of knowledge without having to restructure knowledge already present.

2.4.2.3 Categorisation and semantic hierarchies. Rosch, Mervis, Gray, Johnson, and Boyes-Braem (1976) described the development of categories and semantic hierarchies. They reported that semantic categorisation can be demonstrated by beginning with a global category like animal and then basic level categories such as cat, dog, and finally the subordinate categories, such as tabby, Siamese or poodle, bulldog.

Reif (1984) stated that this type of knowledge structure, which includes abstract and more general concepts at higher levels, is a typical characteristic of expert knowledge. De Jong and Ferguson-Hessler (1996) asserted that knowledge of science topics such as physics is characterised by strong links between elements, a high degree of abstraction, and a hierarchical nature. As mentioned previously, Chi et al. (1981) found that experts categorise problems in physics in ways that differ to novices where experts classified problems according to major principles whereas novices classified problems according to more surface-level characteristics. Although a topic such as physics is characterised by a high degree of abstraction and is hierarchical in nature, differing levels of expertise within the domain will be characterised by qualitatively different categorisation of concepts.

This type of categorisation could be explained in part by the findings Tanaka and Taylor (1991). In a study of domain-expertise, they demonstrated that experts use more specific categories to classify categories such as birds. They found that in the expert knowledge domain,
subjects were able to list a comparable number of attributes at the subordinate and basic level. Putting that into perspective, bird experts were able to demonstrate as much knowledge of the distinguishing properties of “robin” and “crow” as they could the distinguishing properties of “bird”. The experts’ knowledge of birds allowed them to differentiate at different levels of the semantic hierarchy. The findings suggested that expert knowledge is organised at the subordinate level as much as the basic level. This coincides with the speculation made by Rosch et al. (1976) that the individual differences in domain-specific knowledge could determine differences in determining levels of semantic categorisation. That is, the more domain-specific knowledge that a person possesses for a topic, the more likely they are to differentiate semantic categories and to distinguish properties at multiple (hierarchical) levels. A person with little knowledge of birds may not be able to differentiate at the subordinate level between types of birds.

The work of Tanaka and Taylor (1991) was further extended and emphasised by Johnson and Mervis (1997) who found that as expertise is acquired, a greater amount of information is learned about clusters of features that are indicative of subordinate levels in semantic categories. This results in the degree of distinctiveness between categories at the subordinate level having increased to the point where they may function as basic level categories. That is, for experts, the specific category in the semantic hierarchy becomes akin to the basic category.

These studies suggest that findings such as those from Chi et al. (1981) and Gobbo and Chi (1986) that found different types of categorisation for experts and novices, could be determined by experts’ level of domain-specific knowledge, which is hierarchically organised. This further emphasises the link between domain-specific knowledge and the organisation of knowledge in experts.

2.4.2.4 Information processing: Automaticity and working memory. Shiffrin and Dumais (1981) suggested that the role of automaticity in skill acquisition played a fundamental role in both the cognitive and motor-skill domains. In terms of the role of automaticity in skill acquisition, Bloom (1986) stated that in order to master any type of skill whether it is a routine task or a highly refined talent, automatic processing is required. This enables the person to perform the skill unconsciously (with minimal demand on their thinking space) with speed and accuracy while at the same time being able to consciously continue with other processes of brain functioning. Similarly, in an early study of telegraphy performance, Bryan and Harter (1899) concluded that the freedom and speed of the expert is only achieved once all of the necessary
habits have become automatic skills. In terms of the development of expert performance, they suggested that higher-level skills could not be acquired until lower-level skills had been automatised. Improvement in performance was thus attributed to the development of a hierarchy of habits, which reflected increasingly higher-order chunking. The organised nature of expert knowledge thus has implications for knowledge acquisition and expert performance.

Evidence suggests that expertise does not stem from superior memory abilities or larger short-term memory capacity (Chase & Ericsson, 1982; Deakin & Allard, 1991; Eccles, 2006; Kalakoski & Saarilouma, 2001) but rather from long-term memory. In accordance with this notion, Chase and Ericsson (1982) concluded that long-term memory must play a role in skilled memory performance, as short-term memory capacity does not increase with practice. The differences in short term working memory must lie within the organisation of knowledge within long-term memory. Hodges, Huys, and Starkes (2007) suggested that the difference between experts and novices could be attributed to a deeper level of comprehension for the expert rather than merely perceptual recognition. The expert is able to encode and manipulate information in long-term memory that can be accessed for accurate recall and use. This complexity influences the processing capacity of the learner. With increasing structural complexity of knowledge, these more refined representations enable the expert to free-up cognitive capacity for other tasks (Abernethy, Maxwell, Masters, Van Der Kamp, & Jackson, 2007). The more organised and structured knowledge in long-term memory the better students are able to access the information in their working memory.

Cognitive load theory (Sweller, 1988) further supports the idea that expertise does not stem from superior memory abilities or larger short-term memory capacity. According to van Merrienboer and Sweller (2005) the characteristics of working memory are altered by the learner’s long-term memory. Cognitive schemata are stored within long-term memory, which vary in their degree of automation and complexity. It is the knowledge stored in these schemata that contribute to expertise rather than ability to reason with multiple elements that have been organised in long-term memory. Expertise develops as learners develop more complex schemata integrating new ideas into existing knowledge structures and developing automatic processes to activate these schemata. These highly complex organised knowledge structures reduce the load on working memory as they can be dealt with as a single element. The repeated application of
schemata leads to automation (automaticity), allowing the working memory to utilise thinking space for other activities (van Merrienboer & Sweller, 2005).

An example of cognitive load theory can be seen in a real-world context. Coughlin and Patel (1987) found differences in domain knowledge for experts and novices where physicians displayed recall of more critical information and made fewer inferences to determine critical information than medical students. This shows that experts require less ‘activation’ of knowledge to determine key concepts or components that are required when filtering through schemata. For the expert, the information that is ‘critical’ is accessed and retrieved by filtering out unnecessary ‘non-critical’ information as part of the process. They are able to differentiate between information that is necessary and information that may be complementary but not necessary. This displays efficiency in the way experts navigate through their knowledge and focus on relevant knowledge. Their knowledge may be organised in ways that accommodate this process as opposed to a conscious ‘filtering out’ process. What does the expert require in order to ‘filter out’ unnecessary information and focus on the most important aspect? Firstly, domain-specific knowledge, and secondly, the ability to problem solve. These work hand-in-hand as mentioned previously with Sweller’s cognitive load theory.

Links can also be drawn with Urban’s componential theory of creativity (Urban, 1991). The componential theory of creativity (Urban, 1991) is comprised of six components. Three components represent cognitive aspects of creativity and three represent personality components. The three cognitive components of Urban’s theory are divergent thinking and acting, general knowledge and knowledge base, and specific knowledge base and area specific skills. The cognitive components that Urban emphasises relate to general knowledge and thinking base as well as specific knowledge base.

According to Urban (1991) general knowledge and thinking base are integral parts of the creative process as they contribute to the likelihood that a learner will display divergent thinking. General knowledge and thinking base create a platform for the learner to engage in flexible thinking. In order for the learner to display divergent thinking they must be able to reformulate, redefine and reconstruct information. Urban also highlights the importance of domain-specific knowledge in the construction of creative ideas. Creative insights depend on the availability, accessibility and integration of knowledge that is necessary for a given task (Urban, 1999, 2007).
Therefore, the cognitive components of knowledge that facilitate flexible thinking are important to consider as implications of expert-type knowledge.

2.4.2.5 **Summary of the characteristics of expert knowledge.** Research suggests that the cognitive characteristics of experts differ from that of novices. The knowledge of experts contains large rich schemata stored in long-term memory, which are complex and automatised (Von Merrienboer & Sweller, 2005). According to Von Merrienboer and Sweller (2005) the knowledge stored in schemata is the basis for human expertise. The work of de Groot (1978), Charness (1976, 1979), and Chase and Simon (1973) demonstrated that chess experts were able to perceive and recognise structured game patterns as opposed to random placement of chess pieces. This finding highlighted the need for domain-specific knowledge and experience for skill acquisition and the attainment of expertise. Rather than expertise being attributed to superior abilities in general ability or memory, these findings indicated that superior memory performance was attributable to domain-specific knowledge. Similarly, Ericsson and Towne (2013) reported that the superior speed in performance by experts is attributed to the acquisition of cognitive representations (schemata) rather than perceptual speed. Thus the cognitive representations in long-term memory are important in understanding the development of expertise. The amount of knowledge and the organisation of that knowledge have further implications for processing and learning. Experts and highly skilled individuals circumvent the limited capacity of working memory through the storage and organisation of information in long-term memory (Ericsson & Delaney, 1998). Experts are able to maintain more information in an accessible form during processing in domain-specific tasks. This can be explained in part by theories such as cognitive load theory, which proposes that higher degree of automaticity of domain knowledge frees up thinking space when activating knowledge for that topic (Sweller, 1998; van Merrienboer and Sweller, 2005).

2.5 **Applying the Expert Performance Approach to Giftedness**

The vast array of research into expertise and expert performance has thus shaped the remodelling of gifted models and theories, which use the novice-expert transition to help guide current perspectives and understanding of giftedness. As mentioned, researchers (Ericsson, Nandagopa, & Roring, 2005; Ericsson, Roring, & Nandagopa, 2007; Shavanina, 2007; Shore, 2009; Sternberg, 2001, 2005) have proposed that the framework for expert performance be
applied as a conceptual model for describing gifted knowledge. In viewing giftedness from this perspective the similarities in the cognitive characteristics that exist between gifted and expert understanding are identified. Particular models of giftedness such as the Actiotope Model of Giftedness and the Novice-Expert Knower Model provide descriptions of the cognitive characteristics of gifted students based on the expert performance approach. These descriptions stem from the body of work within the expert performance framework described in this chapter and this has been applied to current conceptions of giftedness in order to describe gifted knowledge.

Ziegler et al. (2013) proposed that all people have a unique repertoire of actions or possibilities for acting and experts or gifted persons have a far more effective repertoire of actions, which differs on at least nine characteristics from the repertoires of actions of novices (Ericsson, 1998; Ericsson, Charness, Feltovich, & Hoffman, 2006). The repertoire of actions of experts in their area of specialty includes actions that are more successful, far more extensive, and experts act on the basis of their rich information storage. This rich information storage allows the expert to access effective actions and to create a more action-functional problem representation. Furthermore, experts use more suitable strategies to arrive at solutions and the bodies of experts are adjusted in ways that allow them to perform within their domain. In addition to the extensive cognitive action steps that experts have acquired, these cognitive actions steps have become automated and thus reduce the level of cognitive effort required in retrieval. This allows for cognitive resources to be available for the analysis of problems when solutions are unknown. Taken together, these characteristics explain why experts, with their effective repertoire of actions, are superior to the average capable person in their special field.

Similarly, Munro (2012) outlined the characteristics that signify the transition from novice to expert type understanding that can be used to describe gifted knowledge. The novice-expert knower model focuses on the similarities between an expert and gifted understanding. Both of which have more elaborated and differentiated conceptual networks than their not gifted or non-expert peers. This allows for a more rapid, broader and deeper interpretation of new information and allows the gifted learner and the expert to analyse ‘big picture’ patterns and rules in information. According to the model, the gifted learner and the expert use their conceptual networks more automatically and retain knowledge (according to their area of expertise) more efficiently in working memory. Furthermore, they see deeper relationships and
principles than novices and are able to infer more broadly when monitoring the various effects and implications of their decisions and actions. Gifted learners and experts can also simultaneously link several aspects of their learning rather than working on single aspects and working in a sequential manner. This allows for more efficient and complete knowledge representations.

2.6 Verbal and Nonverbal Domains of Giftedness

Researchers such as Ziegler and Munro describe the ways in which gifted students display gifted knowledge through the application of the expert performance model. These descriptions provide a comprehensive summary of the skills and characteristics that differentiate a gifted and not gifted knowledge or understanding. However, what does the research say about giftedness being domain-specific and the different representation of knowledge and cognitive characteristics for students gifted in different domains? According to Sternberg and Grigorenko (2002), expertise is “the ongoing process of the acquisition and consolidation of a set of skills needed for a high level of mastery in one or more domains of life performance” (p. 267). Thus, a person can be gifted in one domain but not in another.

Song and Porath (2005) stated that the cognitive characteristics of gifted could not be generalised due to unique patterns of development for individuals. One distinction in particular that can be made is that between the abilities or domains in which students have been identified as gifted. Similarly, Munro (2013) asserted that gifted students can show irregular or fluctuating high achievement in the classroom that can be attributed to different areas of exceptionality. Following the assertion that someone can be gifted in one domain but not in another, it is plausible to assume that in order to differentiate curriculum for gifted students, one must determine not just whether or not a student is gifted, but how and in what domains the students is gifted. VanTassel-Baska et al. (2007) support this notion, stating that a new paradigm for identifying students would benefit those students who have previously been underrepresented in gifted programs. This new paradigm would recognise the multiple ways in which students display giftedness.

Previous research has demonstrated multiple domains in which students can be gifted. Benbow and Stanley (1983) investigated the structure of intelligence for students with exceptional general ability and found that academic giftedness could be attributed to at least two
distinct domains: verbal and nonverbal giftedness. Benbow and Minor (1990) reported that
giftedness was not therefore a unitary construct and different cognitive profiles could be
attributed to giftedness in the verbal and nonverbal domains. Based on their research, it was
concluded that students should be selected for special academic programs based upon qualities
required by the particular program and the selection of students for programs based on overall
ability (IQ) was not justifiable. Of particular note was the potential exclusion of nonverbally
gifted students from gifted programs. Students gifted in the nonverbal domain were reported to
be less balanced in their specific abilities and were at risk of being unidentified as gifted when
relying on overall rank or combined indices for ability.

As a result of their research, Benbow and Minor (1990) reported that verbal and nonverbal
giftedness are distinct from one another and procedures for identifying giftedness should include
assessments of both. Furthermore, large differences between verbal and nonverbal reasoning
abilities are much more common among highly able students than among average ability
students (Lohman, Gambrell, & Lakin, 2008). Lohman et al. (2008) suggested that relying on
composite scores or general ability fails to attend to the profile of students’ reasoning abilities.
The reliance on general ability as an identification of giftedness has the potential to exclude or
misinterpret students as not gifted that have relatively weak scores in one domain, detracting
from their high ability in another. This provides a rationale for assessing the cognitive
characteristics for students across both verbal and nonverbal domains of giftedness.

This verbal / nonverbal distinction is consistent with theories such as Dual Coding
Theory (Clark & Paivio, 1991), which states that learners have access to two main systems when
encoding information, verbal and nonverbal. The verbal encoding system allows individuals to
represent and store information in terms of the linguistic properties and semantic features,
whereas the nonverbal system allows individuals to represent and store information in terms of
perceptual and spatial properties. Learners have access to both encoding systems, however, they
can also differ in terms their relative capacity to use both systems. Thus, in theory, students
gifted in the verbal domain would have a greater capacity to represent and store information in
terms of the linguistic and semantic properties than students who are not gifted in this domain.
Similarly, students gifted in the nonverbal domain would have a greater capacity to encode
information in terms of its perceptual and spatial properties.
The relative strengths of verbally gifted students were explored by Munro (2005). He found verbally gifted students possess more elaborated and differentiated conceptual networks than not gifted students. This leads to an enhanced ability to retrieve meanings of verbal concepts and to reason about them and to make links between ideas that may be unexpected. Therefore, students who are verbally gifted are likely to have extensive vocabularies, well-developed conceptual abilities and broad general knowledge. Furthermore, Munro stated that when reading, verbally gifted students may need to use only few of the concepts mentioned in a text in order to identify its context and to comprehend at least some of its propositions. Their more extensive existing network of concepts may be sufficient to inform them of the context and the ideas likely to be mentioned in the text. As a consequence, they don’t need to invest attention in encoding most of the written words to identify the likely intended relationships between concepts in the text. Their existing knowledge would identify this more rapidly.

Silverman (2010) described the characteristics of the ‘visual-spatial’ learner. These characteristics described the visual-spatial learner as having the ability to perceive the interrelatedness of the parts of any situation, learning in a holistic way, having high imagination, and having expert facility with games such as puzzles and mazes. Furthermore, Silverman (2010) also reported that spatial abilities underlie mathematical talent and creativity. Creativity may be evidences in inventiveness, artistic talent, or imagination applied to any field. Mann (2005) in differentiating between spatial or non-verbal abilities and phonological (verbal) abilities reported that the different abilities are associated with different hemispheres in the brain. The non-verbal abilities are associated with right hemisphere processing whereas the verbal abilities are associated with processing in the left hemisphere.

Students, who are spatially gifted, struggle to master rote memorisation material, yet thrive when involved in situations requiring higher order thinking skills and creative problem solving (Baum, 1984; Mann, 2001; Silverman, 2002). Spatial learners tend to process information more slowly (Dixon, 1983; Silverman, 2002; West, 1991); they have to consider the concept and reflect on how individual pieces fit into the main scheme of information as they are holistic in their approach to learning (Silverman, 2002) and may have difficulty attending to details that are presented in isolation. These learners often display an ability to grasp complex relationships between systems, are aware of physical properties and patterns, and understand how the pieces fit together. This holistic preference for acquiring knowledge may result in a
weakness in planning sequentially. Silverman (2010) reported that visual-spatial learners do best when they deal with whole systems, abstract relationships, major concepts, inductive learning, and problem solving. Spatially gifted students may miss easy concepts but will achieve at high levels with more difficult material. The spatial learner often grasps simple concepts only in the context of more complex ones and learns best through inductive or discovery techniques.

The different characteristics of students with strengths in verbal or nonverbal domains provide a basis for revisiting the idea raised by Borland (2005) about the case for no conception of giftedness. Borland suggested that conceptions of giftedness are unnecessary. He stated that, “schools can, and do, employ acceleration without having gifted programs per se. Acceleration does not require identifying students as “gifted,” special teachers, pull-outs, or any of the ordinary trappings of traditional gifted programs. If a student can work ahead of his or her age peers in, say, mathematics, he or she can simply be allowed to do so; there is no reason to identify the student as gifted. To sound a theme to which I return later, acceleration is one example of how gifted education can be effected without either gifted programs or gifted students” (Borland, 2005 p. 11). Borland raised these comments in response to the identification and selection of students for gifted programs on the basis of IQ score. The point raised by Borland highlights the fact that a blanket label for ‘giftedness’ does not provide adequate information or knowledge for teachers to accommodate the specific and varied needs of gifted students. The cognitive characteristics of students gifted in different domains will differ and similar to the findings in expertise research, people will have strengths that are specific to their field of expertise. Thus, it is important to question whether the characteristics that are described in models such as the novice-expert knower model of giftedness provide an accurate description of gifted knowledge, and whether these characteristics differ for students who are gifted in different domains.
CHAPTER 3
REVIEW OF THE LITERATURE ON CONCEPT MAPPING

This chapter outlines the cognitive representations of knowledge and the use of concept mapping to monitor these. Concept mapping procedures are discussed in terms of their efficacy as a way to identify differences between the knowledge of experts and novices. Furthermore, this chapter outlines how concept mapping could be used to monitor the knowledge characteristics of gifted students given their efficacy in identifying cognitive characteristics of experts.

3.1 The Cognitive Representation of Knowledge

A student’s conceptual understanding of a topic provides an indication of the complexity of their domain-specific knowledge. In gaining an accurate representation of a student’s knowledge base it is possible to map and differentiate the levels of conceptual understanding of students at different levels of expertise within a domain of study. The ability to map an individual’s conceptual knowledge of a topic or domain of study into concepts and associated links provides an avenue for describing gifted understanding. The novice-expert model (Munro, 2012) allows the focus to be on what the learner knows, which is consistent with the notion suggested by Ziegler (2005) that it is important view giftedness in terms of learning. Thus, it is appropriate to search for methods that can accurately measure the level of knowledge that a person has acquired. One way of approaching this is through the use of concept maps (Novak, 1972). Concept maps are visual representations of a person’s conceptual knowledge. Concept maps can be used to assess what a person knows about a given topic or domain of study which can be developed from a focus question. Thus concept maps can be useful in identifying the breadth and depth of a learner’s knowledge. Being able to gain an accurate representation of gifted thinking and understanding will allow teachers to develop an understanding into student learning and potential pathways for future learning.

Cognitive psychologists seem to agree that the internal representation of knowledge resembles webs or networks of ideas that are organised and structured (Hiebert & Carpenter,
It is also agreed that the more connections that exist among a set of facts, ideas and procedures for a topic, the better the understanding for that topic (Hiebert & Carpenter, 1992; Hiebert & Lefevre, 1986). Individuals whose knowledge within a particular domain is interconnected and structured will activate large chunks of information when they perform an activity in that knowledge domain (Fisher & Lipson, 1985; Prawat, 1989; Royer et al., 1993). A highly integrated knowledge signals the transition from novice to expert performance. It is theorised that the characteristics that signal the transition from novice to expert performance can be measured using concept maps.

3.2 Concept Maps as a Measure of Conceptual Knowledge

Concept maps provide a direct method of analysing the organisation and structure of a learner’s knowledge within a particular domain (Williams, 1998). Students’ knowledge structures can be represented using concept mapping techniques (Mintzes et al., 1997; Novak & Gowin, 1984). These techniques provide a means of assessing the structure of students’ conceptual knowledge (Novak, 1972).

According to Ruiz-Primo (2004) concept maps can be used to measure important aspects of the structure or organisation of a student’s declarative knowledge. Furthermore, they can be used to represent explicitly a child’s knowledge structure along with the idiosyncrasies that develop with each child’s unique experiences (Edmondson, 2000). Novak (2012) reported that concept maps were developed to gain an accurate representation of the cognitive structure formed by a learner, which explicitly shows how concepts and propositions are integrated into a student’s knowledge.

Concept mapping procedures are effective tools in identifying the relevant knowledge that a learner possesses before or after instruction (Edwards & Fraser, 1983). These techniques are also a direct method of looking at the organisation and structure of an individual’s knowledge within a particular domain. The knowledge represented on a concept map also gives insight into the fluency and efficiency with which the knowledge can be used (Williams, 1998).

3.2.1 How concept maps represent knowledge. According to Novak and Cañas (2006, p. 1), concepts and propositions are the building blocks for knowledge. They define concepts as “perceived regularities or patterns in events, objects, or records of events or objects, which are
designated by a label” and propositions as “statements about some object or event in the universe which is either naturally occurring or constructed.” Furthermore, “propositions contain two or more concepts connected using linking words or phrases to form meaningful statements”. Novak (2010) describes knowledge in his theory of education as based largely on a structure of concepts and propositions with the construction of new knowledge occurring as a result of high levels of meaningful learning. Concept maps are proposed to illustrate the learner’s cognitive structure for a specific topic or domain of study. The cognitive structure reveals the learner’s conceptual understanding and thus gives insight into the developmental potential for that topic of study (Novak & Cañas, 2006).

3.2.2 Use of concept maps to measure expertise. The novice-expert knower model of giftedness draws on models of expert knowledge and performance (i.e. Ericsson & Lehmann, 1996; Ericsson, Patel, & Kintsch, 2000; Farrington-Darby, & Wilson, 2006), which proposes the use of this framework to describe gifted knowing and thinking. The description of gifted knowledge using concept mapping stems from the proposition that the concept maps of experts for a given domain differ in terms of the quality of the knowledge display from the concept maps of novices. Numerous studies have found that the concept maps of experts and novices differ. West et al. (2000) presented evidence of the validity of concept mapping assessment to capture developmental differences as they found significant differences in concept map assessment for learners of various degrees of training, as well as significant improvements from pre-educational to post-educational intervention assessments. Mintzes et al. (1997) demonstrated that experts exhibit concept map structures that are more connected and interrelated than the concept maps of novices. Furthermore, Williams (1998) found that the concept maps of experts are large, complex and more interconnected compared to those of novices. The concept maps of experts are also qualitatively more sophisticated than the concept maps of novices (Marshall, 1995). This is reflective of the knowledge structure of experts, which is characterised by elaborate, highly integrated frameworks of related concepts (Chi, Glaser, & Far, 1988; Mintzes, Wandersee, & Novak, 1997). The reported differences between the concept maps of novices and experts suggest that the tool can capture accurately and represent the different characteristics of expert-type knowledge.

Previous studies have shown that the concept maps of high performing and average performing students differ. Austin and Shore (1993) conducted a study with six college students;
three high performing and three average performing, based on overall average grades at the college level, and two university physics teachers. It was hypothesised that the concept maps of high performing students would have almost all the concepts linked into one composite map, and many of the concepts should have multiple links. Furthermore, the links would be better explained. It was found that the concept maps of high performing students differed from those of average performing students and closely resembled the concept maps of experts, especially when the quality of the links was taken into account (Austin & Shore, 1993).

The research demonstrates that the qualitative and quantitative differences that exist between the knowledge characteristics of experts and novices within a particular domain are revealed when constructing concept maps for that given domain.

**3.2.3 Scoring concept maps.** Scoring systems to quantify the knowledge represented in concept maps have been devised (e.g., Novak & Gowin, 1984). These focus on the validity of propositions, the validity of the hierarchical nature of the concept map, and the significance and validity of the cross-links. As such, concept maps are useful evaluation tools (Novak & Cañas, 2006) and are as effective as clinical interviews in identifying a learner’s knowledge before or after instruction (Edwards & Fraser, 1983). Concept maps that are constructed by students can become part of a portfolio for evaluating their understanding and performance in a topic of study (Novak & Cañas, 2006). However, as noted by Austin and Shore (1993), there is no common method of evaluating concept maps.

**3.3 Concept Maps as a Tool to Assess Knowledge in Current Study**

The expert-knower model utilises the expert performance approach in order to describe the cognitive characteristics of gifted learners. Thus, a tool that could assess the knowledge of gifted students was required for the present study to measure cognitive characteristics for these students. Not only did the tool need to assess the amount of knowledge of the gifted learner but also the characteristics of that knowledge. As noted, concept maps have been used in research assessing the knowledge of experts. The research shows evidence of being able to discriminate and highlight both quantitative and qualitative differences in the knowledge of experts and novices using concept mapping. Furthermore, concept maps facilitate the display of knowledge by providing students with the opportunity to think about the interconnectivity of concepts, the links between the concepts, and the interconnections and cross-links that occur in a specific
domain (Zimmerman, Maker, Gomez-Arizaga, & Pease, 2011). However, no studies have previously used concept maps to assess the cognitive characteristics of gifted students, and the different ways in which knowledge is represented and organised according to different types of giftedness. Given that the models of giftedness explored for the current study stem from the expertise literature, concept maps appear to be an appropriate tool to assess the knowledge of gifted students. Furthermore, given the focus on distinguishing between gifted learning capacity and talented learning outcomes, the present study will use concept maps to examine the characteristics of both the gifted learning capacity and to describe the features of understanding as a consequence of teaching.
CHAPTER 4
THE CURRENT STUDY

This chapter describes the conceptual framework for this research based on the foundations described in the literature. The review of literature in Chapter 2 found that current conceptions of giftedness have integrated the ideas from the expert performance approach to provide an explanation of the cognitive differences between gifted and typical learners. Furthermore, distinctions were made between domains in which students can be gifted, with an emphasis on the verbal and nonverbal domains. The cognitive characteristics of gifted students were further described in chapter two within the context of the classroom and predictions are made for what the knowledge of gifted students across different domains of giftedness might look like. The approach taken in this study identified the expert performance approach to describe the knowledge characteristics of gifted students and how the display of these characteristics might differ for students with relative strengths in the verbal and nonverbal domains. This approach will be used not only to assess these knowledge characteristics that comprise students’ learning outcomes following teaching, but also their learning capacity prior to teaching.

4.1 Background to the Conceptual Framework and Rationale

The present study utilised the novice-expert knower model of giftedness (Munro, 2012). A synthesis of work utilising the expert performance approach from researchers such as Ericsson and colleagues (Ericsson, Nandagopa & Roring, 2005, 2007; Shavinina, 2007; Sternberg, 2005) has produced the model known as the novice-expert knower model of giftedness in which giftedness is described in terms of expert performance (Munro, 2012). This approach allows the opportunity to establish the characteristics such as the depth and quality of domain-specific knowledge that a person has acquired and transition from a novice-type understanding to a more expert-type understanding. The novice-expert knower model proposed by Munro (2012) focuses on the quality of students' knowledge, as well as its quantity, using the 'regular student...
understanding' as a reference point. The focus on domain-specific knowledge assists in dealing
with the questions raised about the usefulness and effectiveness of cut-off points for saying
someone is gifted. The expert-knower model focuses on the quality and complexity of students’
knowledge and the understanding that is constructed. Given that teachers interact with students
and students’ level of understanding for particular topics, the expert-knower model is useful for
the classroom context.

The novice-expert knower model allows the focus to be on what the learner knows rather
than what the learner may potentially be able to achieve based on their general cognitive
functioning or intelligence. As suggested by Ziegler (2005) it is important to view giftedness in
terms of learning. Thus, it is appropriate to search for methods that can accurately measure the
level of knowledge that a person has acquired. One way of approaching this as discussed in the
previous chapter is through the use of concept maps (Novak, 1972). Concept maps are visual
representations of conceptual knowledge. Concept maps can be used to assess what a person
knows about a given topic or domain of study which can be developed from a focus question.
The literature suggests that concept maps can be useful in identifying differences between
leaners’ knowledge structures and the breadth and depth of their understanding (see Austin &
Shore, 1993; Marshall, 1995; Mintzes et al., 1997; Williams, 1998). The display of an accurate
representation of gifted thinking and understanding will allow teachers to develop an
understanding into student learning and potential pathways for future learning.

The ways in which gifted students organise and represent knowledge for different topics
is vital in terms of its importance for teachers within the classroom in order to cater for these
students. Differentiation for high ability students is not a common practice in regular classrooms
(Hertberg-Davis, 2009) and many gifted students have abilities that are not easily recognised
within the context of the school curriculum (Wallace, 2000). Thus, teachers are not in a position
to create opportunities to promote the development of students’ skills and abilities within the
classroom. It is suggested by Wallace that appropriate educational provision within the
classroom is necessary in order to encourage students to reveal their skills, abilities and
understanding. This is commensurate with the reasons for the lack of differentiation listed by
VanTassel-Baska and Stambaugh (2005) who reported that one of the main reasons for the lack
of differentiation for gifted and talented students was teachers’ lack of professional knowledge
about what giftedness looks like in the classroom. In summarising the key areas in response to
this finding, Munro (2011, 2012) proposed that building teachers’ professional knowledge of what giftedness looks like in the classroom context was pivotal in the process of differentiation for gifted learners. In order to build professional knowledge of what giftedness looks like in the classroom, it is necessary to find tools that can assess and distinguish the knowledge of gifted learners in comparison to their not gifted peers. Concept mapping will be used in the present study to assess whether the characteristics of the expert knower are more likely to be displayed by gifted students and this will inform whether concept mapping is a viable tool to assess the knowledge of gifted students. The efficacy of concept mapping as a tool for teachers to identify gifted knowledge in the classroom context targets the issue discussed in Chapter 1 around opportunities for the identification of giftedness within regular classroom interactions.

4.2 The Conceptual Framework

The aim of the present study is to identify the cognitive characteristics of giftedness in classroom context in order to facilitate the differentiation for these learners in regular classroom. Thus, the novice-expert knower model (Munro, 2012) is employed as the foundation for the conceptual framework. The cognitive characteristics described in this model can be interpreted in the classroom context. The transition from novice-expert type understanding will be described in detail in this chapter and will provide the foundation for identifying a gifted understanding in the classroom context. This coincides with the problem identified by Wallace (2000), VanTassel-Baska and Stambaugh (2005) and Munro (2011, 2012), in which the knowledge of gifted students must be more easily recognisable within the classroom.

The novice-expert knower model proposes that each phase in knowledge transformation for a topic can be described in terms of knowledge criteria. The teaching activities can catalyse the change in knowledge from novice-expert type if these are based on the learner’s existing knowledge. Effective teaching is more likely to be a scientific activity when conceptual tools are available and necessary for observing students’ knowledge transformations, in other words, the teachers are equipped to guide students’ learning most effectively. In order for conceptual tools to be available for teachers to utilise, the knowledge characteristics that will be assessed must first be determined. The novice-expert knower model provides a framework for interpreting the knowledge characteristics that could be used to develop conceptual tools for teachers.
4.2.1 Change in students’ understanding according to the novice-expert knower model.

The novice-expert knower model can be used to signal the transition from a novice to expert type understanding. According to Munro (2012) the transition from novice-expert type understanding is characterised by progressively more complex set of actions and interpretation of teaching information. The following descriptions outline the level of understanding displayed by students at differing levels on the novice-expert knower continuum. These descriptions can be used to extract the characteristics that students might display in order to signal higher-level thinking and understanding within a topic.

1. A novice understanding essentially represents the internalisation of the teaching information. The information is interpreted in a literal way. Students who form this understanding initially often use the new ideas in restricted ways, understand them in partial, separate and tentative ways, and need to try them out to see how they fit. They show superficial recall of specific details. They need to be taught to link and relate the ideas (Munro, 2012, p. 9).

2. A spontaneous patterned, more general understanding. Some students, without formal instruction, form an understanding that is more than the internalisation of the teaching information. They extend spontaneously the taught ideas and generate patterns from them. They form new concepts and relationships such as possible causal or consequential trends by asking. For example, How / why did the trend / pattern / change direction? They question and speculate about the patterns and generate ideas and possibilities that were not mentioned in the teaching information; How did the patterns affect / contribute to…? In other words, these students form interpretations, without being instructed, that are more general. These may be in the form of patterns, rules or more abstract formulations (Munro, 2012, p. 9).

3. A spontaneous big picture understanding that is typical in some ways of an expert understanding. Their understanding is broader than that of the patterned understanding. They understand the topic in a big ideas way; they can think about two or more patterns, rules or general propositions at once. As well as formulating rules and principles, they
often link more / ethical issues with them and see possible moves and options. They can apply their big ideas understanding to solve problems fluently and automatically. They make decisions to show that they are thinking in terms of multiple patterns at once, for example, ‘if this happens, then… but because of … I would… They can plan how they will use their new knowledge in creative, novel ways and use to solve problems and make decisions, manage and use their knowledge more efficiently, monitor how they use it and readily change direction or re-question what they know… Their understanding frequently includes creative interpretations. They make links between ideas that are novel, functional and un-expected. Their understanding allows them to see possibilities and options that suggest a far transfer of the ideas (Munro, 2012, pp. 9-10).

4.2.2 Gifted knowledge representations and the novice-expert knower model. The use of the novice-expert knower model in the present study focuses on the acquisition and representation of knowledge by gifted learners. The cognitive aspects of the novice-expert knower model provides an opportunity to describe the cognitive differences that are evident in the knowledge of gifted learners when compared with not gifted learners. These cognitive differences will be important to consider in the classroom as they indicate differing levels of thinking and ability in that specific domain of study. The present study is focused on the cognitive aspects of learning and is specifically tailored towards practical use in the classroom setting based on assessing the gifted student’s learning capacity and what the gifted learner’s knowledge ‘looks like’. Thus, the aim of the present study is to identify the ways in which gifted students know and think by focussing on the ways in which these students display knowledge.

As discussed in the review of the cognitive characteristics of expertise and giftedness, the gifted learner will display characteristics that distinguish their potential to learn that differs from their not gifted peers. This could be described as their learning capacity. The question then arises ‘what does this gifted learning capacity look like?’ The cognitive characteristics of gifted students based on the transition from novice to expert type understanding can be used to assist in determining what the learning capacity of gifted students looks like. At the ‘expert’ level, the knowledge of the gifted students will be characterised by a broader ‘big picture’ understanding that contains multiple links and patterns. This notion of the ‘expert’ can be applied to the topics assessed through concept mapping tasks.
4.2.3 Knowledge representations across domains of giftedness. The characteristics described in the novice-expert knower model leads to predictions about the ways in which gifted students display knowledge in a learning task. From the knowledge characteristics described in the transition from novice to expert type understanding, it is expected that gifted students might differ from not gifted students in the extent to which they display; elaborated and differentiated conceptual networks, efficient and complete knowledge representations, and interconnected networks of knowledge.

It is also important to recognise how the different types of giftedness might differ in terms of the knowledge characteristics that will be displayed. Gifted students have their own unique patterns of development (Clark, 2002; Shavinina, 2007; Tuttle, 1983) and thus the general characteristics that describe expert-type thinking might not be reflective of differences across domains of giftedness. General capabilities may appear as general characteristics such as those described in the novice-expert knower model whereas domain-specific characteristics might demonstrate unique characteristics in specific groups such as twice exceptional or gifted learning disabled (GLD) students (Song, 2004), or students gifted in different domains such as the verbal/nonverbal distinction (Benbow & Minor, 1990). According to Olszewski-Kubilius and Thompson (2014) students show relative strengths and weaknesses in different areas of intellectual reasoning ability such as higher mathematical (nonverbal) reasoning compared to verbal reasoning. This distinction has been reflected in the Talent Search Program which has taken the approach of identifying the multiple ways in which students can be gifted over assessments that focus on general cognitive ability alone (Olszewski-Kubilius & Thompson, 2014). Programs such as talent search, which have been successful in identifying ‘talent’ across different domains of giftedness, provide a rationale for focusing on the different cognitive characteristics for students gifted in either nonverbal or verbal domains (or both). This shifts the focus to identifying students’ unique cognitive profiles with a focus on the distinction between nonverbal and verbal strengths rather than their ‘giftedness’ as a reflection of general cognitive ability.

4.2.3.1 Nonverbal giftedness. Students who are gifted only in the nonverbal areas of knowledge, the ‘gifted visual-spatial’ learning profile (Silverman, 1989) are less likely to have access to the elaborated semantic network available to the verbally gifted students. Their advanced imagery knowledge, linking ideas in nonverbal relationships, is less likely to match the
verbal propositions in written text. A restricted letter cluster knowledge is less likely to be compensated by their gifted nonverbal knowledge. (Munro, 2005). Therefore, it is expected that students who are gifted only in the nonverbal domain will not be as fluent in generating verbal propositions as verbally gifted students.

Despite the lack of verbal propositions that are expected for the nonverbally gifted students, in theory, students that have high nonverbal ability are expected to be able to identify the relevant features in a topic. This stems from the work of Silverman (2010) who reported that students gifted in the nonverbal domain are able to perceive the interrelatedness of the parts of a situation. Furthermore, these students will be able to see relationships between ideas that are provided to them about a topic and subsequently make connections between concepts once integrated into their thinking (Silverman, 2010). The increased capacity in fluid reasoning will result in nonverbally gifted students displaying knowledge that demonstrates novel relationships such as clearly defined links between ideas and an increased capacity to display divergent thinking.

4.2.3.2 Verbal giftedness. Verbally gifted students will be proficient in displaying knowledge that comprises many ideas and concepts; they will display more fluency in generating ideas about a topic (Munro, 2005). Verbal knowledge that is gifted can be conceptualised as comprising verbal semantic networks that are more differentiated and elaborated than that which is not gifted. This leads to an enhanced ability to retrieve the meanings of verbal concepts and to reason about them. Verbally gifted students are likely to have extensive vocabularies, well-developed conceptual abilities and a broad general knowledge. Therefore, students gifted in the verbal domain will likely demonstrate more verbal propositions than the nonverbally gifted students, and will reason about these propositions. The differentiation and elaboration of verbal concepts will manifest in verbal propositions that are organised more semantically than the students gifted only in the nonverbal domain.

However, verbal reasoning might also be important in how increased capacity in fluid reasoning is displayed. For students with low verbal reasoning, the increased capacity in fluid reasoning might assist them in searching for patterns, however, without the verbal proficiency to identify concepts that comprise the topic the opportunities for firstly finding and then defining relationships will be compromised.
4.2.3.3 Global giftedness – verbal and nonverbal giftedness. For students who are identified as being high in both verbal and non-verbal reasoning (globally gifted), it is predicted that their knowledge will show both the elaboration or fluency of ideas and the integration and connectedness of those ideas. The high verbal proficiency will allow the students to draw on their verbal reasoning to develop ideas based on the given concepts in a topic, as well as infer further concepts that contribute to building a comprehensive knowledge display for the topic. The high non-verbal proficiency will allow those students to ‘see’ relationships between the segments of knowledge that are displayed. They will understand the features that underlie the concepts that make up networks of meaning. Understanding these features will allow these students to search for and find relationships between features in one idea or concept with another idea or concept that otherwise might appear unrelated. They will see the semantic relationship that exists between two or more separate ideas.

4.2.3.4 Summary of verbal/nonverbal differences and display of gifted knowledge. It has been reported in the literature that students gifted in different domains such as verbal and mathematical/non-verbal domains have different cognitive profiles (Benbow & Minor, 1990). However, current conceptions of giftedness fail to provide descriptions of these different cognitive profiles based on giftedness across different domains. The current study will attempt to link current conceptions of giftedness, which apply the expert performance approach/model to outline how students gifted in verbal and/or nonverbal domains might differ in terms of their knowledge (cognitive characteristics). The present study will attempt to use concept mapping as a tool to identify these cognitive differences in the classroom context.

4.3 Research Questions and Hypotheses

The following research questions and hypotheses derive from the literature presented in Chapters 2 and 3 and are based on the conceptual framework presented in this chapter.

Research question 1
To what extent do gifted students display a learning capacity that comprises the characteristics of the expert-knower?
• Hypothesis 1: The knowledge of gifted students prior to teaching is characterised by more domain-specific knowledge (verbal propositions) than the knowledge of not gifted students.
• Hypothesis 2: The knowledge of gifted students prior to teaching is more semantically organised than the knowledge of not gifted students.
• Hypothesis 3: The knowledge of gifted students prior to teaching is characterised by more interrelatedness of concepts than the not gifted students.

Research question 2
To what extent does the learning capacity of gifted students differ according to the different types of giftedness?
• Hypothesis 4: Verbally gifted students prior to teaching display more domain-specific knowledge (verbal propositions) and more semantically organised knowledge than nonverbally gifted students.
• Hypothesis 5: Nonverbally gifted students prior to teaching perceive more interrelatedness of concepts than the verbally gifted students for both topics of study.

Research question 3
To what extent do gifted students display knowledge post-teaching that comprises the characteristics of the expert-knower?
• Hypothesis 6: The knowledge of gifted students post-teaching is characterised by more domain-specific knowledge (verbal propositions) than the knowledge of not gifted students.
• Hypothesis 7: The knowledge of gifted students post-teaching is more semantically organised than the knowledge of not gifted students.
• Hypothesis 8: The knowledge of gifted students post-teaching is characterised by more interrelatedness of concepts than the not gifted students.
The current chapter describes the study methods used to address the research questions. The recruitment of the study participants and a summary of the sample characteristics are described. The allocation of students into ‘ability groups’ is also described and the procedure for conducting all of the data collection. Finally, the methods used to conduct statistical analysis are outlined.

5.1 Research Design

Quasi-experimental design was used to assess pre- and post-test differences among different groups of students according to cognitive ability level. Quasi-experiments are studies that aim to evaluate an intervention without the use of randomisation and aim to demonstrate causality between an intervention and an outcome (Harris et al., 2006; Reichardt, 2009). Quasi-experimental studies can use both pre-intervention and post-intervention measurements as well as non-randomly selected control groups (Harris et al., 2006; Reichardt, 2009). The present study measured prior knowledge at phase 1 (T1) before groups were administered teaching at phase 2 (T2). Knowledge was assessed immediately following teaching at phase 2, and again two weeks after teaching at phase 3 (T3). Differences between ability groups were assessed at each phase to determine the extent to which ability predicted quality and level of domain-specific knowledge.

5.2 Participants

Schools within the city of Melbourne were invited to participate in the study. Two government schools in the South-Western Region of Victoria and one independent school agreed to participate. School principals were provided with information about the proposed research and study aims. Once school principals agreed to participate in the research, consent forms and plain language statements were provided to the schools. Both parents and students were provided with plain language statements outlining the aims of the research (see Appendix A). All Year 5
students were invited to participate in the study. Once consent forms were returned to the researcher, the students were recruited into the study (see Appendix B). A total of 112 students from the three schools comprised the overall sample. A summary of the sample can be seen in Table 1. The age of the students ranged from 10 years to 12 years old with the mean age being 11.39 years ($SD = .33$). The proportion of male and female students differed only slightly with 54% of students being female and 46% male. The categorisation of students into gifted and not gifted groups is outlined in section 5.4.3. The Human Research Ethics Committee at the University of Melbourne as well as the Victorian Department of Education and Early Childhood Development (DEECD) provided ethical approval for the study. Informed consent was obtained from both the students and their parents or guardians prior to recruitment into the study.

**5.2.1 Sample size.** The achieved sample size for the study (N=112) is considered to be sufficiently large enough to ensure reasonable probability that any significant relationships in the data will be detected by statistical analysis. According to the guidelines for acceptable levels of power which suggests studies be designed to achieve alpha levels of at least .05 with power levels of 80 per cent (Cohen, 1977; Tabachnick & Fidel, 2001), a researcher who employs between five and ten independent variables will require a sample of between 50 and 100 respondents in order to detect $R^2$ values of approximately 15 per cent and greater (Hair, Anderson, Tatham & Black, 1998). Therefore, the proposed sample size for this study was of sufficient size to ensure an acceptable level of statistical power and a large enough effect size if a true relationship does exist. This is of primary importance if the results of the study are to be useful in extending the understanding of gifted learners and in contributing to the improvement of the understanding of gifted learning.

**5.3 Measuring Intelligence Conceptually**

The search for general principles that govern human intelligence began with the pioneering work of Charles Spearman (Spearman, 1904), who discovered a positive correlation between individual patterns of performance across a broad range of cognitive tests. Following this observation Spearman (Spearman, 1928) proposed that a general factor (g) accounts for performance across the spectrum of cognitive activities (Barbey, et. al, 2013). Spearman argued that general cognitive ability (g) was further comprised of two separate or distinct components, these being eductive and reproductive ability (Raven, 2000). Eductive ability was defined as “the
ability to make meaning out of confusion, the ability to generate high-level, usually nonverbal, schemata which make it easy to handle complexity”; and reproductive ability was defined as “the ability to absorb, recall, and reproduce information that has been made explicit and communicated from one person to another” (Raven, 2000, p. 2). The Cattell-Horn theory of fluid and crystallised intelligence (R. B. Cattell, 1941, 1950, 1971; Horn, 1965; Horn & Cattell, 1966a, 1966b) proposed that general intelligence (g) could be separated into two broader sets of abilities: fluid and crystallised abilities. This model of intelligence was further emphasised by Carrol (1993) following a meta-factor analysis on the research in cognitive ability. According to Carroll (1993), the Cattell–Horn model “appears to offer the most well-founded and reasonable approach to an acceptable theory of the structure of cognitive abilities” (p. 62). Numerous studies have confirmed the validity of this model of intelligence where general cognitive ability (g) is comprised of two separate factors, fluid and crystallised ability (Horn, 1994; Matarazzo, 1990; Ree, Earles, & Teachout, 1994; Snow, Kyllonen, & Marshalek, 1984). Thus, general cognitive ability will be measured in terms of two separate factors, fluid (non-verbal) intelligence and crystallised (verbal) intelligence.

5.3.1 Fluid and crystallised intelligence. Fluid intelligence or fluid reasoning refers to the capacity to think logically and solve problems in a novel situation independent of acquired knowledge (Ferrer, O’Hare, & Bunge, 2009). Fluid intelligence refers to the processing of information and the ability to reason with the aim to understand relationships and abstract propositions (Stankov, 2000). One of the common measures of fluid intelligence is the Raven’s Progressive Matrices (Raven, 2000).

Crystallised intelligence is defined as the skills and knowledge acquired through education and acculturation. It is related to the acquisition, storing, organisation and conceptualisation of pieces of specific information (Chamorro-Premuzic & Furnham, 2005) and is thus distinct from fluid intelligence, which is the general ability to reason abstractly, identify patterns, and recognise relations. Some of the common measures of crystallised intelligence included subtests on the Wechsler Intelligence Scales for Children (WISC) (Wechsler, 1949, 2003) that are used to produce Verbal IQ score and the Mill Hill Vocabulary Scale (Raven, Court, & Raven, 1994).
5.4 Defining Giftedness Operationally

The current study used measures of both fluid and crystallised intelligence scores to define giftedness in terms of non-verbal ability (fluid intelligence) and verbal ability (crystallised intelligence).

5.4.1 Nonverbal ability. Nonverbal ability was assessed using Raven’s Standard Progressive Matrices - Plus (SPM+) (Raven, 1998). Benbow and Minor (1990) reported that the results their research provides support for the use of the Raven’s Progressive Matrices Test for identification of students gifted in the nonverbal domain. Raven’s test performance was high for extremely gifted students’ but was more closely aligned to mathematical than verbal precocity. The Raven’s SPM+ was developed to provide a parallel form of test with a higher ceiling level and discriminative power to the original version of Standard Progressive Matrices (Raven, 2009). Thus, the SPM+ was chosen to discriminate accurately the students at the higher end of nonverbal ability. Students were administered the SPM+ in a group setting. The SPM+ is designed to measure non-verbal reasoning and consists of 60 problems that involve analysing a series of spatial designs with a part missing. The participants were required to select the correct missing part from a number of options. The scores ranged from 0 to 60. Standard scores and percentile ranks were computed from the raw scores. The SPM+ was untimed and students were given enough time to complete all 60 problems. Participants were categorised as either gifted or not gifted based on their percentile rank.

5.4.2 Verbal ability. Verbal ability was assessed using the Mill Hill Vocabulary Scale (MHV) (Raven, 1994). The MHV was designed as a companion measure to the Standard Progressive Matrices and assesses verbal reasoning ability in the general population. The MHV is comprised of two sets of problems, with a total of 88 questions. In Set A, participants were asked to write definitions for the 44 presented words. In Set B, participants were presented with a list of 44 words and were required to select a synonym from a list of multiple-choice options. Standard scores and percentile ranks were computed from the raw scores. The MHV was untimed and therefore students were given enough time to complete all 88 questions. Participants were categorised as either gifted or not gifted based on their percentile rank.

5.4.3 Categorisation of gifted groups.
Students were categorised as ‘gifted’ if they achieved scores in the top 90th percentile on the respective cognitive tests. Thus, four groups of students were identified according to the following criteria:

- **Nonverbal gifted**: Those who scored at or above the 90th percentile on the non-verbal ability test and below the 90th percentile on the Mill Hill Vocabulary Scale.
- **Verbal gifted**: Those who scored at or above the 90th percentile on the verbal ability test and below the 90th percentile on the Raven’s Standard Progressive Matrices - Plus.
- **Globally gifted**: Those who scored at or above the 90th percentile on both the Mill Hill Vocabulary Scale and Raven’s Standard Progressive Matrices.
- **Not gifted**: Those who scored below the 90th percentile on both the Mill Hill Vocabulary Scale and Raven’s Standard Progressive Matrices.

The cut-off at the 90th percentile was based on conceptions of giftedness such as in the Differentiating Model of Giftedness and Talent (Gagne, 1985, 2005) which defines the notion of gifted as “natural abilities or aptitudes (called gifts), in at least one ability domain, to a degree that places an individual at least among the top 10% of age peers” (Gagne, 2013, p. 5). Furthermore, the criteria of achieving scores in at least the top 90th percentile across both measures was to maintain stringent conditions for giftedness. The stringent conditions were utilised to determine the characteristics that were prominent when building a model that identifies the characteristics that define a gifted knowledge.

Eleven students (9.8%) from the overall sample were identified as globally gifted. A combined total of 40 students (21 nonverbal, 19 verbal) were identified as being gifted in a single domain. A higher proportion of male students (52.4%) comprised the nonverbally gifted group, whereas a higher proportion of female students (57.9%) comprised the verbally gifted group. Sample characteristics for these students are shown in Table 1.
Table 1

Sample Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Overall Sample (N=112)</th>
<th>Globally gifted (N=11)</th>
<th>Gifted non-verbal (N=21)</th>
<th>Gifted verbal (N=19)</th>
<th>Not gifted (N=61)</th>
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<tr>
<td>n (%)</td>
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<tr>
<td>Gender</td>
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<tr>
<td>Male</td>
<td>52 (46.4)</td>
<td>6 (54.5)</td>
<td>11 (52.4)</td>
<td>8 (42.1)</td>
<td>27 (44.3)</td>
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<tr>
<td>Female</td>
<td>60 (53.6)</td>
<td>5 (45.5)</td>
<td>10 (47.6)</td>
<td>11 (57.9)</td>
<td>34 (55.7)</td>
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<tr>
<td>Age</td>
<td></td>
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</tr>
<tr>
<td>10 years</td>
<td>14 (12.5)</td>
<td>1 (9.1)</td>
<td>3 (14.3)</td>
<td>2 (10.5)</td>
<td>8 (13.1)</td>
</tr>
<tr>
<td>11 years</td>
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<td>9 (81.8)</td>
<td>16 (76.2)</td>
<td>17 (89.5)</td>
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<tr>
<td>12 years</td>
<td>3 (2.7)</td>
<td>1 (9.1)</td>
<td>2 (9.5)</td>
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<td></td>
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</tr>
<tr>
<td>Private</td>
<td>27 (24.1)</td>
<td>4 (36.4)</td>
<td>8 (38.1)</td>
<td>3 (15.8)</td>
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<td>51 (45.5)</td>
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<td>6 (28.6)</td>
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<td>20 (32.8)</td>
</tr>
</tbody>
</table>

5.5 Measures

5.5.1 Activating prior knowledge. Students’ knowledge was activated using the Getting Knowledge Ready (GKR) task (Munro, 2012). The GKR activity began with students being given an introduction to the topic they are to study. This could be, for example, the front and back cover (with blurb) of a book they will read, the headline of a newspaper article and accompanying photograph, the topic and a few pictures from a factual text they will learn. The students were given time to read each introduction and suggest the topic of each text.

Students are given five minutes for each of the following tasks:

- ‘Possible words’ task: Suggest content words that you think might be in the text. These are words about the topic. Don’t include words such as ‘the’, ‘a’ or ‘is’. Write down as many possible words as you can think of. The reason for mentioning content words is so that the student doesn’t nominate ‘the’ or ‘is’ as content words.
• ‘Questions it might answer’ task: Suggest questions of different types you think the text might answer.

• ‘Ideas it might tell you’ task: Say in sentences two things you think the text might tell you.

Scores were not calculated based on student responses to the GKR tasks described above. The purpose of the task was to activate students’ knowledge of the topics being taught in the study. Therefore, the GKR task was used as a teaching tool prior to the assessment of existing knowledge.

5.5.2 Learning capacity and learning outcomes. Students’ knowledge of a topic was assessed using concept mapping (Novak, 1972) at pre-teaching and post-teaching. The concept mapping tool was used to assess both the learning capacity of students, their ability to represent and display knowledge prior to teaching, and also their learning outcomes following teaching. Concept maps are graphical tools for organising and representing knowledge. Concept maps comprise concepts, usually enclosed in circles or boxes, and relationships between concepts indicated by a connecting line linking two concepts. Words on the line, referred to as linking words or linking phrases, specify the relationship between the two concepts. Concepts are defined as “a perceived regularity or pattern in events or objects, or records of events or objects, designated by a label”, (Novak & Cañas, 2006, p. 1). Concepts that are connected with a linking work or phrase generate a proposition. Propositions contain two or more concepts connected using linking words or phrases to form a meaningful statement, sometimes called semantic units, or units of meaning.

Concept maps have strong psychological and epistemological foundations, based on Ausubel's Assimilation Theory (Ausubel, 1968, 2000) and Novak's Theory of Learning (1972), which explain that people learn new things by using their current knowledge and, to a greater or lesser degree, seeking ways to integrate new knowledge and related knowledge already known. When learning meaningfully, the integration of new concepts into our cognitive knowledge structure takes place through linking this new knowledge to concepts we already understand. Thus a concept map is a graphical representation of these relationships between concepts in our cognitive structure.
5.6 Procedure

5.6.1 Cognitive assessments. Cognitive assessments were administered in group sessions during Term 3 (semester 2) of the school year. Students were provided with the instructions as set out in the Raven’s Assessment Manual and completed both the RSPM+ and MHV assessments during regular school time. Both cognitive assessments were untimed and therefore students completed these at different rates. Students were given two sessions to complete both assessments. The completed assessments were collected and scored to determine students’ percentile ranks. All students completed the cognitive assessments within the given time.

5.6.2 Trial activities and concept map lesson. Students were taught how to complete the classroom assessment tasks by completing trial activities. Students were taught how to complete The Getting Knowledge Ready (GKR) tasks (Munro, 2012) and how to draw concept maps. Students were taught the theory that underpinned concept maps and how to draw them in a lesson using a PowerPoint presentation. The theory was described in a way that was relevant for grade five students. The presentation covered the basic information necessary to understand concept mapping such as defining what a concept is, and providing examples; defining what a linking word/phrase is, and providing examples; and defining what a proposition is, as well as providing examples. A series of different concept maps were also shown to students as examples.

Following this presentation, students completed two tasks that tested their ability to draw concept maps. The topics for the two tasks were ‘The city of Melbourne’ and ‘dogs’. These topics were chosen because students were expected to be familiar with both of these topics. Novak and Gowin (2006) emphasised the importance of this, stating “In learning to construct a concept map, it is important to begin with a domain of knowledge that is very familiar to the person constructing the map” (Novak & Cañas, 2006). The first task involved interpreting a pre-drawn concept map about the ‘city of Melbourne’ from which had been omitted a number of concepts and one linking word or phrase. The missing linking word or phrase connected the concepts of Melbourne and landmarks. The students were provided with the missing concepts and asked to ‘fill-in the gaps’ but were asked to provide a linking word or phrase to make a valid proposition with the concepts of Melbourne and landmarks. Once students had shown the researcher that they had completed this task correctly by including all of the missing concepts
and the linking word or phrase in a way that made sense they were asked to complete the next practice task.

The second practice task involved drawing a concept map with the focus question ‘What do you know about dogs?’ At the beginning of lesson the researcher wrote a list of concepts related to dogs on the whiteboard at the front of the classroom. This was part of the concept map PowerPoint where students were given the opportunity to share ideas on different concepts relating to dogs. The researcher asked the students to use the concepts on the whiteboard as a guide if they needed concepts to help with their practice concept map about dogs. The researcher was available throughout the lesson to assist students if they had difficulty in understanding how to draw their concept map. The concept map training used in the present study was consistent with previous studies where students participated in a one-hour training session to practice making concept maps and talking about the results (Zimmerman, Maker, Gomez-Arizaga, & Pease, 2011).

The students were then given opportunities to practice the GKR tasks to ensure that they were able to perform these tasks satisfactorily. The practice for the GKR tasks involved completing the activities using an activity booklet about the solar system. The activity booklet was in the same format as the activity booklets used for all of the GKR tasks throughout the study. After students had been taught how to draw concept maps and complete the GKR tasks the activities were collected by the researcher for record of their proficiency at these tasks.

5.6.3 Assessing learning capacity. Two topics were used to assess student knowledge throughout the data collection phase of the study. These two topics were chosen to align with the Australian National Year 5 curriculum (ACARA). A science topic and a humanities topic were chosen. The first topic was ‘energy’ with a science focus on the use and importance of energy in everyday life. The second topic was ‘migration’ with a history focus on the reasons why humans have migrated around the world. Two different topics were used to look for both general and specific patterns in students’ thinking and knowledge representations. All students across the three schools completed tasks for the energy topic first and the migration topic second.

Students were firstly introduced to the topic of energy. Students were provided with a booklet that included all of the tasks to be completed in the session. Students were given two minutes to look at the front cover of the booklet that showed a number of energy related pictures. These pictures were used to stimulate thoughts and ideas about the topic as part of the GKR
tasks. Students were then instructed to complete GKR tasks in the activity booklet. These tasks involved listing as many words as they could think of that might come up in a lesson about the given topic and writing down any questions that students thought they might be able to answer after learning about that topic. Students were instructed to spend ten minutes completing the GKR tasks. Once students had completed the GKR tasks they were given instructions to complete the concept map. Students were given a list of energy related concepts along with a focus question ‘What do you know about energy?’ Students were asked to construct a concept map to show what they knew about the topic using the list of concepts. This task was used to assess students’ learning capacity for the topics that would be taught. The concepts provided to students for both topics are shown in Figures 1 and 2. Students were also instructed to include additional concepts if needed to help explain what they knew about energy. Students were given the remainder of the session to complete their concept maps. All students completed their concept maps within the given time. Concept maps were collected at the end of the lesson.

<table>
<thead>
<tr>
<th>Energy</th>
<th>People</th>
<th>Sun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfer</td>
<td>Household Appliances</td>
<td>Pollution</td>
</tr>
<tr>
<td>Work</td>
<td>Cars</td>
<td>Engine</td>
</tr>
<tr>
<td>Food</td>
<td>Fossil fuel</td>
<td>Heat</td>
</tr>
<tr>
<td>Tired</td>
<td>Electricity</td>
<td>Petrol</td>
</tr>
</tbody>
</table>

*Figure 1. Energy concepts provided to students for concept mapping task.*

<table>
<thead>
<tr>
<th>Migration</th>
<th>Aborigines</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movement</td>
<td>Australia</td>
<td>Food</td>
</tr>
<tr>
<td>People/humans</td>
<td>Lake Mungo</td>
<td>Ice Age</td>
</tr>
<tr>
<td>Country</td>
<td>Lifestyle</td>
<td>First Fleet</td>
</tr>
<tr>
<td>World</td>
<td>Boat</td>
<td>Asylum seekers</td>
</tr>
<tr>
<td>Africa</td>
<td>Europeans</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 2. Migration concepts provided to students for concept mapping task.*
5.6.4 Teaching. One week after the learning capacity assessments were conducted for the energy topic, students were presented with a lesson on the topic of energy called ‘The Use of Energy in Everyday Life’. The lesson involved a PowerPoint presentation where main concepts were taught using a narrative that was developed to include all of the concepts in a logical cohesive story. The PowerPoint presentation lasted for approximately 30 minutes. Throughout the presentation students were asked to answer questions and given opportunities to make comments if they felt like making a contribution. Following the PowerPoint presentation, students were given activity booklets and were asked to complete the activities within the remaining time. The first activities in the booklet were the GKR tasks. Once students had completed these tasks they were asked to complete the concept map. Students were given a list of concepts in the activity booklet – the same list of concepts that were used to assess their prior knowledge for the topic (Figure 1, Figure 2). Students were asked to draw a concept map showing what they now knew about the topic after having been exposed to the lesson where they were taught about the main concepts. Students were also asked to include any additional concepts that helped explain what they knew about energy. The teaching lessons were all scheduled in one-hour blocks.

5.6.5 Assessment of Learning Outcomes. Following the lessons where students were taught about the main concepts in the topics and after having drawn their second concept map a period of two weeks elapsed before the follow up activities took place. This two-week period was consistent across all schools and groups to ensure that time between activities were not a confounding factor. During this follow-up session, students were asked to draw a concept map showing what they knew about energy. Students were not given a list of concepts for this activity. This activity was used to activate students’ thinking about the topic, similar to the GKR tasks used in the learning capacity assessment. Once all students had completed the concept map, the researcher collected them. Students were then given the same list of energy concepts that had been used in the previous sessions (Figure 1). Students were asked to draw another concept map showing what they knew about energy using the list of energy concepts provided, and were also asked to include any additional concepts that helped explain what they knew about energy.

The same process was undertaken for the second topic of migration once the tasks were completed for the energy topic. Students completed the tasks within the same time frame for both
topics i.e. learning capacity activities initially, followed by lesson on migration one week later, and followed by the follow-up activities a further two weeks later. Students completed all tasks during regular school time in a regular classroom setting.

5.7 Characteristics as Measured on Concept Maps

The concept maps that students created at each phase in the study were used to assess their knowledge of the topics. From the novice-expert knower model, a number of knowledge characteristics were described in terms of how these differ between the gifted and not gifted students. According to the model, gifted students display more domain-specific knowledge and display more organised knowledge representations than not gifted students. This description is used to inform the assessment of students’ concept maps to determine whether these differences can be observed. The criteria used to assess concept maps for these differences are described.

5.8 Rules for Assessing Concept Maps

This section describes the assessment of knowledge and knowledge characteristics that were used to evaluate students’ concept maps. Concept maps were assessed based on criteria to differentiate between novice and expert type knowledge. The criteria were based on that of Novak and Gowin (1984) with revisions made to incorporate elements of the novice-expert knower model (Munro, 2012). The criteria for assessing concept maps are summarised in Figure 3.
<table>
<thead>
<tr>
<th>Propositions (General validity)</th>
<th>Is the relationship between two concepts indicated by a connecting line and linking word(s)? Is the relationship valid?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propositions (Semantic validity)</td>
<td>Is the relationship between two concepts indicated by a connecting line and linking word(s)? Is the relationship valid? Is the proposition displaying an understanding of the concept(s) that demonstrates an understanding within the topic that is being taught?</td>
</tr>
<tr>
<td>Hierarchy</td>
<td>Does the concept map show hierarchical categorisation?</td>
</tr>
<tr>
<td>Cross links</td>
<td>Does the concept map show links between separate hierarchies or branches – showing common feature or relationship between different concepts?</td>
</tr>
<tr>
<td>Big ideas</td>
<td>Does the concept map show the inference of big ideas indicated by a concept being elaborated by further two or more concepts and at least two levels of elaboration or abstraction?</td>
</tr>
</tbody>
</table>

*Figure 3. Summary of the criteria used to assess concept maps.*

**5.9 Assessing Students’ Knowledge**

The following section describes in detail the measures that were used to evaluate the knowledge characteristics from students’ concept maps. This section also describes how these measures were scored and the criteria that defined the knowledge characteristics.

**5.9.1 General validity of propositions.** The provided concepts as described previously in Figure 1 and Figure 2 were the ‘core’ concepts for each topic that students were asked to represent on their concept maps. For each of the fifteen provided concepts in the science topic and the seventeen concepts in the history topic, students were scored either “1” or “0” indicating whether or not they displayed a valid proposition (1) or not (0) for each of the provided concepts. The total number of valid propositions was calculated by summing the scores for the concepts in each topic.

**5.9.2 Semantic validity of propositions.** The propositions that students displayed using the ‘core’ concepts were sorted into two categories; those that were valid propositions as
described above (5.9.1) and those that were not only valid but also demonstrated ‘contextual’ or semantic validity. For each of the fifteen provided concepts in the science topic and the seventeen concepts in the history topic, students were scored either “1” or “0” indicating whether or not they displayed a semantically valid proposition (1) or not (0) for each of the provided concepts. To display a semantically valid proposition, students must have displayed a proposition that demonstrated an understanding of the concept(s) within the context of the topic. In order to do this, students were required to use the list of concepts provided as the ‘core concepts’ for the topic and infer the meaning of them within the context of the topic. Examples of the definitions that displayed semantic relevance for each energy concept are displayed in Appendix C and for migration concepts in Appendix D. The total number of semantically valid propositions was calculated by summing the scores for the energy concepts.

5.9.3 Additional concepts. The number of additional concepts that students inferred was measured to examine the extent to which students included additional concepts that were not provided to them in their descriptions of what they knew about the topic. For each concept map task, students were instructed to, “include any additional concepts that help explain what you know about the topic”. The number of additional concepts included in each student’s concept maps was assessed. Each additional concept was scored 1 point and the total number of ‘additional’ concepts was calculated.

5.9.4 Hierarchical structure. According to the novice-expert knower model (Munro, 2012), gifted students do not only possess more domain-specific knowledge, but the knowledge of gifted students is organised more efficiently and completely than that of their not gifted peers (Munro, 2012). The formation of semantic hierarchical categories is typical of expert-type knowledge organisation (de Jong & Ferguson-Hessler, 1996; Johnson & Mervis, 1997). Thus, hierarchical structure was measured to determine how gifted students organised concepts in ways that reflect expert-type knowledge organisation.

Hierarchical categories were defined as webs of knowledge that were categorised into at least two levels such as general concept that was then linked to a subordinate (intermediate) concept(s) and more specific concepts. Concept maps were assessed to determine the overall number of hierarchies within the knowledge represented on the concept map. Linking words or phrases (for example, “such as”, “like”) were also useful in facilitating the determination of hierarchical categorisation by displaying the grouping subordinate concepts under a more general
or superordinate idea. Examples of hierarchical categories for both energy and migration topics are shown in Figures 4 and 5, respectively.

Hierarchical categorisation was assessed in multiple ways. Firstly, in terms of the mean number of hierarchical categories displayed. Each valid hierarchical category was scored 1 point and the total number of hierarchical categories displayed was calculated. Secondly, in terms of whether or not any hierarchical categorisation was displayed on the concept map. A concept map that displayed at least one hierarchical category was scored a 1 for hierarchical categorisation and the concept maps that did not display any hierarchical categorisation of concepts were scored 0. This was used to assess differences in the likelihood that this type of organisation was displayed.

Figure 4. Hierarchical categorisation example for science topic.
5.9.5 Big ideas. The assessment of big ideas was included to determine whether differences would be observed in the way that students represent ideas within the structure of their knowledge. The novice-expert knower model states that the knowledge of gifted students differs to that of the not gifted student in the way in which they understand a topic (Munro, 2010). According to this model, the understanding of gifted students is broader than that of the patterned understanding generated by the not gifted student. The gifted students understand the topic in a big ideas way, demonstrated by their ability to think about two or more patterns, rules or general propositions at once (Munro, 2012, 2013). Big ideas are thus measured to assess the notion of ‘big picture’ thinking proposed by Munro (2012, 2013) in which gifted students infer patterns from teaching information and infer ‘big ideas’ that synthesise the patterns.

Big ideas were defined as concepts, which represented a synthesis of patterns or ‘big idea’ within the given topic. This was represented by a concept that was elaborated into at least two semantically different branches (at least two of which were further differentiated beyond one concept). Links between concepts were required to be labelled with appropriate linking words or phrases to display valid propositions. An example of a valid big idea is shown in the circled section of a knowledge representation in Figure 6.

---

**Figure 5.** Hierarchical categorisation example for humanities topic.
Big ideas were assessed in multiple ways. Firstly, in terms of the mean number of big ideas displayed. Each valid big idea was scored 1 point and the total number of big ideas displayed was calculated. Secondly, in terms of whether or not any organisation of concepts into big ideas was displayed on the concept map. A concept map that displayed at least one big idea was scored a 1 and the concept maps that did not display any organisation of concepts into big ideas were scored 0. This was used to assess differences in the likelihood that this type of organisation was displayed.

5.9.6 Cross-links. According to the novice-expert knower model, gifted learners are more likely to transfer and apply their knowledge across content areas boundaries and more likely to make unusual far links and generate creative and novel outcomes (Munro, 2012). The highly organised nature of gifted students’ knowledge allows for these students to ‘see’ relationships between ideas that are activated in their knowledge structures. According to Novak and Cañas (2006) in the creation of new knowledge, cross-links represent creative leaps on the part of the knowledge producer. Cross-links help us see how a concept in one domain of knowledge represented on the map is related to a concept in another domain on the map. Seeking out relationships that show how two different concepts are related.

Cross-links were deemed valid if they showed a connection between separate branches or segments on the concept map. The cross-links can connect or link separate branches or segments...
at any hierarchical level within the knowledge structures. The cross-links demonstrate interrelationships between concepts that are displayed within that body of knowledge. The interrelationships display how the learner sees similarities or relationships between features of concepts within the knowledge, with the overarching topic being the guiding semantic thread. The validity of the cross-links was dependent upon the validity of the propositions that demonstrated the relationship between the concepts being linked. Students that displayed connections between concepts in different segments or branches may have demonstrated interconnectedness in their knowledge, but without the linking-words or linking-phrases to define the relationship, the cross-link was not deemed valid.

Cross-links were assessed in multiple ways. Firstly, in terms of the mean number of cross-links displayed. Each valid cross-link was scored 1 point and the total number of cross-links displayed was calculated. Secondly, in terms of whether or not any interconnectedness was displayed on the concept map. A concept map that displayed at least one cross-link was scored a 1 and the concept maps that did not display any interconnectedness of concepts into big ideas were scored 0. This was used to assess differences in the likelihood that this type of organisation was displayed.

5.10 Summarising Knowledge Characteristics

The measures described in the previous section were used in the present study to inform the hypotheses. The hypotheses tested differences between gifted and not gifted students on their domain specific knowledge, their semantic organisation, and their interconnectedness of knowledge.

The validity of propositions and the additional concepts were used as measures of domain-specific knowledge. The hierarchical categories and big ideas were used as measures of ‘semantic organisation’ of students’ knowledge. Semantic organisation refers to the organisation of meanings that are displayed by students. The cross-links were used as a measure of the interconnectedness and interrelatedness of concepts that students display. Together, these measures covered the characteristics of the ‘expert knower’ that were assessed in the present study.
5.11 Data Analysis

The extent to which each of the predicted variables discriminated between the gifted students and their not gifted peers at each phase of learning, was examined using general linear modeling procedures. The performance of four ability groups of students was compared; that of those students who were gifted both verbally and non-verbally (the globally gifted, n = 8), those of the students who were gifted in one domain (either verbally gifted (n = 13) or nonverbally gifted (n = 13)) and that of those who were not gifted in either domain (n = 33). Performance of each group was examined at three phases: Pre-teaching (T1), immediately post-teaching (T2), and two weeks after teaching (T3). The three assessment phases were selected in order to 1) examine what students knew about the topics prior to teaching; their learning capacity for the topic, 2) examine how students interpreted the teaching information immediately following the lesson, and 3) examine the retention and integration of knowledge in long-term memory following a delay of two weeks.

For the repeated measures ANOVA, the sample size was reduced from the N = 112 to N = 67 (energy tasks) and N = 71 (migration tasks) when accounting for the students that completed the tasks at each phase. For the repeated measures ANOVA, only students who completed all sessions could be included in the analysis. Therefore, the sample size was reduced due to the number of students who were absent during any of session times, either pre-teaching (T1), immediately post-teaching (T2) or two weeks after teaching (T3). The time constraints of the participating schools did not allow for students who were absent to participate in sessions at alternative times.

A 4x3 general linear model was used, with repeated measures on the phases of learning. Planned comparisons procedures and supplementary tests for independent samples were used to compare mean differences among the three groups at each phase of teaching using one-way ANOVA. Correlations were also measured to determine the relationships between the outcome measures at each phase of assessment. Statistical analysis was completed using SPSSx (version 20).

The current chapter has outlined the study methods used to conduct the research for the present study. The next chapter presents the findings for the present study, based on the data analysis described above. These findings will then be interpreted in later chapters to determine how they inform the research questions.
CHAPTER 6
RESULTS

This chapter outlines the results for the present study. The results are presented as a detailed analysis of the measures from the concept mapping tasks. As described in the methods chapter, the measures assessed from the concept maps were the validity of propositions, additional concepts, hierarchical categories, cross-links and big ideas. First, the results across the science topic are presented, followed by the results for the humanities topic. For each measure the results are presented in the following way:

• Description of mean differences at each assessment phase
• Change in means across assessment phases
• Repeated Measures ANOVA
• One-way ANOVA
• Outline of how the data inform hypotheses
Analysis of Concept Maps for Science Topic

6.1 Valid Propositions

The validity of the propositions displayed on students’ prior knowledge concept maps was assessed. Figure 7 shows the mean number of valid concepts at each of the three assessment phases T1, T2 and T3 for the globally gifted, nonverbally gifted, verbally gifted and not gifted students. These data represented in Figure 7 are also displayed in Table 1 in Appendix E.

![Figure 7](image_url)

Figure 7. Mean number of valid propositions displayed at each assessment phase across ability groups.

6.1.1 Mean number of valid propositions across each assessment phase.

6.1.1.1 Pre-teaching (T1). As shown in Figure 7, the globally gifted students displayed approximately three more of the fifteen energy study concepts in valid propositions ($M = 11.00$, $SD = 3.30$) than their not gifted peers ($M = 8.20$, $SD = 3.60$). The nonverbally gifted students displayed on average approximately one more valid concept from the core energy concepts than the not gifted students ($M = 9.10$, $SD = 4.00$). The verbally gifted students displayed approximately the same number of the energy study concepts in valid propositions as not gifted students ($M = 8.40$, $SD = 3.50$).

6.1.1.2 Post-teaching (T2). Immediately following the teaching, the globally gifted students displayed approximately three more of the fifteen energy study concepts in valid
propositions \((M = 12.67, SD = 2.69)\) than their not gifted peers \((M = 9.50, SD = 3.30)\). The nonverbally gifted students displayed on average approximately one more valid concept from the fifteen energy study concepts than the not gifted students \((M = 10.44, SD = 3.58)\). The verbally gifted students displayed on average approximately one fewer energy study concepts in valid propositions than not gifted students \((M = 8.88, SD = 3.48)\).

### 6.1.1.3 Post-teaching, following 2-week delay (T3)

Two weeks after the teaching, the globally gifted students displayed approximately four more of the fifteen energy study concepts in valid propositions \((M = 13.75, SD = 1.83)\) than their not gifted peers \((M = 9.97, SD = 3.67)\). The nonverbally gifted students displayed on average nearly two more valid concepts from the fifteen energy study concepts than the not gifted students \((M = 11.69, SD = 2.98)\). The verbally gifted students displayed approximately one less energy study concepts in a valid proposition than not gifted students \((M = 9.30, SD = 2.95)\).

### 6.1.2 Change across assessment phases

The overall change in mean number of valid propositions across phases of assessment was assessed. First, the change from pre-teaching (T1) to post-teaching (T2) was assessed to determine the difference in students’ display of valid propositions from the pre-teaching concept map activity to the concept map activity that was undertaken immediately after the teaching. Second, the change from pre-teaching (T1) to post-teaching (T3) was assessed to determine the difference in students’ display of valid propositions from the pre-teaching concept map activity to the concept map activity that was undertaken two weeks after the teaching phase.

#### 6.1.2.1 Change from pre-teaching (T1) to post-teaching (T2)

All groups displayed, on average, growth in mean number of valid propositions from pre-teaching to immediately after the teaching. These results are presented in Figure 8. All groups displayed approximately one more valid proposition immediately following the teaching, for example, the globally gifted students \((M = 1.11, SD = 3.41)\), nonverbal gifted \((M = .70, SD = 2.27)\) verbal gifted \((M = .82, SD = 2.98)\), not gifted students \((M = 1.17, SD = 3.77)\).

#### 6.1.2.2 Change from pre-teaching (T1) to post-teaching (T3)

All groups displayed, on average, growth in mean number of valid propositions from pre-teaching to two weeks post-teaching. These results are presented in Figure 8. The globally gifted \((M = 2.63, SD = 2.62)\), nonverbally gifted \((M =1.85, SD = 2.79)\) and verbally gifted \((M = 1.54, SD = 2.57)\), all displayed
an increase in the number of valid propositions following the two-week delay. The not gifted students ($M = 1.03, SD = 3.16$), to a lesser extent compared to the gifted groups, displayed growth in the mean number of valid propositions from pre-teaching to two-weeks after teaching.

![Graph showing change in mean number of valid propositions](image)

*Figure 8. Change in mean number of valid propositions displayed from pre to post-teaching.*

### 6.1.3 Assessing differences at each phase using Repeated Measures ANOVA.

The mean number of valid propositions at each assessment phase T1, T2 and T3 were assessed to determine whether there was a group effect and whether the mean number of valid propositions were influenced by time, that is, across assessment phases. Table 2 shows the mean scores for each group across each assessment phase.
Table 2

Mean Number of Valid Propositions Displayed at Each Assessment Phase

<table>
<thead>
<tr>
<th>Ability group</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
<th>N=67</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Not gifted (NG)</td>
<td>8.94</td>
<td>3.51</td>
<td>9.33</td>
<td>3.37</td>
</tr>
<tr>
<td>Verbally gifted (VG)</td>
<td>7.77</td>
<td>3.63</td>
<td>8.77</td>
<td>3.81</td>
</tr>
<tr>
<td>Nonverbally gifted (NVG)</td>
<td>9.85</td>
<td>3.65</td>
<td>10.38</td>
<td>3.95</td>
</tr>
<tr>
<td>Globally gifted (GG)</td>
<td>11.13</td>
<td>2.85</td>
<td>12.38</td>
<td>2.72</td>
</tr>
</tbody>
</table>

The results show that the mean number of valid propositions was influenced by the time in the teaching phases at which this factor was assessed ($F(2, 62) = 9.33$, $p < .01$, $\eta^2 = .23$) and by the ability group ($F(3, 63) = 3.50$, $p < .05$, $\eta^2 = .14$). The interaction factor time x ability group did not achieve significance ($p > .05$). The comparisons (one-way ANOVA) of mean number of valid propositions displayed by each group of students at each phase of assessment (F ratio and t-value, 2-tailed, assuming equal variances) are shown in Table 3.1

1 For the repeated measures ANOVA, due to attrition, the sample was reduced to $N=67$ for the science topic and $N=71$ for the humanities topics. This was explained in Chapter 4 as a result of student absenteeism from assessment tasks. This attrition impacted on the number of students within each ‘ability group’ for the repeated measures ANOVA. For example, the size of the globally gifted group was reduced to 8 students for both topics. These small groups for the repeated measures ANOVA have been noted by the researcher and considered when interpreting the results.
6.1.4 One-way ANOVA comparisons. The data presented in Table 3 show the following trends in the number of valid propositions displayed. At the two post-teaching phases T2 and T3, the extent of giftedness influenced this. At the pre-teaching phase, no significant differences were found between gifted and not gifted groups. Immediately after teaching and following the two-week delay, the globally gifted students displayed more valid propositions than their not gifted peers. The difference between the globally gifted students and the not gifted students increased at each assessment phase. The two groups gifted in a single domain did not differ at pre-teaching; however the mean difference between the nonverbally and verbally gifted students increased at each assessment phase, with the nonverbally gifted students displaying an increased number of valid propositions compared to the verbally gifted students.

6.1.5 How these data inform hypotheses. These data presented for the validity of propositions inform Hypotheses 1, 4, and 6. These are in relation to the differences between gifted and not gifted students for the number of verbal propositions displayed at pre-teaching, the differences between verbally gifted and nonverbally gifted students at pre-teaching, and the differences between gifted and not gifted students at post-teaching phases. The number of verbal propositions displayed by students are used as part of the assessment of the extent to which
students display more elaborated and differentiated conceptual networks, as described in the novice-expert knower model (Munro, 2012).

6.2 Semantically Valid Propositions

The semantic validity of the concepts displayed on students’ prior knowledge concept maps was assessed to determine whether the propositions that comprised the study concepts displayed an understanding that represented a scientific understanding in relation to the given topic of energy. Figure 9 displays the mean number of contextually and scientifically valid concepts at each of the three assessment points for globally gifted, nonverbally gifted, verbally gifted and not gifted students. These data represented in Figure 9 are also displayed in Table 2 in Appendix E.

![Figure 9](image)

*Figure 9. Mean number of semantically valid propositions displayed at each assessment phase across ability groups.*

6.2.1 Mean number of semantically valid propositions across each assessment phase.

6.2.1.1 Pre-teaching (T1). On average, the globally gifted students ($M = 10.10$, $SD = 2.60$) displayed semantically valid propositions utilising almost four more of the provided concepts than their not gifted peers ($M = 6.40$, $SD = 3.20$). The nonverbally gifted students ($M =
8.10, $SD = 3.80$) displayed on average nearly two more contextually and scientifically valid propositions than the not gifted students. The verbally gifted students ($M = 7.00, SD = 3.10$) displayed on average less than one more semantically valid concept than the not gifted students.

**Differences in use of specific concepts (see Appendix F).** Some of the biggest differences in semantically valid use of the study concepts were seen for concepts such as food, fossil fuel, sun, pollution and engine. For example, more than half (60%) of the globally gifted students displayed a semantically valid proposition with the concept of fossil fuel compared to only 12% of not gifted students. Almost all (90%) of the globally gifted students displayed a contextually and scientifically valid proposition with the concept of sun compared to approximately half (53%) of the not gifted students.

**6.2.1.2 Post-teaching (T2).** Immediately after teaching, on average, the globally gifted students ($M = 11.67, SD = 2.35$) displayed nearly four more scientifically valid propositions with the study concepts than their not gifted peers ($M = 7.69, SD = 3.09$). The nonverbally gifted students ($M = 9.38, SD = 4.01$) displayed on average nearly two more contextually and scientifically valid propositions than the not gifted students. The verbally gifted students ($M = 7.94, SD = 3.09$) displayed on average more contextually and scientifically valid concept than the not gifted students.

**Differences in use of specific concepts (see Appendix F).** Immediately following the teaching, some of the biggest differences in scientifically valid use of the study concepts between globally gifted and not gifted students were seen for concepts such as petrol, fossil fuel, sun, pollution and engine. For example, more than half (67%) of the globally gifted students displayed a contextually and scientifically valid proposition with the concept of fossil fuel compared to 31% of not gifted students. Almost all (89%) of the globally gifted students displayed a contextually and scientifically valid proposition with the concept of sun compared to less than half (45%) of the not gifted students.

**6.2.1.3 Post-teaching, following 2-week delay (T3).** Two weeks after the teaching, the globally gifted students ($M = 12.88, SD = 1.55$) displayed on average approximately four more contextually and scientifically valid propositions with the study concepts than their not gifted peers ($M = 8.94, SD = 3.70$). The nonverbally gifted students ($M = 11.38, SD = 3.12$) displayed on average greater than two more contextually and scientifically valid propositions than the not gifted students. Two weeks after the teaching, the verbally gifted students ($M = 8.77, SD = 2.94$)
displayed on average approximately the same mean number of contextually and scientifically valid propositions than the not gifted students.

*Differences in use of specific concepts (see Appendix F).* Two weeks after the teaching, some of the biggest differences in contextually and scientifically valid use of the study concepts between globally gifted and not gifted students were seen for concepts such as transfer, tired, fossil fuel, pollution and engine. For example, three quarters (75%) of the globally gifted students displayed a contextually and scientifically valid proposition with the concept of *fossil fuel* compared to one third (33%) of not gifted students. All (100%) of the globally gifted students displayed a contextually and scientifically valid proposition with the concept of *pollution* compared to less than half (48%) of the not gifted students. Furthermore, 100% of the globally gifted students, two weeks after the teaching, displayed a contextually and scientifically valid proposition with the concept of engine, compared to less than half (48%) of the not gifted students. The concept of the internal combustion engine which was one of the main ideas presented in the teaching.

**6.2.2 Change across assessment phases.** The overall change in mean number of semantically valid propositions across phases of assessment was assessed. First, the change from pre-teaching (T1) to post-teaching (T2) was assessed to determine the difference in students’ display of semantically valid propositions from the pre-teaching concept map activity to the concept map activity that was undertaken immediately after the teaching. Second, the change from pre-teaching (T1) to post-teaching (T3) was assessed to determine the difference in students’ display of semantically valid propositions from the pre-teaching concept map activity to the concept map activity that was undertaken two weeks after the teaching phase.

**6.2.2.1 Change from pre-teaching (T1) to post-teaching (T2).** All groups, displayed on average, growth in mean number of semantically valid propositions using the energy study concepts from pre-teaching to immediately after the teaching (Fig. 10); globally gifted ($M = 1.11, SD = 2.97$), nonverbal gifted ($M = .63, SD = 2.39$) verbal gifted ($M = 1.12, SD = 2.67$), not gifted students ($M = 1.10, SD = 3.13$).

**6.2.2.2 Change from pre-teaching (T1) to post-teaching (T3).** All groups, displayed on average, growth in mean number of semantically and scientifically valid propositions using the energy study concepts did not differ from pre-teaching to two weeks post-teaching (Fig. 10);
globally gifted \((M = 2.75, SD = 2.54)\), nonverbal gifted \((M = 2.62, SD = 2.72)\) verbal gifted \((M = 2.08, SD = 1.93)\), not gifted students \((M = 1.87, SD = 3.34)\).

Figure 10. Change in mean number of semantically valid propositions displayed from pre to post-teaching.

6.2.3 Assessing differences at each phase using Repeated Measures ANOVA. The mean number of semantically valid propositions at each assessment phase T1, T2 and T3 were assessed to determine whether there was a group effect and whether the mean number of semantically valid propositions was influenced by time, that is, across assessment phases. Table 4 shows the mean scores for each group across each assessment phase.
Table 4

Mean Number of Semantically Valid Propositions Displayed at Each Assessment Phase

<table>
<thead>
<tr>
<th>Ability group</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
<th>N = 67</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Not gifted</td>
<td>7.06</td>
<td>3.27</td>
<td>7.85</td>
<td>3.13</td>
</tr>
<tr>
<td>Verbally gifted</td>
<td>6.69</td>
<td>2.96</td>
<td>7.92</td>
<td>3.45</td>
</tr>
<tr>
<td>Nonverbally gifted</td>
<td>8.77</td>
<td>3.59</td>
<td>9.15</td>
<td>4.43</td>
</tr>
<tr>
<td>Globally gifted</td>
<td>10.13</td>
<td>2.03</td>
<td>11.25</td>
<td>2.12</td>
</tr>
</tbody>
</table>

The mean number of semantically valid propositions was influenced by the time in the teaching phases at which this factor was assessed \( F(2, 62) = 16.22, \ p < .01, \eta^2 = .34 \) and by the ability group \( F(3, 63) = 4.62, \ p < .01, \eta^2 = .18 \). The interaction factor time x ability group did not achieve significance \( p > .05 \). The comparisons (one-way ANOVA) of mean number of semantically valid propositions displayed by each group of students at each phase of assessment (F ratio and t-value, 2-tailed, assuming equal variances) are shown in Table 5.

Table 5

Mean Comparisons for Total Number of Semantically Valid Propositions at Each Assessment Phase

<table>
<thead>
<tr>
<th>Groups</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
<th>F statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>VG - NG</td>
<td>.59</td>
<td>-1.70, 2.89</td>
<td>.25</td>
<td>-2.18, 2.68</td>
</tr>
<tr>
<td>NVG - NG</td>
<td>1.7</td>
<td>-.64, 4.05</td>
<td>1.68</td>
<td>-.80, 4.17</td>
</tr>
<tr>
<td>GG - NG</td>
<td>3.69**</td>
<td>.74, 6.64</td>
<td>3.98**</td>
<td>.87, 7.08</td>
</tr>
<tr>
<td>NVG - VG</td>
<td>1.11</td>
<td>-1.68, 3.91</td>
<td>1.43</td>
<td>-1.51, 4.38</td>
</tr>
<tr>
<td>GG - VG</td>
<td>3.1</td>
<td>-.22, 6.42</td>
<td>3.73*</td>
<td>.24, 7.21</td>
</tr>
<tr>
<td>GG - NVG</td>
<td>1.99</td>
<td>-1.36, 5.34</td>
<td>2.29</td>
<td>-1.22, 5.81</td>
</tr>
</tbody>
</table>

*significant at \( p < .05 \) **significant at \( p < .01 \)
6.2.4 One-way ANOVA comparisons. The data presented in Table 5 show the following trends in the number of semantically valid propositions displayed. At all phases, the extent (or type) of giftedness influenced the mean number of semantically valid propositions. At the pre-teaching phase, immediately after teaching, and following the two-week delay, the globally gifted students displayed more semantically valid propositions than their not gifted peers. At each phase of assessment, the difference was approaching four propositions. The two groups gifted in a single gifted domain did not differ, however, the difference between nonverbally gifted students and the verbally gifted students increased at each phase.

6.2.5 How these data inform hypotheses. The data presented for the semantic validity of propositions are used in addition to the validity of propositions to inform Hypotheses 1, 4, and 6. These are in relation to the differences between gifted and not gifted students for the elaboration and differentiation of conceptual networks displayed at pre-teaching, the differences between verbally gifted and nonverbally gifted students for the extent to which their knowledge is elaborated and differentiated, and the differences between gifted and not gifted students for the extent to which their knowledge of the topics is elaborated and differentiated at post-teaching phases.

6.3 Additional Concepts

The mean number of additional concepts was assessed to determine whether the extent to which students included additional concepts to describe their understanding of the topic. Figure 11 displays the mean number of additional concepts at each of the three assessment points for globally gifted, nonverbally gifted, verbally gifted and not gifted students. These data represented in Figure 11 are also displayed in Table 3 in Appendix E.
6.3.1 Mean number of additional concepts across each assessment phase. 6.3.1.1

**Pre-teaching (T1).** Globally gifted students \((M = 7.70, SD = 5.72)\) on average inferred approximately the same number of additional concepts on their prior knowledge concept maps than their not gifted peers \((M = 8.00, SD = 7.95)\). Students gifted in the nonverbal domain on average inferred approximately one less additional concept than their not gifted peers \((M = 7.20, SD = 5.77)\). Students gifted in the verbal domain \((M = 9.80, SD = 6.73)\) on average inferred nearly two more additional concepts than the not gifted students.

**Post-teaching (T2).** Immediately following the teaching, globally gifted students \((M = 5.00, SD = 6.67)\) on average inferred approximately the same number of additional concepts on their concept maps than their not gifted peers \((M = 5.10, SD = 5.20)\). Students gifted in the nonverbal domain on average inferred approximately one less additional concept than their not gifted peers \((M = 4.38, SD = 3.63)\). Students gifted in the verbal domain on average inferred almost three more additional concepts than their not gifted peers \((M = 7.82, SD = 5.95)\).

**Post-teaching, following 2-week delay (T3).** Two weeks after the teaching, globally gifted students \((M = 5.75, SD = 5.72)\) on average inferred approximately the same number of additional concepts on their concept maps than their not gifted peers \((M = 5.69, SD = 6.86)\). Students gifted in the nonverbal domain on average inferred approximately one more
additional concept than their not gifted peers \( (M = 6.46, SD = 5.17) \). Students gifted in the verbal domain \( (M = 8.70, SD = 5.27) \) on average inferred more than two more additional concepts than the not gifted students.

**6.3.2 Change across assessment phases.** The overall change in mean number of additional concepts across phases of assessment was assessed. First, the change from pre-teaching (T1) to post-teaching (T2) was assessed to determine the difference in students’ display of additional concepts from the pre-teaching concept map activity to the concept map activity that was undertaken immediately after the teaching. Second, the change from pre-teaching (T1) to post-teaching (T3) was assessed to determine the difference in students’ display of additional concepts from the pre-teaching concept map activity to the concept map activity that was undertaken two weeks after the teaching phase.

**6.3.2.1 Change from pre-teaching (T1) to post-teaching (T2).** All groups displayed a decrease in the number of additional concepts from pre-teaching to immediately after teaching; globally gifted \( (M = -2.11, SD = 5.62) \), nonverbal gifted \( (M = -2.06, SD = 4.06) \), verbal gifted \( (M = -2.94, SD = 4.06) \), not gifted students \( (M = -3.17, SD = 6.67) \). These data are displayed in Figure 12.

**6.3.2.2 Change from pre-teaching (T1) to post-teaching (T3).** All groups displayed a decrease in the number of additional concepts from pre-teaching to two weeks after the teaching; globally gifted \( (M = -1.38, SD = 5.63) \), nonverbal gifted \( (M = -0.54, SD = 4.82) \), verbal gifted \( (M = -2.23, SD = 6.87) \), not gifted students \( (M = -2.79, SD = 6.69) \). These data are displayed in Figure 12.
6.3.3 Assessing differences at each phase using Repeated Measures ANOVA. The mean number of additional concepts at each assessment phase T1, T2 and T3 were assessed to determine whether there was a group effect and whether the mean number of additional concepts was influenced by time, that is, across assessment phases. Table 6 shows the mean scores for each group across each assessment phase.

Table 6

<table>
<thead>
<tr>
<th>Ability group</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
<th>N = 67</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Not gifted</td>
<td>8.41</td>
<td>8.55</td>
<td>5.25</td>
<td>4.98</td>
</tr>
<tr>
<td>Verbally gifted</td>
<td>10.31</td>
<td>6.54</td>
<td>8.00</td>
<td>6.14</td>
</tr>
<tr>
<td>Nonverbally gifted</td>
<td>7.00</td>
<td>5.26</td>
<td>3.92</td>
<td>2.63</td>
</tr>
<tr>
<td>Globally gifted</td>
<td>7.13</td>
<td>6.13</td>
<td>5.25</td>
<td>7.09</td>
</tr>
</tbody>
</table>

The mean number of additional concepts was influenced by the time in the teaching phases at which this factor was assessed \( F(2, 62) = 5.40, \ p < .01, \eta^2 = .15 \). The mean number of
additional concepts was not influenced by the ability group ($F(3, 63) = .89, \ p > .05, \eta^2 = .04$). The interaction factor time x ability group did not achieve significance ($p > .05$). The comparisons (one-way ANOVA) of mean number of additional concepts displayed by each group of students at each phase of assessment (F ratio and t-value, 2-tailed, assuming equal variances) are shown in Table 7.

### Table 7

**Mean Comparisons for Total Number of Additional Concepts at Each Assessment Phase**

<table>
<thead>
<tr>
<th>Groups</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Diff</td>
<td>95% CI</td>
<td>Mean Diff</td>
</tr>
<tr>
<td>VG - NG</td>
<td>1.88</td>
<td>-3.18, 6.94</td>
<td>2.75</td>
</tr>
<tr>
<td>NVG - NG</td>
<td>-.79</td>
<td>-5.95, 4.37</td>
<td>-.70</td>
</tr>
<tr>
<td>GG - NG</td>
<td>-.26</td>
<td>-6.76, 6.24</td>
<td>-.07</td>
</tr>
<tr>
<td>NVG - VG</td>
<td>-2.68</td>
<td>-8.83, 3.48</td>
<td>-3.45</td>
</tr>
<tr>
<td>GG - NVG</td>
<td>.53</td>
<td>-6.85, 7.91</td>
<td>.63</td>
</tr>
</tbody>
</table>

F statistic

- $F(3, 92) = .49$
- $F(3, 80) = 1.46$
- $F(3, 63) = .52$

*significant at $p < .05$  **significant at $p < .01$

6.3.4 **One-way ANOVA comparisons.** These data show the following trends in the number of additional concepts displayed. At all phases, the extent (or type) of giftedness did not influence the mean number of additional concepts. At the pre-teaching phase, immediately after teaching, and following the two-week delay, the verbally gifted students, on average inferred a higher mean number of additional concepts than not gifted, nonverbally gifted and globally gifted peers. The differences were not large enough to reach statistical significance at $p<.05$.

6.3.5 **How these data inform hypotheses.** The data presented for the inference of additional concepts in addition to the validity and semantic validity of propositions are used to inform Hypotheses 1, 4, and 6. These are in relation to the differences between gifted and not gifted students for the elaboration and differentiation of conceptual networks displayed at pre-teaching, the differences between verbally gifted and nonverbally gifted students for the extent to which their knowledge is elaborated and differentiated, and the differences between gifted and
not gifted students for the extent to which their knowledge of the topics is elaborated and differentiated at post-teaching phases.

### 6.4 Hierarchical Categories.

The mean number of hierarchical categories that students displayed was assessed to determine the extent to which students organised knowledge into hierarchies. Figure 13 displays the mean number of hierarchical categories at each of the three assessment points for globally gifted, nonverbally gifted, verbally gifted and not gifted students. These data represented in Figure 13 are also displayed in Table 4 in Appendix E.

![Figure 13](image)

**Figure 13.** Mean number of hierarchical categories displayed at each assessment phase across ability groups.

#### 6.4.1 Mean number of hierarchical categories across each assessment phase.

**6.4.1.1 Pre-teaching (T1).** The data displayed in Figure 12 show that globally gifted students ($M = 1.90$, $SD = 1.30$) displayed on average approximately two hierarchical categories compared to one hierarchical category for not gifted students ($M = .90$, $SD = 1.20$). Nonverbally gifted students ($M =1.30$, $SD = 1.10$) displayed on average a comparable number of hierarchical
categories on their energy prior knowledge concept maps compared to their not gifted peers. The verbally gifted students \((M = 1.80, SD = 1.70)\) displayed approximately the same number of hierarchical categories as the globally gifted students, twice the number of hierarchical categories as the not gifted students.

**6.4.1.2 Post-teaching (T2).** Immediately following the teaching, the globally gifted students \((M = 1.67, SD = 1.58)\) displayed on average less than one more hierarchical category than not gifted students \((M = 1.02, SD = 1.20)\). Nonverbally gifted students \((M = .88, SD = .89)\) displayed on average less than one hierarchical category. The verbally gifted students \((M = 1.53, SD = 1.18)\) displayed on average approximately one more hierarchical category than the not gifted students.

**6.4.1.3 Post-teaching, following 2-week delay (T3).** Two weeks after the teaching, the globally gifted students \((M = 2.13, SD = 1.58)\) displayed on average more than two hierarchical categories compared to approximately one for the not gifted students \((M = 1.21, SD = 1.24)\). Nonverbally gifted students \((M = 1.54, SD = 1.45)\) displayed on average more than one and a half hierarchical categories. The verbally gifted students \((M = 1.92, SD = 1.04)\) displayed on average nearly two hierarchical categories.

**6.4.2 Change across assessment phases.** The overall change in mean number of hierarchical categories across phases of assessment was assessed. First, the change from pre-teaching (T1) to post-teaching (T2) was assessed to determine the difference in students’ display of hierarchical categories from the pre-teaching concept map activity to the concept map activity that was undertaken immediately after the teaching. Second, the change from pre-teaching (T1) to post-teaching (T3) was assessed to determine the difference in students’ display of hierarchical categories from the pre-teaching concept map activity to the concept map activity that was undertaken two weeks after the teaching phase. These data are displayed in Figure 14.

**6.4.2.1 Change from pre-teaching (T1) to post-teaching (T2).** Differences were found between groups in the change in mean number of hierarchical categories from pre-teaching to immediately after the teaching (Figure 14). Globally gifted \((M = .00, SD = 1.12)\) and not gifted students \((M = .02, SD = 1.24)\) displayed approximately the same number of hierarchical categories immediately after teaching, whilst nonverbal gifted \((M = -.38, SD = 1.26)\) and verbal
gifted ($M = -.41, SD = 2.21$) displayed fewer hierarchical categories immediately after teaching, when compared to pre-teaching.

### 6.4.2.2 Change from pre-teaching (T1) to post-teaching (T3)

Differences were found between groups in the change in mean number of hierarchical categories from pre-teaching to immediately after the teaching (Figure 14). Globally gifted ($M = .50, SD = .93$), nonverbally gifted ($M = .23, SD = 1.17$) and not gifted students ($M = .18, SD = 1.07$) all displayed an increase in hierarchical categories from pre-teaching to two weeks after teaching, compared to verbally gifted students ($M = -.20, SD = 1.77$) who displayed on average less hierarchical categories two weeks after teaching when compared to pre-teaching.

![Figure 14](image-url)

*Figure 14. Change in mean number of hierarchical categories displayed from pre to post-teaching.*

### 6.4.3 Assessing differences at each phase using Repeated Measures ANOVA.

The mean number of hierarchical categories at each assessment phase T1, T2 and T3 were assessed to determine whether there was a group effect and whether the mean number of hierarchical categories was influenced by time, that is, across assessment phases. Table 8 shows the mean scores for each group across each assessment phase.
Table 8

Mean Number of Hierarchical Categories Displayed at Each Assessment Phase

<table>
<thead>
<tr>
<th>Ability group</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
<th>N = 67</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Not gifted</td>
<td>1.03</td>
<td>1.33</td>
<td>1.06</td>
<td>1.25</td>
</tr>
<tr>
<td>Verbally gifted</td>
<td>2.08</td>
<td>1.80</td>
<td>1.69</td>
<td>1.25</td>
</tr>
<tr>
<td>Nonverbally gifted</td>
<td>1.31</td>
<td>1.18</td>
<td>.77</td>
<td>.83</td>
</tr>
<tr>
<td>Globally gifted</td>
<td>1.62</td>
<td>1.42</td>
<td>1.88</td>
<td>1.55</td>
</tr>
</tbody>
</table>

The mean number of hierarchical categories was not influenced by the time in the teaching phases at which this factor was assessed ($F(2, 62) = 1.63, p > .05, \eta^2 = .05$). The interaction factor time x ability group did not achieve significance ($p > .05$). The mean number of hierarchical categories was influenced by the ability group ($F(3, 63) = 2.72, p = .052, \eta^2 = .12$). The comparisons (one-way ANOVA) of mean number of hierarchical categories displayed by each group of students at each phase of assessment (F ratio and t-value, 2-tailed, assuming equal variances) are shown in Table 9.

Table 9

Mean Comparisons for Total Number of Hierarchical Categories at Each Assessment Phase

<table>
<thead>
<tr>
<th>Groups</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Diff</td>
<td>95% CI</td>
<td>Mean Diff</td>
</tr>
<tr>
<td>VG - NG</td>
<td>.89</td>
<td>-0.03, 1.81</td>
<td>.51</td>
</tr>
<tr>
<td>NVG - NG</td>
<td>.44</td>
<td>-0.51, 1.38</td>
<td>-0.15</td>
</tr>
<tr>
<td>GG - NG</td>
<td>1.00</td>
<td>-0.18, 2.19</td>
<td>.64</td>
</tr>
<tr>
<td>NVG - VG</td>
<td>-.46</td>
<td>-1.58, .67</td>
<td>-.65</td>
</tr>
<tr>
<td>GG - VG</td>
<td>.11</td>
<td>-1.22, 1.44</td>
<td>.14</td>
</tr>
<tr>
<td>GG - NVG</td>
<td>.57</td>
<td>-0.78, 1.91</td>
<td>.79</td>
</tr>
</tbody>
</table>

F statistic

$F(3, 92) = 3.12^*$
$F(3, 80) = 1.58$
$F(3, 63) = 1.64$

*significant at $p < .05$  **significant at $p < .01$
6.4.4 One-way ANOVA comparisons. These data (Table 9) show the following trends in the number hierarchical categories displayed. At the pre-teaching phase, the extent of giftedness influenced this. The extent of giftedness did not influence hierarchical categorisation at the post-teaching phases. At the pre-teaching phase, the globally gifted students displayed one more hierarchical category than the not gifted students. Similarly, students gifted in the verbal domain only displayed approximately one more hierarchical category than the not gifted students at the pre-teaching phase. These differences did not reach statistical significance at p<.05.

6.4.5 How these data inform hypotheses. The data presented for the number of hierarchical categories are used to inform Hypotheses 2, 4, and 7. These are in relation to the differences between gifted and not gifted students for the semantic organisation displayed at pre-teaching, the differences between verbally gifted and nonverbally gifted students for the extent to which their knowledge is organised semantically, and the differences between gifted and not gifted students for the extent to which their knowledge of the topics is organised semantically at post-teaching phases.

6.5 Cross-Links

The mean number of cross links that students displayed was assessed to determine the extent to which students displayed relationships between concepts across their concept maps. Figure 15 displays the mean number of cross-links at each of the three assessment points for the globally gifted, nonverbally gifted, verbally gifted and not gifted students. These data represented in Figure 15 are also displayed in Table 5 in Appendix E.
6.5.1 Mean number of cross-links across each assessment phase.

6.5.1.1 Pre-teaching (T1). The data presented in Figure 15 show that globally gifted students (\(M = 1.60\), \(SD = 1.30\)) displayed on average more than twice the number of cross-links on their pre-teaching concept maps than their not gifted peers (\(M = .60\), \(SD = 1.00\)). Similarly, nonverbally gifted students (\(M = 1.30\), \(SD = 1.20\)) displayed more than twice the number of cross-links than the not gifted students. The verbally gifted students (\(M = .90\), \(SD = 1.20\)) displayed on average approximately one cross-link each.

6.5.1.2 Post-teaching (T2). Immediately following the teaching, the globally gifted students (\(M = 1.89\), \(SD = 1.54\)) displayed on average almost two cross-links compared to 1.31 cross-links for not gifted students (\(SD = 1.44\)). The nonverbally gifted students (\(M = 1.00\), \(SD = 1.00\)) displayed less cross-links on their energy concept maps immediately after the teaching than their not gifted peers. The verbally gifted students (\(M = 2.35\), \(SD = 2.15\)) displayed on average approximately one more cross-link than the not gifted students.

6.5.1.3 Post-teaching, following 2-week delay (T3). Two weeks after the teaching, the globally gifted students (\(M = 1.63\), \(SD = 1.41\)) displayed on average more than twice the number
of cross links compared to their not gifted peers ($M = .64$, $SD = .99$). Two weeks after the teaching, the nonverbally gifted students ($M = 1.77$, $SD = 1.69$) displayed nearly three times the number of cross-links compared to their not gifted peers. Two weeks after the teaching, the verbally gifted students ($M = 2.23$, $SD = 2.15$) displayed on average more than two cross links each.

6.5.2 Change across assessment phases. The overall change in mean number of cross-links across phases of assessment was assessed and results are displayed in Figure 16. First, the change from pre-teaching (T1) to post-teaching (T2) was assessed to determine the difference in students’ display of cross-links from the pre-teaching concept map activity to the concept map activity that was undertaken immediately after the teaching. Second, the change from pre-teaching (T1) to post-teaching (T3) was assessed to determine the difference in students’ display of cross-links from the pre-teaching concept map activity to the concept map activity that was undertaken two weeks after the teaching phase.

6.5.2.1 Change from pre-teaching (T1) to post-teaching (T2). Differences were seen between groups in the change in mean number of cross-links displayed from pre-teaching to immediately after the teaching (Figure 16). The globally gifted ($M = .11$, $SD = 2.67$), verbally gifted ($M = 1.41$, $SD = 1.77$), and not gifted students ($M = .67$, $SD = 1.56$) displayed on average an increase in the mean number of cross-links displayed from pre-teaching to immediately after the teaching. The nonverbally gifted students ($M = -.56$, $SD = 1.46$) displayed on average less cross-links immediately after teaching compared to pre-teaching.

6.5.2.2 Change from pre-teaching (T1) to post-teaching (T3). Differences were seen between groups in the change in mean number of cross-links displayed from pre-teaching to post-teaching following the two-week delay (Figure 16). The globally gifted students ($M = -.38$, $SD = 1.92$) displayed less cross-links on average at two weeks after the teaching when compared to pre-teaching. The not gifted students ($M = .00$, $SD = 1.06$) displayed on average approximately the same number of cross-links at pre-teaching and two weeks after teaching. Both the verbally gifted students ($M = 1.38$, $SD = 1.66$) and the nonverbally gifted students ($M = .23$, $SD = 2.01$) displayed more cross-links two weeks after teaching compared to the mean number of cross-links displayed at pre-teaching.
6.5.3 Assessing differences at each phase using Repeated Measures ANOVA. The mean number of cross-links at each assessment phase T1, T2 and T3 were assessed to determine whether there was a group effect and whether the mean number of cross-links was influenced by time, that is, across assessment phases. Table 10 shows the mean scores for each group across each assessment phase.

Table 10

Mean Number of Cross-Links Displayed at Each Assessment Phase

<table>
<thead>
<tr>
<th>Ability group</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
<th>N = 67</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Not gifted</td>
<td>0.64</td>
<td>1.03</td>
<td>1.36</td>
<td>1.48</td>
</tr>
<tr>
<td>Verbally gifted</td>
<td>0.85</td>
<td>1.35</td>
<td>2.00</td>
<td>2.20</td>
</tr>
<tr>
<td>Nonverbally gifted</td>
<td>1.58</td>
<td>1.38</td>
<td>1.08</td>
<td>1.00</td>
</tr>
<tr>
<td>Globally gifted</td>
<td>2.00</td>
<td>1.20</td>
<td>1.75</td>
<td>1.58</td>
</tr>
</tbody>
</table>

Figure 16. Change in mean number of cross links displayed from pre to post-teaching.
The mean number of cross links was influenced by the ability group \((F(3, 62) = 10.34, p < .05, \eta^2 = .15)\). The mean number of cross links was not influenced by the time in the teaching phases at which this factor was assessed \((F(2, 61) = 1.32, p > .05, \eta^2 = .04)\). The interaction factor time x ability was significant, \((F(6, 124) = 2.84, p < .05, \eta^2 = .12)\). The comparisons (one-way ANOVA) of mean number of cross links displayed by each group of students at each phase of assessment (F ratio and t-value, 2-tailed, assuming equal variances) are shown in Table 11.

Table 11

<table>
<thead>
<tr>
<th>Groups</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VG - NG</td>
<td>Mean Diff 0.3, 95% CI -0.49, 1.10</td>
<td>Mean Diff 1.04, 95% CI -1.2, 2.21</td>
<td>Mean Diff 1.59**, 95% CI 0.43, 2.76</td>
</tr>
<tr>
<td>NVG - NG</td>
<td>Mean Diff 0.74, 95% CI -0.07, 1.55</td>
<td>Mean Diff -0.31, 95% CI -1.50, .88</td>
<td>Mean Diff 1.13^^, 95% CI -0.03, 2.30</td>
</tr>
<tr>
<td>GG - NG</td>
<td>Mean Diff 1.01^, 95% CI -0.01, 2.03</td>
<td>Mean Diff 0.6, 95% CI -0.91, 2.07</td>
<td>Mean Diff 0.99, 95% CI -0.41, 2.39</td>
</tr>
<tr>
<td>NVG - VG</td>
<td>Mean Diff 0.44, 95% CI -0.53, 1.41</td>
<td>Mean Diff -1.35, 95% CI 2.77, .06</td>
<td>Mean Diff -0.46, 95% CI -1.85, .93</td>
</tr>
<tr>
<td>GG - VG</td>
<td>Mean Diff 0.71, 95% CI -0.44, 1.85</td>
<td>Mean Diff -0.46, 95% CI -2.13, 1.21</td>
<td>Mean Diff -0.61, 95% CI -2.20, .99</td>
</tr>
<tr>
<td>GG - NVG</td>
<td>Mean Diff 0.27, 95% CI -0.89, 1.43</td>
<td>Mean Diff 0.89, 95% CI -0.80, 2.58</td>
<td>Mean Diff -0.14, 95% CI -1.74, 1.45</td>
</tr>
</tbody>
</table>

**F statistic**

\(F(3, 92) = 3.42^*\) \(F(3, 80) = 2.67\) \(F(3, 63) = 5.43^{**}\)

*significant at \(p < .05\)  **significant at \(p < .01\)  ^p=.054  ^^p=.059

**6.5.4 One-way ANOVA comparisons.** These data show the following trends in the number of cross-links displayed. At the pre-teaching and the post-teaching (after two-week delay) phases, the extent of giftedness influenced this. At pre-teaching, the globally gifted students displayed more cross-links than the not gifted students (verging on statistical significance, \(p = .054\)). Two weeks after teaching, the verbally gifted students displayed more cross-links than the not gifted students. Following the two-week delay, difference between the verbally gifted students and the not gifted students was approximately two cross-links. The nonverbally gifted students displayed approximately one more cross-link than the not gifted students.
students at the post-teaching phase following the two-week delay (verging on statistical significance, $p = .059$).

**6.5.5 How these data inform hypotheses.** The data presented for the number of cross-links are used to inform Hypotheses 3, 5, and 8. These are in relation to the differences between gifted and not gifted students for interconnectedness of conceptual networks displayed at pre-teaching, the differences between verbally gifted and nonverbally gifted students for the extent to which their knowledge is interconnected, and the differences between gifted and not gifted students for the extent to which their knowledge of the topics is interconnected at post-teaching phases.

**6.6 Big Ideas**

The mean number of big ideas that students displayed was assessed to determine the extent to which students organised knowledge into large chunks of information. Figure 17 displays the mean number of big ideas at each of the three assessment points for globally gifted, nonverbal gifted, verbal gifted and not gifted students. These data represented in Figure 17 are also displayed in Table 6 in Appendix E.

![Figure 17](image)  
*Figure 17. Mean number of big ideas displayed at each assessment phase across ability groups.*
6.6.1 Mean number of big ideas across each assessment phase.

6.6.1.1 Pre-teaching (T1). The data presented in Figure 17 show that globally gifted students ($M = 2.40, SD = 1.10$) displayed more than twice as many big ideas than the not gifted students ($M = .90, SD = .90$). The nonverbally gifted students ($M = 1.60, SD = 1.00$) displayed nearly twice the number of big ideas compared to the not gifted students. Verbally gifted students ($M = 1.40, SD = 1.30$) displayed a comparable number of big ideas to the nonverbally gifted students at the pre-teaching phase.

6.6.1.2 Post-teaching (T2). Immediately following the teaching, the globally gifted students ($M = 1.67, SD = .71$) and the verbally gifted students ($M = 1.41, SD = 1.37$) displayed more than three times as many big ideas than the not gifted students ($M = .55, SD = .59$). The nonverbally gifted students ($M = 1.00, SD = .82$) displayed nearly twice the number of big ideas compared to the not gifted students at the post-teaching phase, T2.

6.6.1.3 Post-teaching, following 2-weeks delay (T3). Two weeks after the teaching, globally gifted students ($M = 1.50, SD = .53$) displayed nearly twice as many big ideas than the not gifted students ($M = .79, SD = .93$). The nonverbally gifted students ($M = 1.77, SD = 1.30$) displayed more than twice the number of big ideas compared to the not gifted students. Verbally gifted students ($M = 1.23, SD = 1.30$) displayed more than one big idea on average after the two-week delay.

6.6.2 Change across assessment phases. The overall change in mean number of big ideas across phases of assessment was assessed and the data are presented in Figure 18. First, the change from pre-teaching (T1) to post-teaching (T2) was assessed to determine the difference in students’ display of big ideas from the pre-teaching concept map activity to the concept map activity that was undertaken immediately after the teaching. Second, the change from pre-teaching (T1) to post-teaching (T3) was assessed to determine the difference in students’ display of big ideas from the pre-teaching concept map activity to the concept map activity that was undertaken two weeks after the teaching phase.

6.6.2.1 Change from pre-teaching (T1) to post-teaching (T2). From pre-teaching to immediately after the teaching the globally gifted ($M = -.67, SD = .71$), nonverbal gifted ($M = -.56, SD = .89$) verbal gifted ($M = -.12, SD = 1.65$) and not gifted students ($M = -.36, SD = .98$) all displayed a decrease in the mean number of bid ideas.
6.6.2.2 Change from pre-teaching (T1) to post-teaching (T3). From pre-teaching to two weeks post-teaching the globally gifted students ($M = -0.75, SD = 1.04$), verbally gifted students ($M = -0.15, SD = 1.14$) and not gifted students ($M = -0.15, SD = 1.15$) all displayed a decrease in the mean number of big ideas displayed. The nonverbally gifted students ($M = 0.20, SD = 1.34$) displayed on average more big ideas two weeks after teaching when compared to pre-teaching.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure18.png}
\caption{Change in mean number of big ideas displayed from pre to post-teaching.}
\end{figure}

6.6.3 Assessing differences at each phase using Repeated Measures ANOVA. The mean number of big ideas at each assessment phase T1, T2 and T3 were assessed to determine whether there was a group effect and whether the mean number of big ideas was influenced by time, that is, across assessment phases. Table 12 shows the mean scores for each group across each assessment phase.
Table 12

Mean Number of Big Ideas Displayed at Each Assessment Phase

<table>
<thead>
<tr>
<th>Ability group</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
<th>N = 67</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Not gifted</td>
<td>.94</td>
<td>.83</td>
<td>.58</td>
<td>.61</td>
</tr>
<tr>
<td>Verbally gifted</td>
<td>1.38</td>
<td>1.19</td>
<td>1.54</td>
<td>1.51</td>
</tr>
<tr>
<td>Nonverbally gifted</td>
<td>1.62</td>
<td>1.04</td>
<td>1.00</td>
<td>.91</td>
</tr>
<tr>
<td>Globally gifted</td>
<td>2.25</td>
<td>1.17</td>
<td>1.63</td>
<td>.74</td>
</tr>
</tbody>
</table>

The mean number of big ideas was influenced by the ability group \( F(3, 63) = 6.41, \ p < .01, \eta^2 = .23 \). The mean number of big idea was not influenced by the time in the teaching phases at which this factor was assessed \( F(2, 62) = 2.61, \ p > .05, \eta^2 = .08 \). The interaction factor time x ability group did not achieve significance \( p > .05 \). The comparisons (one-way ANOVA) of mean number of big ideas displayed by each group of students at each phase of assessment \( F \) ratio and t-value, 2-tailed, assuming equal variances) are shown in Table 13.


Table 13

*Mean Group Comparisons for Total Number of Big Ideas at Each Assessment Phase*

<table>
<thead>
<tr>
<th>Groups</th>
<th>Pre-teaching (T1)</th>
<th>95% CI</th>
<th>Post-teaching (T2)</th>
<th>95% CI</th>
<th>After delay (T3)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>VG - NG</td>
<td>.43</td>
<td>-.28, 1.14</td>
<td>.86**</td>
<td>.22, 1.51</td>
<td>.44</td>
<td>-.47, 1.35</td>
</tr>
<tr>
<td>NVG - NG</td>
<td>.62</td>
<td>-.10, 1.34</td>
<td>.45</td>
<td>-.21, 1.11</td>
<td>.98*</td>
<td>.07, 1.89</td>
</tr>
<tr>
<td>GG - NG</td>
<td>1.46**</td>
<td>.55, 2.37</td>
<td>1.12**</td>
<td>.29, 1.94</td>
<td>.71</td>
<td>-.39, 1.81</td>
</tr>
<tr>
<td>NVG - VG</td>
<td>.19</td>
<td>-.67, 1.05</td>
<td>-.41</td>
<td>-1.19, .37</td>
<td>.54</td>
<td>-.55, 1.63</td>
</tr>
<tr>
<td>GG - VG</td>
<td>1.03*</td>
<td>.01, 2.05</td>
<td>.25</td>
<td>-.67, 1.18</td>
<td>.27</td>
<td>-.98, 1.52</td>
</tr>
<tr>
<td>GG - NVG</td>
<td>.84</td>
<td>-.19, 1.88</td>
<td>.67</td>
<td>-.27, 1.60</td>
<td>-.27</td>
<td>-1.52, .98</td>
</tr>
</tbody>
</table>

**F statistic**

- F(3, 92) = 6.58**
- F(3, 80) = 6.86**
- F(3, 63) = 3.11*

*significant at p < .05  **significant at p < .01

6.6.4 One-way ANOVA comparisons. These data (Table 13) show the following trends in the number of big ideas displayed. At all phases, the extent of giftedness influenced this. At the pre-teaching phase and immediately after teaching, the globally gifted students displayed more big ideas than their not gifted peers. The two groups who gifted in a single gifted domain did not differ. Two weeks after the teaching, nonverbally gifted students displayed more big ideas than the not gifted students.

6.6.5 How these data inform hypotheses. The data presented for the number of big ideas are used to inform Hypotheses 2, 4, and 4. These are in relation to the differences between gifted and not gifted students for the semantic organisation displayed at pre-teaching, the differences between verbally gifted and nonverbally gifted students for the extent to which their knowledge is organised semantically, and the differences between gifted and not gifted students for the extent to which their knowledge of the topics is organised semantically at post-teaching phases.
Analysis of Concept Maps for Humanities Topic

6.7 Valid Propositions

The validity of the concepts displayed on students’ prior knowledge concept maps was assessed to determine whether the propositions that comprised the study concepts made sense. Figure 19 displays the mean number of valid concepts at each of the three assessment phases T1, T2 and T3 for globally gifted, nonverbal gifted, verbal gifted and not gifted students. These data represented in Figure 19 are also displayed in Table 7 in Appendix E.

![Figure 19](image)

Figure 19. Mean number of valid propositions displayed at each assessment phase across ability groups.

6.7.1 Mean number of valid propositions across each assessment phase.

6.7.1.1 Pre-teaching (T1). The globally gifted students (M = 13.70, SD = 3.60) displayed approximately four more of the seventeen migration study concepts in valid propositions than their not gifted peers (M = 9.30, SD = 4.20). The nonverbally gifted students (M = 11.40, SD = 4.40) displayed on average approximately two more valid concepts from the seventeen migration study concepts than the not gifted students. The verbally gifted students (M = 9.70, SD = 3.80) displayed approximately the same number of the migration study concepts in valid propositions,
with both groups of students displaying on average less than ten of the seventeen study concepts in valid propositions.

6.7.1.2 Post-teaching (T2). Immediately following the teaching, the globally gifted students \( M = 13.75, \ SD = 3.88 \) displayed approximately three more of the seventeen migration study concepts in valid propositions than their not gifted peers \( M = 10.55, \ SD = 4.30 \). The nonverbally gifted students \( M = 12.20, \ SD = 4.14 \) displayed on average almost two more valid concepts from the seventeen migration study concepts than the not gifted students. The verbally gifted students \( M = 10.22, \ SD = 3.56 \) displayed approximately the same number of the migration study concepts in valid propositions, with both groups of students displaying approximately ten out of the seventeen study concepts in valid propositions.

6.7.1.3 Post-teaching, following 2-week delay (T3). Two weeks after the teaching, the globally gifted students \( M = 14.50, \ SD = 2.93 \) displayed nearly five more of the seventeen migration study concepts in valid propositions than their not gifted peers \( M = 9.92, \ SD = 4.16 \). Two weeks after the teaching, the nonverbally gifted students \( M = 12.27, \ SD = 3.84 \) displayed on average approximately two more valid propositions using the seventeen migration study concepts than the not gifted students. The verbally gifted students \( M = 11.11, \ SD = 4.13 \) displayed approximately one more of the migration study concepts in valid propositions compared to the not gifted students.

6.7.2 Change across assessment phases. The overall change in mean number of valid propositions across phases of assessment was assessed and these data are displayed in Figure 20. First, the change from pre-teaching (T1) to post-teaching (T2) was assessed to determine the difference in students’ display of valid propositions from the pre-teaching concept map activity to the concept map activity that was undertaken immediately after the teaching. Second, the change from pre-teaching (T1) to post-teaching (T3) was assessed to determine the difference in students’ display of valid propositions from the pre-teaching concept map activity to the concept map activity that was undertaken two weeks after the teaching phase.

6.7.2.1 Change from pre-teaching (T1) to post-teaching (T2). All groups displayed on average growth in the mean number of valid propositions from pre-teaching to immediately after the teaching: globally gifted \( M = .75, \ SD = 2.12 \), nonverbally gifted \( M = .80, \ SD = 1.86 \), verbally gifted \( M = .33, \ SD = 3.16 \), and not gifted students \( M = 1.13, \ SD = 2.69 \).
6.7.2.2 Change from pre-teaching (T1) to post-teaching (T3). All groups displayed on average growth in mean number of valid propositions from pre-teaching to two weeks after the teaching; globally gifted ($M = 1.50, SD = 2.73$), nonverbally gifted ($M = 0.87, SD = 3.23$), verbally gifted ($M = 1.22, SD = 3.73$), not gifted students ($M = 0.44, SD = 3.32$).

![Figure 20](image.png)

*Figure 20.* Change in mean number of valid propositions displayed using study concepts from pre to post-teaching.

6.7.3 Assessing differences at each phase using Repeated Measures ANOVA. The mean number of valid propositions at each assessment phase T1, T2 and T3 were assessed to determine whether there was a group effect and whether the mean number of valid propositions were influenced by time, that is, across assessment phases. Table 14 shows the mean scores for each group across each assessment phase.
Table 14

Mean Number of Valid Propositions Displayed at Each Assessment Phase

<table>
<thead>
<tr>
<th>Ability group</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
<th>N = 71</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Not gifted</td>
<td>9.49</td>
<td>4.41</td>
<td>10.69</td>
<td>4.26</td>
</tr>
<tr>
<td>Verbally gifted</td>
<td>9.89</td>
<td>4.51</td>
<td>10.22</td>
<td>3.56</td>
</tr>
<tr>
<td>Nonverbally gifted</td>
<td>11.40</td>
<td>4.42</td>
<td>12.20</td>
<td>4.14</td>
</tr>
<tr>
<td>Globally gifted</td>
<td>13.00</td>
<td>3.74</td>
<td>13.75</td>
<td>3.88</td>
</tr>
</tbody>
</table>

The mean number of valid propositions was not influenced by the time in the teaching phases at which this factor was assessed ($F(2, 66) = 2.75, \ p > .05, \eta^2 = .08$). The interaction factor time x ability group did not achieve significance ($p > .05$). The mean number of valid propositions was not influenced by the ability group ($F(3, 67) = 2.59, \ p > .05, \eta^2 = .10$). The comparisons of mean number of valid propositions displayed by each group of students at each phase of assessment (F ratio and t-value, 2-tailed, assuming equal variances) are shown in Table 15.

Table 15

Mean Group Comparisons for Total Number of Valid Propositions at Each Assessment Phase

<table>
<thead>
<tr>
<th>Groups</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
<th>F statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Diff</td>
<td>95% CI</td>
<td>Mean Diff</td>
<td>95% CI</td>
</tr>
<tr>
<td>VG - NG</td>
<td>0.39</td>
<td>-2.95, 3.72</td>
<td>-0.33</td>
<td>-4.35, 3.70</td>
</tr>
<tr>
<td>NVG - NG</td>
<td>2.07</td>
<td>-1.18, 5.33</td>
<td>1.65</td>
<td>-1.65, 4.95</td>
</tr>
<tr>
<td>GG - NG</td>
<td>4.37*</td>
<td>.57, 8.18</td>
<td>3.2</td>
<td>-1.03, 7.43</td>
</tr>
<tr>
<td>NVG - VG</td>
<td>1.69</td>
<td>-2.34, 5.71</td>
<td>1.98</td>
<td>-2.62, 6.58</td>
</tr>
<tr>
<td>GG - VG</td>
<td>3.99</td>
<td>-.50, 8.47</td>
<td>3.53</td>
<td>-1.77, 8.83</td>
</tr>
<tr>
<td>GG - NVG</td>
<td>2.3</td>
<td>-2.13, 6.73</td>
<td>1.55</td>
<td>-3.23, 6.33</td>
</tr>
</tbody>
</table>

*significant at $p < .05$  **significant at $p < .01$
6.7.4 **One-way ANOVA comparisons.** These data (Table 15) show the following trends in the number of valid propositions displayed. At the pre-teaching and post-teaching (after two week delay) phase, the extent of giftedness influenced this. At the pre-teaching phase and two weeks after teaching, the globally gifted students displayed more valid propositions than their not gifted peers. The two groups who gifted in a single gifted domain did not differ, however, the nonverbally gifted students displayed on average between one and two more valid propositions than the verbally gifted students at each phase. From immediately after the teaching, to two weeks after the teaching, the trend shows that all gifted groups increased the mean number of valid propositions displayed in comparison to not gifted students.

6.7.5 **How these data inform hypotheses.** These data presented for the validity of propositions inform Hypotheses 1, 4, and 6. These are in relation to the differences between gifted and not gifted students for the number of verbal propositions displayed at pre-teaching, the differences between verbally gifted and nonverbally gifted students at pre-teaching, and the differences between gifted and not gifted students at post-teaching phases. The number of verbal propositions displayed by students are used as part of the assessment of the extent to which students display more elaborated and differentiated conceptual networks, as described in the novice-expert knower model (Munro, 2012).

6.8 **Semantically Valid Propositions**

The semantic validity of the concepts displayed on students’ prior knowledge concept maps was assessed to determine whether the propositions that comprised the study concepts displayed an understanding that represented a scientific understanding (semantically valid) in relation to the given topic of energy. Figure 21 displays the mean number of semantically valid concepts at each of the three assessment points for globally gifted, nonverbal gifted, verbal gifted and not gifted students. These data represented in Figure 21 are also displayed in Table 8 in Appendix E.
6.8.1 Mean number of semantically valid propositions across each assessment phase.

6.8.1.1 Pre-teaching (T1). At pre-teaching, the globally gifted students ($M = 12.70$, $SD = 3.90$) displayed semantically valid propositions utilising almost five more of the study concepts than their not gifted peers ($M = 8.10$, $SD = 4.20$). The nonverbally gifted students ($M = 10.00$, $SD = 4.10$) displayed on average approximately two more semantically valid propositions than the not gifted students. The verbally gifted students ($M = 8.90$, $SD = 3.60$) displayed on average approximately one more semantically valid concept than the not gifted students.

Differences in use of specific concepts (see Appendix E). Some of the biggest differences in semantically valid use of the study concepts were seen for concepts such as world, aborigines, lifestyle, boat, water, first fleet and asylum seekers. For example, almost all (90%) of the globally gifted students displayed a semantically valid proposition with the concept of *aborigines* compared to 55% of not gifted students. The majority (80%) of globally gifted students displayed a semantically valid proposition with the concept of *asylum seekers* compared to only 28% of the not gifted students. Similarly, 80% of the globally gifted students displayed a semantically valid proposition with the concept of *lifestyle* compared to 40% of the not gifted students.

Figure 21. Mean number of semantically valid propositions displayed at each assessment phase across ability groups.
6.8.1.2 Post-teaching (T2). Immediately following the teaching, the globally gifted students \((M = 13.75, SD = 3.90)\) displayed semantically valid propositions utilising approximately four more of the study concepts than their not gifted peers \((M = 10.10, SD = 4.28)\). The nonverbally gifted students \((M = 11.80, SD = 4.00)\) displayed on average approximately two more semantically valid propositions than the not gifted students, whilst the verbally gifted students \((M = 10.00, SD = 3.77)\) displayed on average approximately the same number of semantically valid concepts than the not gifted students.

*Differences in use of specific concepts (see Appendix E).* Some of the biggest differences between globally gifted and not gifted students in semantically valid use of the study concepts were seen for concepts such as world, lifestyle, ice age, first fleet and asylum seekers. For example, almost all (88%) of the globally gifted students displayed a semantically valid proposition with the concept of *ice age* compared to 40% of not gifted students. Three-quarters (75%) of globally gifted students displayed a semantically valid proposition with the concept of *asylum seekers* compared to less than half (40%) of the not gifted students.

6.8.1.3 Post-teaching, following 2-week delay (T3). Two weeks after the teaching, the globally gifted students \((M = 14.50, SD = 2.93)\) displayed semantically valid propositions with five more of the study concepts than their not gifted peers \((M = 9.51, SD = 2.93)\). The nonverbally gifted students \((M = 11.87, SD = 3.52)\) displayed on average more than two more semantically valid propositions than the not gifted students. The verbally gifted students \((M = 11.00, SD = 4.00)\) displayed on average approximately one and a half more semantically valid concept than the not gifted students.

*Differences in use of specific concepts (see Appendix E).* Some of the biggest differences in semantically valid use of the study concepts were seen for concepts such as Lake Mungo, lifestyle, water, food and ice age. For example, three-quarters (75%) of the globally gifted students displayed a semantically valid proposition with the concept of *ice age* compared to only 21% of not gifted students. All (100%) of the globally gifted students displayed a semantically valid proposition with the concepts of *water* and *food* compared to only 51% of the not gifted students. Most notable was the difference between the proportions of students who displayed a semantically valid proposition for the concept Lake Mungo, given that this was one of the main ideas in the teaching. All (100%) of the globally gifted students displayed a semantically valid proposition with the concept of *Lake Mungo* compared to 56% of not gifted students.
6.8.2 Change across assessment phases. The overall change in mean number of semantically valid propositions across phases of assessment was assessed and these data are presented in Figure 22. First, the change from pre-teaching (T1) to post-teaching (T2) was assessed to determine the difference in students’ display of semantically valid propositions from the pre-teaching concept map activity to the concept map activity that was undertaken immediately after the teaching. Second, the change from pre-teaching (T1) to post-teaching (T3) was assessed to determine the difference in students’ display of semantically valid propositions from the pre-teaching concept map activity to the concept map activity that was undertaken two weeks after the teaching phase.

6.8.2.1 Change from pre-teaching (T1) to post-teaching (T2). All groups displayed on average growth in mean number of semantically valid propositions using the energy study concepts from pre-teaching to immediately after the teaching; globally gifted ($M = 1.13, SD = 1.81$), nonverbally gifted ($M =1.80, SD = 1.69$), verbally gifted ($M = .78, SD = 2.33$), not gifted students ($M = 1.80, SD = 3.15$).

6.8.2.2 Change from pre-teaching (T1) to post-teaching (T3). All groups displayed on average growth in mean number of semantically valid propositions using the energy study concepts from pre-teaching to two weeks after the teaching; globally gifted ($M = 1.88, SD = 2.36$), nonverbally gifted ($M =1.87, SD = 2.79$), verbally gifted ($M = 1.78, SD = 3.87$), not gifted students ($M = 1.18, SD = 3.73$).
6.8.3 Assessing differences at each phase using Repeated Measures ANOVA. The mean number of valid propositions at each assessment phase T1, T2 and T3 were assessed to determine whether there was a group effect and whether the mean number of semantically valid propositions was influenced by time, that is, across assessment phases. Table 16 shows the mean scores for each group across each assessment phase.

Table 16
Mean Number of Semantically Valid Propositions Displayed at Each Assessment Phase

<table>
<thead>
<tr>
<th>Ability group</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
<th>N = 71</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Not gifted</td>
<td>8.33</td>
<td>4.24</td>
<td>10.23</td>
<td>4.25</td>
</tr>
<tr>
<td>Verbally gifted</td>
<td>9.22</td>
<td>4.12</td>
<td>10</td>
<td>3.78</td>
</tr>
<tr>
<td>Nonverbally gifted</td>
<td>10</td>
<td>4.07</td>
<td>11.8</td>
<td>4</td>
</tr>
<tr>
<td>Globally gifted</td>
<td>12.63</td>
<td>3.89</td>
<td>13.75</td>
<td>3.88</td>
</tr>
</tbody>
</table>

Figure 22. Change in mean number of semantically valid propositions displayed using study concepts from pre to post-teaching.
The mean number of semantically valid propositions was influenced by the time in the teaching phases at which this factor was assessed \((F(2, 66) = 7.55, \ p < .01, \eta^2 = .19)\) and by the ability group \((F(3, 67) = 3.35, \ p < .05, \eta^2 = .13)\). The interaction factor time x ability group did not achieve significance \((p > .05)\). The comparisons of mean number of semantically valid propositions displayed by each group of students at each phase of assessment (F ratio and t-value, 2-tailed, assuming equal variances) are shown in Table 17.

Table 17

| Mean Group Comparisons for Total Number of Semantically Valid Propositions at Each Assessment Phase |
|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| Groups                                          | Pre-teaching (T1)                               | Post-teaching (T2)                               | After delay (T3)                                 |
| VG - NG                                         | Mean Diff 0.79 95% CI -2.50, 4.08               | Mean Diff -0.1 95% CI -4.11, 3.91               | Mean Diff 1.49 95% CI -2.34, 5.31               |
| NVG - NG                                        | Mean Diff 1.93 95% CI -1.27, 5.14               | Mean Diff 1.7 95% CI -1.59, 4.99                | Mean Diff 2.35 95% CI -0.79, 5.49               |
| GG - NG                                         | Mean Diff 4.63** 95% CI 0.88, 8.38               | Mean Diff 3.65 95% CI -5.6, 7.86                | Mean Diff 4.99* 95% CI 0.97, 8.99               |
| NVG - VG                                        | Mean Diff 1.14 95% CI -2.83, 5.11               | Mean Diff 1.8 95% CI -2.78, 6.38                | Mean Diff 0.87 95% CI -3.49, 5.23               |
| GG - VG                                         | Mean Diff 3.84 95% CI -.58, 8.27                | Mean Diff 3.75 95% CI -1.53, 9.03               | Mean Diff 3.5 95% CI -1.52, 8.52                |
| GG - NVG                                        | Mean Diff 2.7 95% CI -1.66, 7.06                | Mean Diff 1.95 95% CI -2.81, 6.71               | Mean Diff 2.63 95% CI -1.89, 7.16               |
| **F statistic**                                 | \(F(3, 78) = 3.79^*\)                           | \(F(3, 68) = 2.15\)                             | \(F(3, 67) = 4.15^{**}\)                        |

*significant at \(p < .05\)  **significant at \(p < .01\)

6.8.4 One-way ANOVA comparisons. These data (Table 17) show the following trends in the number of semantically valid propositions displayed. At the pre-teaching and post-teaching (after two-week delay) phases, the extent of giftedness influenced this. At the pre-teaching phase and two weeks after teaching, the globally gifted students displayed more semantically valid propositions than their not gifted peers. The two groups gifted in a single gifted domain did not differ. Two weeks after the teaching, the mean number of semantically valid propositions displayed by all three gifted groups increased from immediately after the teaching, in comparison to the not gifted students.

6.8.5 How these data inform hypotheses. The data presented for the semantic validity of propositions are used in addition to the validity of propositions to inform Hypotheses 1, 4, and
6. These are in relation to the differences between gifted and not gifted students for the elaboration and differentiation of conceptual networks displayed at pre-teaching, the differences between verbally gifted and nonverbally gifted students for the extent to which their knowledge is elaborated and differentiated, and the differences between gifted and not gifted students for the extent to which their knowledge of the topics is elaborated and differentiated at post-teaching phases.

6.9 Additional Concepts

The mean number of additional concepts was assessed to determine whether the extent to which students included additional concepts to describe their understanding of the topic. Figure 23 displays the mean number of additional concepts at each of the three assessment points for globally gifted, nonverbal gifted, verbal gifted and not gifted students. These data represented in Figure 23 are also displayed in Table 9 in Appendix E.

![Figure 23. Mean number of additional concepts displayed at each assessment phase across ability groups.](image)

6.9.1 Mean number of additional concepts across each assessment phase.

6.9.1.1 Pre-teaching (T1). Globally gifted students \((M = 2.80, SD = 2.57)\) on average inferred approximately two less additional concepts on their prior knowledge concept maps than their not gifted peers \((M = 4.70, SD = 4.74)\). Students gifted in the nonverbal domain \((M = 6.10, SD = 6.34)\) on average...
on average inferred approximately one more additional concept than their not gifted peers, whereas students gifted in the verbal domain \((M = 6.70, SD = 7.14)\) on average inferred two more additional concepts than their not gifted peers.

**6.9.1.2 Post-teaching (T2).** Immediately following the teaching, globally gifted students \((M = 1.63, SD = 1.92)\) on average inferred approximately two less additional concepts than their not gifted peers \((M = 3.50, SD = 5.53)\). Students gifted in the nonverbal domain \((M = 3.33, SD = 4.92)\) and students gifted in the verbal domain \((M = 3.11, SD = 3.48)\) on average inferred approximately the same number of additional concepts as their not gifted peers.

**6.9.1.3 Post-teaching, following 2-week delay (T3).** Two weeks after the teaching, globally gifted students \((M = 1.75, SD = 2.49)\) on average inferred more than one less additional concept than their not gifted peers \((M = 3.15, SD = 3.92)\). Students gifted in the nonverbal domain \((M = 4.20, SD = 7.49)\) on average inferred approximately one more additional concepts than the not gifted students. Students gifted in the verbal domain \((M = 5.67, SD = 3.61)\) on average inferred two and a half more additional concepts than their not gifted peers and approximately four more additional concepts when compared to the globally gifted students.

**6.9.2 Change across assessment phases.** The overall change in mean number of additional concepts across phases of assessment was assessed and these data are presented in Figure 24. First, the change from pre-teaching (T1) to post-teaching (T2) was assessed to determine the difference in students’ display of additional concepts from the pre-teaching concept map activity to the concept map activity that was undertaken immediately after the teaching. Second, the change from pre-teaching (T1) to post-teaching (T3) was assessed to determine the difference in students’ display of additional concepts from the pre-teaching concept map activity to the concept map activity that was undertaken two weeks after the teaching phase.

**6.9.2.1 Change from pre-teaching (T1) to post-teaching (T2).** From pre-teaching to immediately after the teaching, the globally gifted \((M = -1.13, SD = 1.96)\), nonverbally gifted \((M = -2.80, SD = 5.52)\), verbally gifted \((M = -2.33, SD = 4.27)\), and not gifted students \((M = -1.23, SD = 3.95)\) all displayed fewer additional concepts.

**6.9.2.2 Change from pre-teaching (T1) to post-teaching (T3).** From pre-teaching to two weeks after the teaching, the globally gifted \((M = -1.00, SD = .93)\), nonverbal gifted \((M = -1.93, SD = 3.43)\), and not gifted students \((M = -1.59, SD = 3.04)\) all displayed fewer additional
concepts. The verbally gifted students \((M = .22, SD = 3.23)\) displayed on average more additional concepts two weeks after teaching when compared to pre-teaching.

**Figure 24.** Change in mean number of additional concepts displayed from pre to post-teaching.

### 6.9.3 Assessing differences at each phase using Repeated Measures ANOVA.

The mean number of additional concepts at each assessment phase T1, T2 and T3 were assessed to determine whether there was a group effect and whether the mean number of additional concepts was influenced by time, that is, across assessment phases. Table 18 shows the mean scores for each group across each assessment phase.
### Table 18

**Mean number of Additional Concepts Displayed at Each Assessment Phase**

<table>
<thead>
<tr>
<th>Ability group</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Not gifted</td>
<td>4.74</td>
<td>4.89</td>
<td>3.56</td>
<td>5.59</td>
</tr>
<tr>
<td>Verbally gifted</td>
<td>5.44</td>
<td>5.36</td>
<td>3.11</td>
<td>3.48</td>
</tr>
<tr>
<td>Nonverbally gifted</td>
<td>6.13</td>
<td>9.32</td>
<td>3.33</td>
<td>4.92</td>
</tr>
<tr>
<td>Globally gifted</td>
<td>2.75</td>
<td>2.44</td>
<td>1.63</td>
<td>1.92</td>
</tr>
</tbody>
</table>

The mean number of additional concepts was influenced by the time in the teaching phases at which this factor was assessed ($F(2, 66) = 5.31, \ p < .01, \eta^2 = .14$). The mean number of additional concepts was not influenced by the ability group ($F(3, 67) = .58, \ p > .05, \eta^2 = .03$). The interaction factor time x ability group did not achieve significance ($p > .05$). The comparisons of mean number of additional concepts displayed by each group of students at each phase of assessment (F ratio and t-value, 2-tailed, assuming equal variances) are shown in Table 19.

### Table 19

**Mean Group Comparisons for Total Number of Additional Concepts at Each Assessment Phase**

<table>
<thead>
<tr>
<th>Groups</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Diff</td>
<td>95% CI</td>
<td>Mean Diff</td>
</tr>
<tr>
<td>VG - NG</td>
<td>2.04</td>
<td>-2.87, 6.95</td>
<td>-3.9</td>
</tr>
<tr>
<td>NVG - NG</td>
<td>1.46</td>
<td>-3.33, 6.24</td>
<td>-1.7</td>
</tr>
<tr>
<td>GG - NG</td>
<td>-1.87</td>
<td>-7.48, 3.72</td>
<td>-1.88</td>
</tr>
<tr>
<td>NVG - VG</td>
<td>-0.58</td>
<td>-6.51, 5.35</td>
<td>-0.22</td>
</tr>
<tr>
<td>GG - VG</td>
<td>-3.91</td>
<td>-10.52, 2.69</td>
<td>-1.49</td>
</tr>
</tbody>
</table>

*F statistic*  

\[ F(3, 78) = 1.02 \]  

\[ F(3, 68) = .33 \]  

\[ F(3, 67) = 1.16 \]

*significant at \( p < .05 \)  **significant at \( p < .01 \)

#### 6.9.4 One-way ANOVA comparisons.

These data (Table 19) show the following trends in the number of additional concepts displayed. At all phases, the extent (or type) of giftedness
did not influence the mean number of additional concepts. On average, the globally gifted students displayed fewer additional concepts than the not gifted students at each phase. These differences were not statistically significant.

6.9.5 How these data inform hypotheses. The data presented for the inference of additional concepts in addition to the validity and semantic validity of propositions are used to inform Hypotheses 1, 4, and 6. These are in relation to the differences between gifted and not gifted students for the elaboration and differentiation of conceptual networks displayed at pre-teaching, the differences between verbally gifted and nonverbally gifted students for the extent to which their knowledge is elaborated and differentiated, and the differences between gifted and not gifted students for the extent to which their knowledge of the topics is elaborated and differentiated at post-teaching phases.

6.10 Hierarchical Categories

The mean number of hierarchical categories that students displayed was assessed to determine the extent to which students organised knowledge into hierarchies. Figure 25 displays the mean number of hierarchical categories at each of the three assessment points for globally gifted, nonverbal gifted, verbal gifted and not gifted students. These data represented in Figure 25 are also displayed in Table 10 in Appendix E.

![Figure 25](image_url)

*Figure 25. Mean number of hierarchical categories displayed at each assessment phase across ability groups.*
6.10.1 Mean number of hierarchical categories across each assessment phase.

6.10.1.1 Pre-teaching (T1). Globally gifted students displayed on average the same number of hierarchical categories on their migration prior knowledge concept maps than their not gifted peers. Both the globally gifted students \((M = 1.00, SD = .70)\) and the not gifted students \((M = .98, SD = 1.00)\) displayed on average one hierarchical category. Nonverbally gifted students \((M = .93, SD = 1.00)\) and verbally gifted students \((M = 1.10, SD = 1.00)\) displayed on average one hierarchical category on their migration prior knowledge concept maps.

6.10.1.2 Post-teaching (T2). Immediately following the teaching, globally gifted students \((M = 1.25, SD = 1.28)\) displayed on average more than one hierarchical category on their migration concept maps whilst their not gifted peers \((M = .78, SD = .86)\) displayed less than one hierarchical category. The nonverbally gifted students \((M = 1.60, SD = 1.40)\) displayed on average nearly one more hierarchical category than the not gifted students. The verbally gifted students \((M = 1.44, SD = 1.40)\) displayed on average nearly one and a half hierarchical categories on their migration concept maps.

6.10.1.3 Post-teaching, following 2-week delay (T3). Two weeks after the teaching, the globally gifted students \((M = 1.75, SD = .71)\) displayed on average approximately two hierarchical categories on their migration concept maps compared to approximately one hierarchical category for the not gifted students \((M = 1.18, SD = .88)\). The nonverbally gifted students \((M = 1.14, SD = 1.03)\) displayed on average a comparable number of hierarchical categories to the not gifted students. The verbally gifted students \((M = .89, SD = .93)\) displayed on average less than one hierarchical category on their migration concept maps two weeks after teaching.

6.10.2 Change across assessment phases. The overall change in mean number of hierarchical categories across phases of assessment was assessed and these data are presented in Figure 26. First, the change from pre-teaching (T1) to post-teaching (T2) was assessed to determine the difference in students’ display of hierarchical categories from the pre-teaching concept map activity to the concept map activity that was undertaken immediately after the teaching. Second, the change from pre-teaching (T1) to post-teaching (T3) was assessed to determine the difference in students’ display of hierarchical categories from the pre-teaching
concept map activity to the concept map activity that was undertaken two weeks after the teaching phase.

6.10.2.1 Change from pre-teaching (T1) to post-teaching (T2). From pre-teaching to immediately after the teaching all three gifted groups, the globally gifted ($M = .25, SD = .71$) verbally gifted ($M = .44, SD = 1.42$), and nonverbally gifted ($M = .67, SD = 1.45$) displayed an increase in the mean number of hierarchical categories. The not gifted students ($M = -.20, SD = 1.36$) displayed on average fewer hierarchical categories immediately after the teaching compared to pre-teaching.

6.10.2.2 Change from pre-teaching (T1) to post-teaching (T3). From pre-teaching to two weeks post-teaching, the globally gifted students ($M = .75, SD = .71$), nonverbally gifted students ($M = .13, SD = 1.30$) and the not gifted students ($M = .18, SD = 1.43$) all displayed an increase in the mean number of hierarchical categories displayed. The verbally gifted students ($M = -.11, SD = 1.17$) displayed on average fewer hierarchical categories two weeks after teaching when compared to pre-teaching.

![Graph showing change in mean number of hierarchical categories from pre to post-teaching.](figure26.png)

*Figure 26.* Change in mean number of hierarchical categories displayed from pre to post-teaching.

6.10.3 Assessing differences at each phase using Repeated Measures ANOVA. The mean number of hierarchical categories at each assessment phase T1, T2 and T3 were analysed to determine whether there was a group effect and whether the mean number of hierarchical
categories was influenced by time, that is, across assessment phases. Table 20 shows the mean scores for each group across each assessment phase.

Table 20

Mean Number of Hierarchical Categories Displayed at Each Assessment Phase

<table>
<thead>
<tr>
<th>Ability group</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
<th>N = 71</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Not gifted</td>
<td>1.00</td>
<td>1.03</td>
<td>.79</td>
<td>.86</td>
</tr>
<tr>
<td>Verbally gifted</td>
<td>1.00</td>
<td>1.00</td>
<td>1.44</td>
<td>1.01</td>
</tr>
<tr>
<td>Nonverbally gifted</td>
<td>.79</td>
<td>.89</td>
<td>1.64</td>
<td>1.45</td>
</tr>
<tr>
<td>Globally gifted</td>
<td>1.00</td>
<td>.76</td>
<td>1.25</td>
<td>1.28</td>
</tr>
</tbody>
</table>

The mean number of hierarchical categories was not influenced by the time in the teaching phases at which this factor was assessed. \( F(2, 65) = 1.75, p > .05, \eta^2 = .05 \) or by the ability group \( F(3, 66) = .72, p > .05, \eta^2 = .03 \). The interaction factor time x ability group did was significant \( F(6, 132) = 2.24, p < .05, \eta^2 = .09 \). The comparisons (one-way ANOVA) of mean number of hierarchical categories displayed by each group of students at each phase of assessment (F ratio and t-value, 2-tailed, assuming equal variances) are shown in Table 21.
Table 21

*Mean Group Comparisons for Total Number of Hierarchical Categories at Each Assessment Phase*

<table>
<thead>
<tr>
<th>Comparison groups</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Diff</td>
<td>95% CI</td>
<td>Mean Diff</td>
</tr>
<tr>
<td>VG - NG</td>
<td>.17</td>
<td>-.63, .96</td>
<td>.67</td>
</tr>
<tr>
<td>NVG - NG</td>
<td>-.04</td>
<td>-.82, .73</td>
<td>.83^</td>
</tr>
<tr>
<td>GG - NG</td>
<td>.02</td>
<td>-.88, .93</td>
<td>.48</td>
</tr>
<tr>
<td>NVG - VG</td>
<td>-.21</td>
<td>-1.17, .75</td>
<td>.16</td>
</tr>
<tr>
<td>GG - VG</td>
<td>-.14</td>
<td>-1.21, .93</td>
<td>-.19</td>
</tr>
<tr>
<td>GG - NVG</td>
<td>.07</td>
<td>-.99, 1.12</td>
<td>-.35</td>
</tr>
</tbody>
</table>

*F statistic* 

\[ F(3, 78) = .13 \quad F(3, 68) = 2.73 \quad F(3, 67) = 1.44 \]

*significant at \( p < .05 \)  **significant at \( p < .01 \)  ^\( p = .058 \)

6.10.4 One-way ANOVA comparisons. These data (Table 21) show that at all phases, the extent of giftedness did not influence the number of hierarchical categories. Immediately after teaching, the students gifted in the non-verbal domain only, displayed approximately one more hierarchical category on average than their not gifted peers; this difference tended towards significance (\( p = .058 \)). Two weeks after the teaching, globally gifted students displayed an increase in the difference compared to those students gifted in a single domain and the not gifted students, however, these differences were not significant.

6.10.5 How these data inform hypotheses. The data presented for the number of hierarchical categories are used to inform Hypotheses 2, 4, and 7. These are in relation to the differences between gifted and not gifted students for the semantic organisation displayed at pre-teaching, the differences between verbally gifted and nonverbally gifted students for the extent to which their knowledge is organised semantically, and the differences between gifted and not gifted students for the extent to which their knowledge of the topics is organised semantically at post-teaching phases.
6.11 Cross-Links

The mean number of cross links that students displayed was assessed to determine the extent to which students displayed relationships between concepts across their concept maps. Figure 27 displays the mean number of cross-links at each of the three assessment points for globally gifted, nonverbal gifted, verbal gifted and not gifted students. These data represented in Figure 27 are also displayed in Table 11 in Appendix E.

![Figure 27. Mean number of cross links displayed at each assessment phase for across ability groups.](image)

**6.11.1 Mean number of cross-links across each assessment phase.**

**6.11.1.1 Pre-teaching (T1).** Globally gifted students displayed on average a comparable number of cross-links to their not gifted peers on their prior knowledge migration concept maps. The globally gifted students ($M = 1.10, SD = 1.00$) and the not gifted students ($M = 1.00, SD = 1.20$) displayed on average one cross-link. Nonverbally gifted students ($M = .70, SD = .90$) displayed on average less than one cross-link on their migration prior knowledge concept maps whilst verbally gifted students ($M = 1.40, SD = 1.50$) displayed the highest mean number of cross-links on migration prior knowledge concept maps.
6.11.1.2 Post-teaching (T2). Immediately following the teaching, globally gifted students displayed on average a comparable number of cross-links to their not gifted peers on their migration concept maps. The globally gifted students ($M = 1.00, SD = 1.19$) and the not gifted students ($M = .90, SD = 1.10$) displayed on average one cross-link on their concept maps. Nonverbally gifted students ($M = 1.27, SD = .90$) displayed on average more than one cross-link. Verbally gifted students ($M = .67, SD = 1.41$) displayed on average the least number of cross-links on migration concept maps immediately after the teaching.

6.11.1.3 Post-teaching, following 2-week delay (T3). Two weeks after the teaching, both the globally gifted students ($M = .75, SD = .71$) and the not gifted students ($M = .56, SD = .91$) displayed on average less than one cross-link on their concept maps. Nonverbally gifted students ($M = .64, SD = .84$) displayed on average a comparable number of cross-links to the not gifted students. The verbally gifted students ($M = 1.33, SD = 1.32$) displayed on average the most number of cross-links on migration concept maps two weeks after the teaching.

6.11.2 Change across assessment phases. The overall change in mean number of cross-links across phases of assessment was assessed and these data are presented in Figure 28. First, the change from pre-teaching (T1) to post-teaching (T2) was assessed to determine the difference in students’ display of cross-links from the pre-teaching concept map activity to the concept map activity that was undertaken immediately after the teaching. Second, the change from pre-teaching (T1) to post-teaching (T3) was assessed to determine the difference in students’ display of cross-links from the pre-teaching concept map activity to the concept map activity that was undertaken two weeks after the teaching phase.

6.11.2.1 Change from pre-teaching (T1) to post-teaching (T2). From pre-teaching to immediately after the teaching, the globally gifted ($M = -.38, SD = 1.06$), verbal gifted ($M = -.56, SD = 2.19$) and not gifted students ($M = -.15, SD = 1.33$) all displayed a decrease in the mean number of cross-links. The nonverbally gifted students ($M = .60, SD = 1.55$) displayed on average more cross-links immediately after teaching compared to pre-teaching.

6.11.2.2 Change from pre-teaching (T1) to post-teaching (T3). From pre-teaching to two weeks post-teaching for globally gifted ($M = -.63, SD = 1.41$), nonverbal gifted ($M = -.07, SD = 1.03$) and not gifted students ($M = -.48, SD = 1.41$) all displayed a decrease in the mean
number of cross-links. The verbally gifted students ($M = .11, SD = 1.69$) displayed on average more cross-links two weeks after teaching when compared to pre-teaching.

![Figure 28. Change in mean number of cross-links displayed from pre to post-teaching.](image)

**6.11.3 Assessing differences at each phase using Repeated Measures ANOVA.** The mean number of cross-links at each assessment phase T1, T2 and T3 were assessed to determine whether there was a group effect and whether the mean number of cross-links was influenced by time, that is, across assessment phases. Table 22 shows the mean scores for each group across each assessment phase.

**Table 22**

*Mean Number of Cross-Links Displayed at Each Assessment Phase*

<table>
<thead>
<tr>
<th>Ability group</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
<th>N = 71</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Not gifted</td>
<td>1.05</td>
<td>1.28</td>
<td>.92</td>
<td>1.11</td>
</tr>
<tr>
<td>Verbally gifted</td>
<td>1.22</td>
<td>1.56</td>
<td>.67</td>
<td>1.41</td>
</tr>
<tr>
<td>Nonverbally gifted</td>
<td>.71</td>
<td>.91</td>
<td>1.36</td>
<td>1.22</td>
</tr>
<tr>
<td>Globally gifted</td>
<td>1.38</td>
<td>1.21</td>
<td>1.00</td>
<td>1.2</td>
</tr>
</tbody>
</table>
The mean number of cross links was not influenced by the time in the teaching phases at which this factor was assessed ($F(2, 65) = 1.33, p > .05, \eta^2 = .04$), or by the ability group ($F(3, 66) = .26, p > .05, \eta^2 = .01$). The interaction factor time x ability was significant, ($F(6, 132) = 2.32, p < .05, \eta^2 = .10$). The comparisons of mean number of cross links displayed by each group of students at each phase of assessment (F ratio and t-value, 2-tailed, assuming equal variances) are shown in Table 23.

**Table 23**

*Mean Group Comparisons for Total Number of Cross-Links at Each Assessment Phase*

<table>
<thead>
<tr>
<th>Groups</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Diff</td>
<td>95% CI</td>
<td>Mean Diff</td>
</tr>
<tr>
<td>VG - NG</td>
<td>0.41</td>
<td>-.57, 1.38</td>
<td>-0.23</td>
</tr>
<tr>
<td>NVG - NG</td>
<td>-0.36</td>
<td>-1.30, .59</td>
<td>0.37</td>
</tr>
<tr>
<td>GG - NG</td>
<td>0.08</td>
<td>-1.03, 1.18</td>
<td>0.1</td>
</tr>
<tr>
<td>NVG - VG</td>
<td>-0.76</td>
<td>-1.93, .41</td>
<td>0.6</td>
</tr>
<tr>
<td>GG - VG</td>
<td>-0.33</td>
<td>-1.63, .98</td>
<td>0.33</td>
</tr>
<tr>
<td>GG - NVG</td>
<td>0.43</td>
<td>-.85, 1.72</td>
<td>-0.27</td>
</tr>
</tbody>
</table>

*F statistic*  
$F(3, 78) = .98$  
$F(3, 68) = .56$  
$F(3, 67) = 1.71$

*significant at $p < .05$  **significant at $p < .01$

**6.11.4 One-way ANOVA comparisons.** These data (Table 23) show the following trends in the number of cross-links displayed. At all phases, the extent of giftedness did not influence this. Following the two-week delay, the verbally gifted students displayed approximately one more cross-link compared to the not gifted students. This difference was not large enough to reach significance. The globally gifted students displayed a comparable number of cross-links to the not gifted students at each assessment phase.

**6.11.5 How these data inform hypotheses.** The data presented for the number of cross-links are used to inform Hypotheses 3, 5, and 8. These are in relation to the differences between gifted and not gifted students for interconnectedness of conceptual networks displayed at pre-teaching, the differences between verbally gifted and nonverbally gifted students for the extent to
which their knowledge is interconnected, and the differences between gifted and not gifted
students for the extent to which their knowledge of the topics is interconnected at post-teaching
phases.

6.12 Big Ideas

The mean number of big ideas that students displayed was assessed to determine the
extent to which students organised knowledge into large chunks of information. Figure 29
displays the mean number of big ideas at each of the three assessment points for globally gifted,
nonverbal gifted, verbal gifted and not gifted students. These data represented in Figure 29 are
also displayed in Table 12 in Appendix E.

![Figure 29: Mean number of big ideas displayed at each assessment phase across ability groups.](image)

6.12.1 Mean number of big ideas across each assessment phase.

6.12.1.1 Pre-teaching (T1). The globally gifted students \((M =1.90, SD = .57)\) displayed
more than twice as many big ideas than the not gifted students \((M =.70, SD = .77)\). The
nonverbally gifted students \((M =1.10, SD = 1.16)\) displayed on average more than one big idea at
pre-teaching. The verbally gifted students \((M =1.20, SD = .97)\) displayed almost twice as many
big ideas as the not gifted students on the migration prior knowledge concept maps.
6.12.1.2 Post-teaching (T2). Immediately following the teaching, the globally gifted students ($M =1.38, SD =.74$) displayed more than twice as many big ideas than the not gifted students ($M =.50, SD =.60$). The nonverbally gifted students ($M =.87, SD = .92$) displayed approximately one big idea on average. The verbally gifted students ($M =.67, SD = .87$) displayed on average a comparable number of big ideas to the not gifted students on the concept maps immediately following the teaching.

6.12.1.3 Post-teaching, following 2-week delay (T3). Two weeks after the teaching, the globally gifted students ($M =1.25, SD = .71$) displayed more than twice as many big ideas than the not gifted students ($M =.51, SD = .68$). The nonverbally gifted students ($M =.86, SD = .77$) displayed slightly less than one big idea two weeks after the teaching. The verbally gifted students ($M =.67, SD =1.11$) displayed on average a comparable number of big ideas as the not gifted students on the concept maps two weeks after the teaching.

6.12.2 Change across assessment phases. The overall change in mean number of big ideas across phases of assessment was assessed and these data are presented in Figure 30. First, the change from pre-teaching (T1) to post-teaching (T2) was assessed to determine the difference in students’ display of big ideas from the pre-teaching concept map activity to the concept map activity that was undertaken immediately after the teaching. Second, the change from pre-teaching (T1) to post-teaching (T3) was assessed to determine the difference in students’ display of big ideas from the pre-teaching concept map activity to the concept map activity that was undertaken two weeks after the teaching phase.

6.12.2.1 Change from pre-teaching (T1) to post-teaching (T2). Immediately after the teaching globally gifted ($M = -.63, SD = .92$), nonverbal gifted ($M = -.20, SD = 1.26$), verbal gifted ($M = -.33, SD = .87$), and not gifted students ($M = -.23, SD = .99$) all displayed fewer big ideas when compared to pre-teaching.

6.12.2.2 Change from pre-teaching (T1) to post-teaching (T3). Two weeks post-teaching, the globally gifted ($M = -.75, SD = .89$), nonverbal gifted ($M = .27, SD = .89$), verbal gifted ($M = -.33, SD = 1.12$), and not gifted students ($M = -.21, SD = 1.10$) all displayed fewer big ideas when compared to the mean number of big ideas displayed at pre-teaching.
Figure 30. Change in mean number of big ideas displayed from pre to post-teaching.

6.12.3 Assessing differences at each phase using Repeated Measures ANOVA. The mean number of big ideas at each assessment phase T1, T2 and T3 were assessed to determine whether there was a group effect and whether the mean number of big ideas was influenced by time, that is, across assessment phases. Table 24 shows the mean scores for each group across each assessment phase.

Table 24
Mean Number of Big Ideas Displayed at Each Assessment Phase

<table>
<thead>
<tr>
<th>Ability group</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
<th>N = 71</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Not gifted</td>
<td>0.72</td>
<td>0.79</td>
<td>0.51</td>
<td>0.6</td>
</tr>
<tr>
<td>Verbally gifted</td>
<td>1.0</td>
<td>1.0</td>
<td>0.67</td>
<td>0.87</td>
</tr>
<tr>
<td>Nonverbally gifted</td>
<td>1.14</td>
<td>1.17</td>
<td>0.93</td>
<td>0.92</td>
</tr>
<tr>
<td>Globally gifted</td>
<td>2.0</td>
<td>0.54</td>
<td>1.38</td>
<td>0.74</td>
</tr>
</tbody>
</table>
The mean number of big ideas was influenced by the time in the teaching phases at which this factor was assessed ($F(2, 65) = 3.45, p < .05, \eta^2 = .10$). The interaction factor time x ability group did not achieve significance ($p > .05$). The mean number of big ideas was influenced by the ability group ($F(3, 66) = 6.50, p < .01, \eta^2 = .23$). The comparisons of mean number of big ideas displayed by each group of students at each phase of assessment (F ratio and t-value, 2-tailed, assuming equal variances) are shown in Table 25.

Table 25

<table>
<thead>
<tr>
<th>Groups</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>After delay (T3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Diff</td>
<td>95% CI</td>
<td>Mean Diff</td>
</tr>
<tr>
<td>VG - NG</td>
<td>0.52</td>
<td>-.19, 1.22</td>
<td>0.17</td>
</tr>
<tr>
<td>NVG - NG</td>
<td>0.37</td>
<td>-.32, 1.06</td>
<td>0.37</td>
</tr>
<tr>
<td>GG - NG</td>
<td>1.20**</td>
<td>.40, 2.01</td>
<td>.88*</td>
</tr>
<tr>
<td>NVG - VG</td>
<td>-0.15</td>
<td>-.99, .70</td>
<td>0.2</td>
</tr>
<tr>
<td>GG - VG</td>
<td>0.69</td>
<td>-.26, 1.63</td>
<td>0.71</td>
</tr>
<tr>
<td>GG - NVG</td>
<td>0.83</td>
<td>-.10, 1.77</td>
<td>0.51</td>
</tr>
</tbody>
</table>

F statistic

\[ F(3, 78) = 5.59^{**} \]
\[ F(3, 68) = 3.61^* \]
\[ F(3, 67) = 2.20 \]

*significant at $p < .05$  **significant at $p < .01$  ^$p = .074$

6.12.4 One-way ANOVA comparisons. These data (Table 25) show the following trends in the number of big ideas displayed. At the pre-teaching phase and immediately after the teaching, the extent of giftedness influenced this. At the pre-teaching phase and immediately following the teaching, the globally gifted students displayed more big ideas than their not gifted peers. At each phase, the two groups gifted in a single gifted domain did not differ.

6.12.5 How these data inform hypotheses. The data presented for the number of big ideas are used to inform Hypotheses 2, 4, and 4. These are in relation to the differences between gifted and not gifted students for the semantic organisation displayed at pre-teaching, the differences between verbally gifted and nonverbally gifted students for the extent to which their knowledge is organised semantically, and the differences between gifted and not gifted students
for the extent to which their knowledge of the topics is organised semantically at post-teaching phases.

6.13 Display of Knowledge Characteristics

In the preceding sections, the outcome measures were reported in terms of the mean number displayed by students. Another way of comparing the knowledge characteristics of students, in particular, differences between gifted and not gifted students is in terms of how likely students are to display expert-type characteristics in their knowledge representations. In this section the characteristics of students' knowledge, that is, their hierarchical categorisation of concepts, cross-links, and the inference of big ideas are examined as binary outcomes; the students either displayed these characteristic or they did not.

The equality of proportions between gifted and not gifted groups were tested using two-sample tests of proportions. P-values were calculated from the proportion differences and these data are displayed in Table 26 to Table 31. These data are used to describe the differences outlined in the following sections.

6.13.1 Hierarchical categorisation for science topic. Hierarchical categorisation was assessed to determine the proportion of students who organised knowledge into semantic hierarchies. Figure 31 shows the proportions of students across each particular assessment phase that displayed hierarchical categorisation of concepts for the science topic. The differences between groups are outlined in the following section.
6.13.1.1 Hierarchical categorisation (T1). At pre-teaching, a higher proportion of globally gifted displayed hierarchical categorisation compared to the not gifted students ($p < .01$). Furthermore, the students gifted in a single domain were also more likely to display hierarchical categorisation of concepts than the not gifted students ($p < .05$). The results for comparisons between groups are displayed in Table 26.

6.13.1.2 Hierarchical categorisation (T2). Immediately following the teaching, no significant differences were seen between the gifted and the not gifted students in terms of proportion of students who displayed hierarchical categorisation of concepts. The results for comparisons between groups are displayed in Table 28.

6.13.1.3 Hierarchical categorisation (T3). Two weeks after the teaching, a higher proportion of the globally gifted and verbally gifted students displayed hierarchical categorisation of concepts compared to the not gifted students ($p < .05$). No differences were found between the proportion of nonverbally gifted and not gifted students in the likelihood that concepts were organised into hierarchical categories. The results for comparisons between groups are displayed in Table 30.

6.13.2 Cross links for science topic. The inclusion of cross-links was assessed to determine the proportion of students who displayed interconnected knowledge. Figure 32 shows
the proportions of students across each particular assessment phase that displayed cross-links for the science topic. The differences between groups are outlined in the following section.

![Figure 32](image)

**Figure 32.** Proportion of students at each assessment phase within each ability group that displayed cross-links for the science topic.

**6.13.2.1 Cross links (T1).** A higher proportion of globally gifted students displayed cross-links at pre-teaching compared to the not gifted students ($p < .01$). The nonverbally gifted students were also more likely to display cross-links than the not gifted students at pre-teaching ($p < .05$). No differences were found between the verbally gifted and not gifted students. The results for comparisons between groups are displayed in Table 26.

**6.13.2.2 Cross links (T2).** Immediately following the teaching, no differences were found in the proportion of gifted and not gifted students who displayed cross-links. The results for comparisons between groups are displayed in Table 28.

**6.13.2.3 Cross links (T3).** Two weeks after the teaching, a higher proportion of verbally gifted students displayed cross-links compared to not gifted students ($p < .01$). Furthermore, the globally gifted and nonverbally gifted students were more likely to display cross-links than the not gifted students ($p < .05$). The results for comparisons between groups are displayed in Table 30.
6.13.3. Big ideas for science topic. The inclusion of big ideas was assessed to determine the proportion of students who displayed this type of semantic organisation. Figure 33 shows the proportions of students across each particular assessment phase that displayed big ideas for the science topic. The differences between groups are outlined in the following section.

Figure 33. Proportion of students at each assessment phase within each ability group that displayed big ideas for the science topic.

6.13.3.1 Big ideas (T1). At pre-teaching the globally gifted students were more likely to display big ideas than the not gifted students ($p < .05$). All of the globally gifted students displayed big ideas at pre-teaching. The results for comparisons between groups are displayed in Table 26.

6.13.3.2 Big ideas (T2). Immediately following the teaching, a higher proportion of globally gifted students displayed big ideas than not gifted students ($p < .01$). Furthermore, the students gifted in a single domain were also more likely to display big ideas than the not gifted students ($p < .05$). The results for comparisons between groups are displayed in Table 28.

6.13.3.3 Big ideas (T3). Two weeks after the teaching, the globally gifted students and the nonverbally gifted students were more likely than the not gifted students to display big ideas ($p < .01$). There was no difference between the proportion of verbally gifted and not gifted students. The results for comparisons between groups are displayed in Table 30.
6.13.4 Hierarchical categorisation for humanities topic. Hierarchical categorisation was assessed to determine the proportion of students who organised knowledge into semantic hierarchies. Figure 34 shows the proportions of students across each particular assessment phase that displayed hierarchical categorisation of concepts for the science topic. The differences between groups are outlined in the following section.

![Hierarchies T1-Hierarchies T3](image)

*Figure 34. Proportion of students at each assessment phase within each ability group that displayed hierarchical categorisation for the humanities topic.*

**6.13.4.1 Hierarchical categorisation (T1).** At pre-teaching, no differences were found in the proportion of gifted and not gifted students who displayed hierarchical categories. The results for comparisons between groups are displayed in Table 27.

**6.13.4.2 Hierarchical categorisation (T2).** Immediately after the teaching, no differences were found in the proportion of gifted and not gifted students who displayed hierarchical categories. The results for comparisons between groups are displayed in Table 29.

**6.13.4.3 Hierarchical categorisation (T3).** Two weeks after the teaching, all globally gifted students displayed hierarchical categorisation of concepts. However, no differences were found in the proportion of gifted and not gifted students who displayed hierarchical categories. The results for comparisons between groups are displayed in Table 31.
6.13.5 Cross-links for humanities topic. The inclusion of cross-links was assessed to determine the proportion of students who displayed interconnected knowledge. Figure 35 shows the proportions of students across each particular assessment phase that displayed cross-links for the science topic. The differences between groups are outlined in the following section.

![Figure 35](image)

*Figure 35.* Proportion of students at each assessment phase within each ability group that displayed cross-links for the humanities topic.

6.13.5.1 Cross links (T1). At pre-teaching, no differences were found in the proportion of gifted and not gifted students who displayed cross-links. The results for comparisons between groups are displayed in Table 27.

6.13.5.2 Cross links (T2). Immediately following the teaching, no differences were found in the proportion of gifted and not gifted students who displayed cross-links. The results for comparisons between groups are displayed in Table 29.

6.13.5.3 Cross links (T3). Two weeks after the teaching, a higher proportion of verbally gifted students displayed cross-links when compared to the not gifted students ($p < .01$). Almost twice the proportion of globally gifted students displayed cross-links compared to not gifted students, however, the difference was not statistically significant. The results for comparisons between groups are displayed in Table 31.
6.13.6 **Big ideas for humanities topic.** The inclusion of big ideas was assessed to determine the proportion of students who displayed this type of semantic organisation. Figure 36 shows the proportions of students across each particular assessment phase that displayed big ideas for the humanities topic. The differences between groups are outlined in the following section.

![Figure 36. Proportion of students at each assessment phase within each ability group that displayed big ideas for the humanities topic.](image)

6.13.6.1 **Big ideas (T1).** At pre-teaching, the globally gifted students were more likely than the not gifted students to display big ideas ($p < .01$). In fact, all of the globally gifted students (100%) displayed big ideas at pre-teaching. Furthermore, a higher proportion of verbally gifted students displayed big ideas than not gifted students ($p < .05$). No difference was found between nonverbally gifted and not gifted students. The results for comparisons between groups are displayed in Table 27.

6.13.6.2 **Big ideas (T2).** Immediately following the teaching, the globally gifted students were more likely to display big ideas than the not gifted students ($p < .01$). Similar to the findings at pre-teaching, all globally gifted students displayed big ideas immediately after the
teaching. No differences were found between the students gifted in a single domain and the not gifted students. The results for comparisons between groups are displayed in Table 29.

6.13.6.3 Big ideas (T3). Two weeks after the teaching, the globally gifted students were more likely to display big ideas than the not gifted students ($p < .01$). Similar to the findings at pre-teaching and immediately after the teaching, all globally gifted students displayed big ideas two weeks after the teaching. No differences were found between the students gifted in a single domain and the not gifted students. The results for comparisons between groups are displayed in Table 31.

6.14 Analysis of Proportion Differences.

The following tables display the data from the equality of proportion tests conducted to assess the significance of the differences between gifted and not gifted groups for the display of knowledge characteristics at each assessment phase. The previous section summarised the data that are displayed in these tables.

Table 26

*Group Differences for Display of Knowledge Characteristics at Pre-Teaching Phase for Science Topic*

<table>
<thead>
<tr>
<th>Ability groups</th>
<th>Proportion 1</th>
<th>Proportion 2</th>
<th>Difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hierarchical categorisation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GG - NG</td>
<td>0.90</td>
<td>0.49</td>
<td>0.41**</td>
<td>0.008</td>
</tr>
<tr>
<td>VG - NG</td>
<td>0.79</td>
<td>0.49</td>
<td>0.3*</td>
<td>0.012</td>
</tr>
<tr>
<td>NVG - NG</td>
<td>0.72</td>
<td>0.49</td>
<td>0.23*</td>
<td>0.045</td>
</tr>
<tr>
<td>Cross links</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GG - NG</td>
<td>0.80</td>
<td>0.39</td>
<td>0.41**</td>
<td>0.008</td>
</tr>
<tr>
<td>VG - NG</td>
<td>0.47</td>
<td>0.39</td>
<td>0.08</td>
<td>0.259</td>
</tr>
<tr>
<td>NVG - NG</td>
<td>0.78</td>
<td>0.39</td>
<td>0.39*</td>
<td>0.002</td>
</tr>
<tr>
<td>Big ideas</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GG - NG</td>
<td>1.00</td>
<td>0.67</td>
<td>0.33*</td>
<td>0.017</td>
</tr>
<tr>
<td>VG - NG</td>
<td>0.74</td>
<td>0.67</td>
<td>0.07</td>
<td>0.305</td>
</tr>
<tr>
<td>NVG - NG</td>
<td>0.83</td>
<td>0.67</td>
<td>0.16</td>
<td>0.099</td>
</tr>
</tbody>
</table>

*significant at $p < .05$  **significant at $p < .01$
Table 27

*Group Differences for Display of Knowledge Characteristics at Pre-Teaching Phase for Humanities Topic*

<table>
<thead>
<tr>
<th>Ability groups</th>
<th>Proportion 1</th>
<th>Proportion 2</th>
<th>Difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hierarchical categorisation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GG - NG</td>
<td>0.80</td>
<td>0.60</td>
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<tr>
<td>VG - NG</td>
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<td>0.60</td>
<td>0.11</td>
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</tr>
<tr>
<td>NVG - NG</td>
<td>0.60</td>
<td>0.60</td>
<td>0.00</td>
<td>0.512</td>
</tr>
<tr>
<td>Cross links</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GG - NG</td>
<td>0.70</td>
<td>0.58</td>
<td>0.12</td>
<td>0.244</td>
</tr>
<tr>
<td>VG - NG</td>
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<td>0.58</td>
<td>-0.01</td>
<td>0.526</td>
</tr>
<tr>
<td>NVG - NG</td>
<td>0.40</td>
<td>0.58</td>
<td>-0.18</td>
<td>0.887</td>
</tr>
<tr>
<td>Big ideas</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GG - NG</td>
<td>1.00</td>
<td>0.51</td>
<td>0.49**</td>
<td>0.002</td>
</tr>
<tr>
<td>VG - NG</td>
<td>0.79</td>
<td>0.51</td>
<td>0.28*</td>
<td>0.035</td>
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<td>NVG - NG</td>
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<td>0.51</td>
<td>0.16</td>
<td>0.149</td>
</tr>
</tbody>
</table>

*significant at $p < .05$  **significant at $p < .01$
Table 28

*Group Differences for Display of Knowledge Characteristics Immediately After Teaching for Science Topic*

<table>
<thead>
<tr>
<th>Ability groups</th>
<th>Proportion 1</th>
<th>Proportion 2</th>
<th>Difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hierarchical categorisation</td>
<td>GG - NG</td>
<td>0.78</td>
<td>0.57</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>VG - NG</td>
<td>0.76</td>
<td>0.57</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>NVG - NG</td>
<td>0.56</td>
<td>0.57</td>
<td>-0.01</td>
</tr>
<tr>
<td>Cross links</td>
<td>GG - NG</td>
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<td>0.64</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>VG - NG</td>
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<td>0.64</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>NVG - NG</td>
<td>0.63</td>
<td>0.64</td>
<td>-0.02</td>
</tr>
<tr>
<td>Big ideas</td>
<td>GG - NG</td>
<td>1.00</td>
<td>0.50</td>
<td>0.5**</td>
</tr>
<tr>
<td></td>
<td>VG - NG</td>
<td>0.76</td>
<td>0.50</td>
<td>0.26*</td>
</tr>
<tr>
<td></td>
<td>NVG - NG</td>
<td>0.75</td>
<td>0.50</td>
<td>0.25*</td>
</tr>
</tbody>
</table>

*significant at p < .05  **significant at p < .01
Table 29

*Group Differences for Display of Knowledge Characteristics Immediately After Teaching for
Humanities Topic*

<table>
<thead>
<tr>
<th>Ability groups</th>
<th>Proportion 1</th>
<th>Proportion 2</th>
<th>Difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hierarchical categorisation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GG - NG</td>
<td>0.63</td>
<td>0.53</td>
<td>0.1</td>
<td>0.302</td>
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<td>VG - NG</td>
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</tr>
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<td>0.082</td>
</tr>
<tr>
<td>Cross links</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GG - NG</td>
<td>0.5</td>
<td>0.5</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>VG - NG</td>
<td>0.22</td>
<td>0.5</td>
<td>-0.22</td>
<td>0.935</td>
</tr>
<tr>
<td>NVG - NG</td>
<td>0.733</td>
<td>0.5</td>
<td>0.23</td>
<td>0.06</td>
</tr>
<tr>
<td>Big ideas</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GG - NG</td>
<td>1</td>
<td>0.45</td>
<td>0.55**</td>
<td>0.002</td>
</tr>
<tr>
<td>VG - NG</td>
<td>0.44</td>
<td>0.45</td>
<td>-0.01</td>
<td>0.512</td>
</tr>
<tr>
<td>NVG - NG</td>
<td>0.6</td>
<td>0.45</td>
<td>0.15</td>
<td>0.161</td>
</tr>
</tbody>
</table>

*significant at p < .05  **significant at p < .01
Table 30

*Group Differences for Display of Knowledge Characteristics Two Weeks After Teaching for Science Topic*

<table>
<thead>
<tr>
<th>Ability groups</th>
<th>Proportion 1</th>
<th>Proportion 2</th>
<th>Difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hierarchical categorisation</td>
<td>GG - NG</td>
<td>1.00</td>
<td>0.67</td>
<td>0.33*</td>
</tr>
<tr>
<td></td>
<td>VG - NG</td>
<td>0.92</td>
<td>0.67</td>
<td>0.26*</td>
</tr>
<tr>
<td></td>
<td>NVG - NG</td>
<td>0.69</td>
<td>0.67</td>
<td>0.03</td>
</tr>
<tr>
<td>Cross links</td>
<td>GG - NG</td>
<td>0.75</td>
<td>0.39</td>
<td>0.36*</td>
</tr>
<tr>
<td></td>
<td>VG - NG</td>
<td>0.92</td>
<td>0.39</td>
<td>0.53**</td>
</tr>
<tr>
<td></td>
<td>NVG - NG</td>
<td>0.69</td>
<td>0.39</td>
<td>0.30*</td>
</tr>
<tr>
<td>Big ideas</td>
<td>GG - NG</td>
<td>1.00</td>
<td>0.52</td>
<td>0.48**</td>
</tr>
<tr>
<td></td>
<td>VG - NG</td>
<td>0.62</td>
<td>0.52</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>NVG - NG</td>
<td>0.92</td>
<td>0.52</td>
<td>0.41**</td>
</tr>
</tbody>
</table>

*significant at p < .05  **significant at p < .01
Table 31

*Group Differences for Display of Knowledge Characteristics Two Weeks After Teaching for Humanities Topic*

<table>
<thead>
<tr>
<th>Ability groups</th>
<th>Proportion 1</th>
<th>Proportion 2</th>
<th>Difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hierarchical categorisation</td>
<td>GG - NG</td>
<td>1.00</td>
<td>0.77</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>VG - NG</td>
<td>0.56</td>
<td>0.77</td>
<td>-0.21</td>
</tr>
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<td></td>
<td>NVG - NG</td>
<td>0.60</td>
<td>0.77</td>
<td>-0.17</td>
</tr>
<tr>
<td>Cross links</td>
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<td>0.33</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>VG - NG</td>
<td>0.78</td>
<td>0.33</td>
<td>0.44**</td>
</tr>
<tr>
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<td>NVG - NG</td>
<td>0.40</td>
<td>0.33</td>
<td>0.07</td>
</tr>
<tr>
<td>Big ideas</td>
<td>GG - NG</td>
<td>1</td>
<td>0.41</td>
<td>0.59**</td>
</tr>
<tr>
<td></td>
<td>VG - NG</td>
<td>0.33</td>
<td>0.41</td>
<td>-0.08</td>
</tr>
<tr>
<td></td>
<td>NVG - NG</td>
<td>0.60</td>
<td>0.41</td>
<td>0.19</td>
</tr>
</tbody>
</table>

*significant at p < .05  **significant at p < .01
6.15 Analysis of Prior Knowledge

The strength and direction of associations between outcome measures at pre-teaching and post-teaching assessment phases were examined using Pearson's correlations. Pearson correlation coefficients were generated and these are displayed in Table 32.

Table 32
Correlations Between Knowledge Outcome Measures at Pre-Teaching and Post-teaching Assessments

<table>
<thead>
<tr>
<th>Outcome measure</th>
<th>Energy (T2)</th>
<th>Energy (T3)</th>
<th>Migration (T2)</th>
<th>Migration (T3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional concepts</td>
<td>.59**</td>
<td>.58**</td>
<td>.72**</td>
<td>.86**</td>
</tr>
<tr>
<td>Valid (general) concepts</td>
<td>.57**</td>
<td>.66**</td>
<td>.83**</td>
<td>.72**</td>
</tr>
<tr>
<td>Valid (semantic) concepts</td>
<td>.65**</td>
<td>.65**</td>
<td>.80**</td>
<td>.68**</td>
</tr>
<tr>
<td>Cross-links</td>
<td>.19</td>
<td>.33**</td>
<td>.20</td>
<td>.20</td>
</tr>
<tr>
<td>Hierarchical categories</td>
<td>.35**</td>
<td>.60**</td>
<td>.15</td>
<td>.09</td>
</tr>
<tr>
<td>Big ideas</td>
<td>.40**</td>
<td>.41**</td>
<td>.30*</td>
<td>.32**</td>
</tr>
</tbody>
</table>

*significant at p<.05 ** significant at p<.01

For the energy topic, all outcome measures, except for cross-links immediately after teaching (T2), were highly correlated (p < .01) with the scores on the outcome measures at pre-teaching (T1). For the migration topic, cross-links at post-teaching T2 and T3 and hierarchical categories at post-teaching T2 and T3 were correlated significantly with the scores for these outcome measures at pre-teaching (T1). All other outcome measures at post-teaching (T3) were highly correlated (p < .01).
CHAPTER 7
DISCUSSION

This chapter discusses the findings for the present study. The previous chapter reported the results in terms of the separate measures assessed from students’ concept maps. In this chapter these results are now interpreted in light of the hypotheses.

The characteristics described in the novice-expert knower model led to predictions about the ways in which gifted students display knowledge in a learning task. From the knowledge characteristics described in the transition from novice to expert type understanding, it was expected that gifted students would differ from not gifted students in the extent to which they displayed elaborated and differentiated conceptual networks, efficient and complete knowledge representations, and interconnected networks of knowledge (Munro, 2012). Each hypothesis will address these characteristics based on the novice-expert knower model and will address specific aspects of these broad predictions.  

7.1 Hypothesis 1

_The knowledge of gifted students prior to teaching is characterised by more domain-specific knowledge (verbal propositions) than the knowledge of not gifted students._

In addressing Hypothesis 1, evidence for the elaboration and differentiation of conceptual networks utilising results across both topics was explored. It was hypothesised that gifted students display more domain-specific knowledge of the topics at pre-teaching than their not gifted peers (Salthouse, 1991; Shore, 2009; Sternberg 1995, 1998; Van Merrienboer & Sweller, 2005). Sternberg (1995) proposed that one of the main differences between novices and experts is the amount of domain-specific knowledge, where experts have a larger store of domain

\[ \text{_____________________} \]

\[ ^2 \text{It is noted by the author that references from the 1980s and 1990s are used frequently in the discussion chapter. The issue of what gifted knowing looks like has not attracted recently the ‘in depth’ examination or interest that is shown in this thesis. Therefore, the discussion draws on the earlier ‘expert performance’ work that was conducted during these decades to evaluate the findings of the present study.} \]
knowledge than novices. Domain-specific knowledge was assessed in terms of the number of valid propositions that students displayed, using core concepts for each topic and the number of additional concepts that students displayed.

7.1.1 Valid propositions, energy topic. The results from the pre-teaching phase showed that there was no difference in the number of valid propositions displayed using the fifteen energy concepts when comparing the gifted groups with the not gifted students. However, when the propositions were assessed to determine whether the students displayed an understanding that demonstrated context specific (semantic) validity, for the fifteen provided energy concepts, the globally gifted students displayed more valid propositions (p<.01) at pre-teaching than the not gifted students. The students gifted in a single domain did not display more semantically valid propositions than the not gifted students.

7.1.2 Valid propositions, migration topic. For the migration topic, the results from the pre-teaching phase showed that globally gifted students displayed more valid propositions using the seventeen provided study concepts than the not gifted students. Contrary to the findings for the energy topic, the globally gifted students displayed more valid propositions (p<.05) compared to the not gifted students, without taking the contextual validity of the propositions into account. However, in accordance with the findings from the energy topic, the globally gifted students displayed more semantically valid propositions (p<.01) at pre-teaching than the not gifted students. The magnitude of the difference between gifted and not gifted students increased when the context-specific validity was assessed. Consistent with the findings from the energy topic, the students gifted in a single domain did not display more semantically valid propositions using the migration concepts than the not gifted students.

7.1.3 Summary (valid propositions). Across both topics, the biggest differences between gifted and not gifted students in terms of the mean number of valid propositions displayed, was seen when the ‘semantic’ validity of propositions was assessed. This result is consistent with the findings from Austin and Shore (1993) who compared experts in physics with high achieving and average achieving physics college students. It was found that the concept maps constructed by high performing students differed from those of average performing students and closely resembled the concept maps of physics experts. This was especially notable when the quality of the links between concepts was taken into account (Austin & Shore, 1993). Their study showed that there was no difference in the total number of linkages (propositions)
that the average students and high achieving students displayed on their concept maps. However, when the linkages were coded in terms of their explanation of the topic, those displayed by the average-achieving students were lower in quality than the high performing students. The findings from the present study are consistent with these findings, where the quality of the links differed according to levels of expertise. That is, the biggest differences between globally gifted and not gifted students was seen when semantic validity of the propositions was assessed.

Furthermore, the difference with the semantic validity demonstrates that the globally gifted students were more able to display an understanding of the topic that demonstrated their capacity to accurately contextualise the concepts within the topic. Students used the provided concepts to build a picture of the topic by fitting the concepts within the topic from the introductory activities, where the context for the topic was provided. The context for both topics was provided through a display of images and real-life examples, which were used to stimulate ideas about ‘the use of energy in everyday life’ and ‘the human journey: Australia and human migration’ (see Appendix F). The list of provided concepts as well as the images and examples provided enough contextual information for the globally gifted students to activate knowledge of the topic to produce contextually valid information for the concepts. This finding echoes the findings of Gobbo and Chi (1986) who found differences in the way expert and novice children represented domain-specific knowledge about dinosaurs. They found that expert children produced a greater amount of implicit information about dinosaurs than novice children, whereas both produced the same amount of explicit information. Upon seeing a picture of a dinosaur they knew, expert children were able to activate its representation. This allowed students to produce implicit information about it from their knowledge base. Novices on the other hand, produced fewer statements of an implicit nature since their representations of the dinosaurs was sparse. Similarly, the findings from the present study indicate that the globally gifted students in particular, upon seeing the information for the energy and migration topics, were able to identify the implicit information relating to the context of the concepts being presented within each topic. This resulted in these students identifying more contextually relevant statements or propositions to demonstrate their understanding of the energy and migration concepts.

7.1.4 Additional concepts. In assessing domain-specific knowledge, it was also hypothesised that gifted students would display more additional concepts than not gifted students at pre-teaching. However, no differences were found between gifted and not gifted students in
the mean number of additional concepts at pre-teaching across both topics. For both topics, the data show that the students gifted the verbal domain displayed the highest mean number of additional concepts, with the magnitude of the difference with the other groups not large enough to reach significance.

The finding that globally gifted students did not display more additional concepts is contrary to the literature on expertise, which states that experts have greater amounts of domain-specific knowledge (e.g., Glaser & Chi, 1988; Kalyuga, Ayres, Chandler, & Sweller, 2010). However, following closer inspection of students’ concept maps, an increase in the number of additional concepts included in the concept map did not necessarily equate to a more comprehensive description of the main idea. The task that was presented to students was to create a concept map demonstrating their understanding of a topic having been given a set of ‘skeletal’ concepts, which comprised the main concepts that would form the ‘story’ to be presented in the teaching.

What was found was that the globally gifted students used the ‘skeletal’ concepts as the basis of their description more efficiently than the not gifted students and the students gifted in a single domain. They were able to demonstrate semantically valid descriptions of these concepts within the given topics. The globally gifted students, in particular, were less likely to infer concepts that expanded on the ideas beyond what was closely related to the overall topic. They showed well-organised and relevant descriptions of the topic based on the context that was provided.

Gobbo and Chi (1986) reported that expert children tended to focus on the ‘deep-level’ concepts whereas the novice children tended to focus on the ‘surface-type’ features of concepts. This could provide context for the findings in the present study where globally gifted students did not infer more concepts than the not gifted students. Typically, the students who were globally gifted did not infer concepts that were semantically distanced from the main idea of ‘energy’. The specific detailed ideas and concepts that are more likely represented in the concept maps of not gifted students show a different type of understanding. This is indicative of a knowledge base that is less developed in terms of hierarchical structure, with a focus on concepts that lack semantic relatedness with the main idea. An example of this can be seen with the concept map of student A shown in Figure 37. Student A was one of the globally gifted students. His concept map was comprised only of the provided concepts without the inclusion of any
additional concepts and displayed a sophisticated understanding of the concepts within the overall context of ‘the use of energy in everyday life’. A comparative concept map from one of the not gifted students is shown in Figure 38. This concept map shows the inclusion of a number of additional specific concepts that highlights the difference expressed by Gobbo and Chi (1986) where the novice children focus more on the surface level concepts. For example, student B includes the concepts of ‘bath’, ‘shower’, and ‘basin’ in the description of ‘hot water’. Although these concepts show the student’s understanding of how ‘hot water’ can be used, these propositions do not enhance the description of energy.

*Figure 37. Pre-teaching science concept map for Student A.*
The concept map drawn by student A demonstrates the capacity to display a comprehensive representation of the energy topic without inferring additional concepts. The use of only the provided concepts did not restrict the explanation of the topic for this student who demonstrated a big picture understanding (Munro, 2013) of the topic. This is commensurate with the notion of ‘big picture’ thinking proposed by Munro (2013) in which gifted students infer patterns from teaching information and infer ‘big ideas’ that synthesise the patterns. This type of knowledge structure and organisation will be discussed further in terms of semantic organisation of knowledge.

7.1.5 Summary (domain-specific knowledge). The hypothesis that gifted students would display more domain-specific knowledge or verbal propositions for the topics at pre-teaching was assessed in terms of the quality of the propositions and in terms of the amount of knowledge displayed for the topic. In terms of the quality of the propositions displayed, the globally gifted students displayed more domain-specific knowledge than not gifted students at pre-teaching. In order to display valid propositions, students were required to demonstrate an understanding of the concepts within the context of the topic. This can be described as domain-specific knowledge, equating to a larger knowledge base for the topic when compared to the not
gifted students. The globally gifted students showed that they were able to infer a greater amount of domain-specific knowledge for the topics than the not gifted students. The larger knowledge base for the topics for the globally gifted students is commensurate with the notion of the expert knower and previous findings in both the expertise and giftedness research where the knowledge base of experts and gifted students is larger than that of novices or not gifted students (Glaser & Chi, 1988; Kalyuga, Ayres, Chandler, & Sweller, 2010; Song & Parath, 2005; Steiner & Carr, 2003; Sternberg, 1998; Subotnik & Jarvin, 2005; Sweller, Clark, & Kirschner, 2010).

Overall, the differences between the students gifted in a single domain and the not gifted students were not as great as the differences between the globally gifted students and the not gifted students. Being gifted in both verbal and nonverbal domains (globally gifted) was associated with greater domain-specific knowledge for both topics. This is consistent with the idea from Lohman, Gambrell, and Lakin (2008) that emphasised the difference between students gifted in multiple domains and students gifted in a single domain. According to Lohman et al. (2008), students gifted in multiple domains are highly able and students gifted in a single domain are more likely to display discrepancies.

7.2 Hypothesis 2

The knowledge of gifted students prior to teaching is more semantically organised than the knowledge of not gifted students.

In addressing Hypothesis 2, evidence for the efficient and complete knowledge representations was explored from the results across both topics. It was hypothesised that the gifted students display more semantic organisation in their knowledge of the topics at pre-teaching than their not gifted peers. According to Zimmerman and Martinez-Pons (1990), gifted students use more strategies for organising and transforming information when compared to not gifted peers. This is consistent with the predictions made about expert children’s knowledge by Gobbo and Chi (1986), who stated that not only will expert children have better access to their knowledge, they will have better access to more structured knowledge. This more structured knowledge will be characterised by strong links between concepts, a high degree of abstraction, and will be hierarchical in nature (de Jong & Ferguson-Hessler, 1996). According to Munro (2012), the taxonomic hierarchical classification of concepts is a complex and sophisticated way of categorising and forming concepts. In addition, Munro (2012, 2013) reported that gifted
students infer patterns from teaching information and infer ‘big ideas’ that synthesise the patterns. In the present study, the organisation of students’ knowledge was assessed through the measures of hierarchical categorisation of concepts and the inference of big ideas to organise and represent ideas in broad semantic categories (Munro, 2012, 2013).

### 7.2.1 Hierarchical categorisation, energy topic

The results showed that the globally gifted and verbally gifted students displayed approximately one more hierarchical category than the not gifted students at pre-teaching. The mean difference of approximately one hierarchical category was not sufficiently large enough to reach statistical significance. When considering the likelihood that students displayed at least some hierarchical categorisation of concepts, differences were seen between gifted and not gifted students. At pre-teaching the globally gifted students (p<.01) and the students gifted in a single domain, both verbally and nonverbally gifted (p<.05), were more likely to display hierarchical categorisation of concepts for the energy topic, compared to the not gifted students. Almost twice as many globally gifted students displayed hierarchical categorisation of energy concepts compared to the not gifted students. More than seventy per cent of the students gifted in a single domain displayed hierarchical categorisation of energy concepts.

The data show that the gifted students, in particular the globally gifted students, were more likely to organise concepts into semantic hierarchies with a more abstract concept being differentiated into superordinate concepts. An example of this was “energy can be kinetic” or “household appliances such as toasters”, where energy/household appliances are the more general or abstract concepts and kinetic/toasters are subordinate to the concepts of energy/household appliances. The categorisation of concepts in this way demonstrates a more structured and organised knowledge, where students can differentiate more superordinate concepts with subordinate concepts into semantic hierarchies, typical of expert type knowledge (de Jong and Ferguson-Hessler, 1996; Johnson & Mervis, 1997; Tanaka & Taylor, 1991). As reported by Munro (2012) this type of taxonomic hierarchical classification of concepts is a complex and sophisticated way of categorising and forming concepts and typical of expert-type knowledge representation.

The findings from Johnson and Mervis (1997) provide a possible explanation for why gifted students were more likely than not gifted students to organise concepts into semantic hierarchies. They found that for experts, essentially the specific category becomes a basic
category in the semantic hierarchy. This follows from the results of Tanaka and Taylor (1991) who demonstrated that experts used more specific categories to name birds (such as sparrow, robin etc.), whereas non-experts used more basic categories such as bird. The experts see the type of bird as the basic category as their knowledge of birds increase. For those who are non-experts in the domain of birds, it is difficult to build a semantic hierarchy to differentiate the type of bird without knowledge of the specific categories.

The development of more domain-specific knowledge will therefore allow students to organise knowledge into semantic hierarchies with more levels of abstraction or subordinate categorisation. Given that gifted students, in particular the globally gifted students, displayed more domain-specific knowledge of the energy topic, this would indicate that these students were able to access more knowledge to differentiate into hierarchical categories. Furthermore, with the verbally gifted students, although these students did not display significantly more domain-specific knowledge than not gifted students at pre-teaching, they displayed the highest mean number of additional concepts. Thus, verbally gifted students had access to knowledge that could be categorised into semantic hierarchies. In accordance with the findings from Johnson and Mervis (1997) and Tanaka and Taylor (1991), the gifted students were able to categorise concepts into semantic categories, perhaps due to more knowledge of basic and specific concepts for the energy topic.

7.2.2 Hierarchical categorisation, migration topic. At pre-teaching for the migration topic, contrary to the findings for the energy topic, no differences were found in the mean number of hierarchical categories displayed by gifted and not gifted students. The globally gifted students and the students gifted in the verbal domain were more likely to display hierarchical categorisation of concepts for the migration topic compared to the not gifted students, however the differences were not sufficiently large enough to reach significance. Eighty per cent of the globally gifted and approximately seventy per cent of the verbally gifted students organised concepts into semantic hierarchies with a more abstract concept being differentiated into superordinate concepts. An example of this was “country such as Australia”, where country is the more general or abstract concept and Australia is subordinate to the concept of country. Sixty per cent of the not gifted students were found to display knowledge in this way at pre-teaching.
Figure 39. Proportion of students displaying hierarchical categorisation at pre-teaching across both topics.

7.2.3 Summary (hierarchical categorisation). Figure 39 displays the proportion of students within each group who displayed hierarchical categorisation. Across both topics, there appears to be a similar trend, with a slightly smaller proportion of all three gifted groups displaying hierarchical categorisation for the migration topic compared to the energy topic. Furthermore, a slightly higher proportion of not gifted students displayed hierarchical categorisation for the migration topic compared to the energy topic. Although the results show that there was no statistically significant difference in the proportion of gifted versus not gifted students who displayed hierarchical categorisation for the migration topic, a high proportion of globally gifted students displayed hierarchical categorisation across both topics and this should be noted to inform the knowledge characteristics of these students. For both topics, at least eighty-percent of globally gifted students displayed hierarchical categorisation of concepts.

7.2.4 Big ideas, energy topic. In addition to the organisation of concepts into hierarchical categories, the globally gifted students displayed more big ideas than the not gifted students at pre-teaching for the energy topic (p < .01). The big ideas represented broader semantic categories or ‘big ideas’ that demonstrated chunking of semantically related concepts.
The globally gifted students were significantly more likely to display big ideas when compared with the not gifted students ($p < .05$). All globally gifted students (100%) displayed big ideas at pre-teaching compared to approximately two-thirds (67%) of the not gifted students. Although higher proportion of students gifted in a single domain displayed hierarchies when compared to not gifted students, the differences were not sufficiently large enough to reach significance (see Figure 33).

The findings demonstrate that a key feature of the gifted students was their display of knowledge for the topic that categorised concepts into broader semantic pathways such as: ‘use of energy’, ‘types of energy’ or ‘users of energy’. The gifted students inferred these types of broader categories to differentiate concepts and ideas within the topic. The students who were not gifted were less likely to display these types of hierarchical categories in which broader categories of concepts were contained to represent semantic paths. The not gifted students were more likely to represent ideas in an algorithmic way without categorising concepts into semantic hierarchies or broad semantic categories. These findings are consistent with Chi et al. (1981) who found that experts in physics classified categories according to the major physics principle governing the solution to a problem. Novices described mostly objects and other surface type characteristics. The descriptions given by experts involved explanation of the ‘big picture’, which included the laws of physics. These findings indicate that the knowledge of experts is organised around core concepts or ‘big ideas’ that guide their thinking in the topic or domain.

7.2.5 Big ideas, migration topic. For the migration topic, the globally gifted students displayed significantly more big ideas than the not gifted students at pre-teaching ($p < .01$). This was consistent with the findings for the energy topic. Furthermore, a higher proportion of globally gifted students displayed big ideas when compared to not gifted students ($p < .01$). In fact, all globally gifted students displayed big ideas at pre-teaching for the migration topic, which was consistent with the findings for the energy topic. The students gifted in the verbal domain were also significantly more likely to display big ideas than the not gifted students ($p < .05$). The difference between the proportion of nonverbally gifted students and not gifted students was not large enough to reach significance.

As discussed with the findings from the energy topic, a feature of the gifted students was their display of knowledge for this topic that categorised concepts into broader semantic pathways such as ‘groups of people who migrate(d)’, ‘places to migrate to/from’ or ‘reasons for
migration’. The gifted students inferred these types of broader categories to differentiate concepts and ideas within the topic. The not gifted students were less likely to display these types of semantic categories in which broader categories of concepts were contained to represent semantic paths. The not gifted students were more likely to represent ideas in an algorithmic way without categorising concepts into semantic hierarchies or semantic networks.

7.2.6 Summary (big ideas). A similar pattern was observed across both energy and migration topics with the globally gifted students and the students gifted in a single domain more likely to display big ideas at pre-teaching when compared to the not gifted students. This type of organisation demonstrates the ‘chunking’ of information by these (gifted) students and organisation of knowledge according to key concepts or ideas. Instead of displaying knowledge that was more linear and algorithmic, these students displayed chunks or categories of ideas that were more closely related semantically.

7.2.7 Summary (semantic organisation of knowledge). Overall, gifted students, to some extent, displayed knowledge that was more efficient and complete in terms of the hierarchical categorisation of concepts and the display of big ideas representing broad semantically related categories. This type of knowledge organization is consistent with previous findings (Austin & Shore, 1993; de Jong & Ferguson-Hessler, 1996; Gobbo & Chi, 1986; Larkin, McDermott, Simon, & Simon, 1980; Sternberg, 1998) that described expert knowledge as being organised in ways that demonstrated more complete and efficient conceptual networks.

Gifted students were more likely to display hierarchical categorisation of concepts than their not gifted peers for the energy topic specifically. The concept maps of the globally gifted students in particular, showed more hierarchical categories and were more likely to contain broader semantically connected categories than the concept maps of not gifted students. The hierarchical nature of the concept maps drawn by gifted students indicates the type of efficiently organised knowledge structures in long-term memory that is symbolic and indicative of expert-type knowledge (Sternberg, 1998). Gobbo and Chi (1986) described the “groupings” or categorisation of information as reflective of a sophisticated knowledge base for expert children. The hierarchical and big idea structures represented in the concept maps of gifted students show that the gifted students are able to prioritise the main ideas within a given topic and infer logical patterned understanding that reflects ‘expert type’ understanding of a topic (Munro, 2013).
The organization of knowledge into hierarchical structures within a domain of knowledge shows that the student can prioritise key concepts that comprise a topic (Munro, 2012). This is important to develop further knowledge within the knowledge domain. Larkin and colleagues were some of the early researchers to stress the role of the structure of knowledge in memory (Larkin, McDermott, Simon, & Simon, 1980). They concluded from studies on problem solving in experts and novices that the large amount of knowledge stored in the memory of an expert is made possible not by a general superiority of memory, but by the superior organization of their knowledge. More specifically, chunking of information into large, meaningful units – a type of organization that novices lack. These results are consistent with the early results found by Chase and Simon (1973) on the perception and memory of chess masters, in which groups of stimuli (chessboard configurations) were perceived and remembered as units. Furthermore, Ausubel (1968) suggested that what a learner already knows and how it is organised directly affects further learning and memory.

Reif (1984; Reif & Heller, 1982) and others (Camacho & Good, 1989; Elio & Scharf, 1990; Prawat, 1989) stressed the benefits of a hierarchical knowledge structure in particular. Reif (1984) stated that a hierarchic knowledge structure is the type most suited for retention of knowledge, for quick and efficient search processes, and for fitting in new elements of knowledge without restructuring knowledge already present. According to Reif, this type of structure, which contains abstract and general concepts at the higher levels, is typical of expert knowledge. This idea was emphasised further by Tashman (2013). According to Tashman (2013), not only do experts possess a greater body of knowledge in their domains, but the superior organisation. That is, the representation of this knowledge in long-term memory also impacts on the ability to perform subsequent tasks and learning. Berliner (1994) stated that the expert, given the superior organisation of knowledge, is better able to link newly learned knowledge with other knowledge that they possess and such knowledge is more easily retrievable in appropriate situations and more transferable to new situations.

These findings show that the knowledge of gifted students at pre-teaching was more characteristic of expert type knowledge than the not gifted students, to a larger extent, for the science topic in particular. The inference of hierarchical categories demonstrates gifted students’ capacity to “interpret new information rapidly and broadly and deeply and look for and analyse big picture patterns and rules in information” (Munro, 2013, p. 15). This is in accordance with
the novice-expert knower model of giftedness (Munro, 2010). Although the differences between gifted and not gifted students in terms of hierarchical categorisation of concept for migration topic were not statistically significant, a similar proportion of globally gifted students categorised concepts into semantic hierarchies across both topics; thus it could be interpreted as a ‘characteristic’ of gifted knowledge.

7.3 Hypothesis 3

The knowledge of gifted students prior to teaching is characterised by more interrelatedness of concepts than the not gifted students.

In addressing Hypothesis 3, evidence for the interrelatedness between concepts utilising results across both topics was explored. The knowledge structure of experts is characterised by elaborate and highly integrated networks of related concepts (Chi, Glaser, & Far, 1988; Mintzes, Wandersee, & Novak, 1997). According to Gobbo and Chi (1986) the structures of knowledge become more cohesive and integrated as children acquire expertise in a domain. The display of cross-links on a concept map demonstrates a relationship that the learner has perceived between different segments or semantic paths within their display of knowledge for the topic. Thus, cross-links can demonstrate the level of interconnectivity, cohesion and integration of a student’s knowledge of a topic. Furthermore, according to Novak and Cañas (2006), cross-links often represent creative leaps on the part of the knowledge producer. In the present study, the interrelatedness of concepts in students’ knowledge was assessed through the assessment of cross-links on students’ concept maps.

7.3.1 Cross-links, energy topic. At pre-teaching the globally gifted students displayed on average one more cross-link than the not gifted students. This difference of one cross-link was verging on statistical significance (p = .059). When the proportion of students who displayed at least some integration and interconnectivity of concepts (at least one cross-link) was considered, the globally gifted students and the nonverbally gifted students were more likely to display concept maps at pre-teaching that were interconnected than the not gifted students for the energy topic (p < .01). Approximately eighty per cent of the globally gifted and nonverbally gifted students displayed cross-links at pre-teaching, compared to less than half of the not gifted students.
7.3.2 *Cross-links, migration topic*. At pre-teaching, no differences were observed in the mean number of cross-links displayed, when comparing the gifted and not gifted students for the migration topic. The highest proportion of students across the four groups to display cross-links was the globally gifted group, however, the difference when compared with the not gifted students was not sufficiently large enough to reach statistical significance. Overall, seventy per cent of globally gifted students displayed cross-links at pre-teaching for the migration topic compared to fifty-eight per cent of the not gifted students. The students gifted in a single domain were no more likely than the not gifted students to display at least some cross-links at pre-teaching for the migration topic.

7.3.3 *Summary (interrelatedness of concepts)*. The display of cross-links on students’ concept maps showed mixed results across the two topics. It was hypothesised that the gifted students would display more cross-links than the not gifted students, however this was only found for the energy topic. No significant differences were found between gifted and not gifted groups in the display of cross-links for the migration topic at pre-teaching. The non-significant result for the migration topics could be attributed to differences within the topics in terms of subject-type characteristics. Austin and Shore (1993) expected that students drawing concept maps for *physics* topics would define many links between concepts given the interrelated nature of the physical sciences as a subject. Furthermore, de Jong and Ferguson-Hessler (1996) described knowledge within the domain of physics to be characterised by strong links and to be hierarchical in nature. Returning to the definition, cross-links represent links between concepts in different segments or domains of knowledge on a concept map and explain how the concepts or sub-domains are related (Novak & Cañas, 2006). Thus, the nature of physics or physical science type concepts may provide more hierarchical categorisation, which allowed students to more easily draw links between ideas. This provides a possible justification as to why students might have more easily sought cross-links for the energy topic.

Furthermore, Austin and Shore (1995) described the difference between a high achieving and low achieving student in their capacity to ‘see’ links between concepts in constructing a concept map. Both the high achieving student and the low achieving student expressed difficulty in the exercise of finding links between concepts, however, for different reasons. The high achieving student expressed that she didn’t know where to start because she could see so many links between the concepts whereas the low achieving students was having trouble beginning
because he could not see any links. Students’ knowledge structures become more interconnected and integrated as they develop knowledge of a topic and move further along the novice-expert continuum (Gobbo & Chi, 1986; Munro, 2010, 2012, 2013; Sternberg, 1995, 1998). Thus, students may have found the process of describing links between concepts for the migration more difficult than the energy topic. It is possible that students did not have sufficient breadth and depth of knowledge in order to demonstrate relationships between concepts for the migration topic specifically.

However, the findings for the energy topic in the present study are consistent with findings such as those from Austin and Shore (1993) who found that high performing students displayed more connectivity on their concept maps of physics concepts, compared to the average performing students, though less than that of the experts. This result demonstrated that like experts, high performing students displayed a higher degree of integration of the physics concepts, compared to the average performing students. The findings for the energy topic are also commensurate with the findings from Mintzes, Wandersee, and Novak (1997), who reported that experts exhibit deeper, more connected and interrelated concept map structures when compared with the knowledge structures of novices. This follows from research outlined in Chapter 2 that has consistently demonstrated that the knowledge of experts is categorised by highly integrated domain-relevant knowledge (Mayfield, Kardash, & Kivlighan, 1999) and highly integrated frameworks of related concepts (Chi et al., 1988).

A number of factors may need to be considered important in leading to the display of cross-links. Firstly, hierarchical structures are necessary to build the networks necessary for the identification of cross-links. By definition, a cross-link connects two concepts across different segments of a concept map that is hierarchically organised (Novak & Cañas, 2006). The hierarchical nature of the concept maps for gifted students encourages the identification of patterns or similarities to be sought between concepts and subsequent segments of knowledge. This could provide further justification for the non-significant differences seen for the migration topic, as no significant differences were found between gifted and not gifted students for hierarchical categorisation for the migration topic. Thus, hierarchical categorisation could be important in its link with students’ ability to ‘see’ interrelatedness between concepts or sub-domains of knowledge within a topic.
Therefore, the representation of knowledge could increase the likelihood that students seek out and find cross-links. The cross-links identify similarities that are identified within ideas. For example, one gifted student made a cross-link between the concepts *car* and *toaster*. The cross-link was made because the student saw a relationship between the two concepts on the basis that both relied on *electrical energy* to function. In forming a conceptual network in which concepts are defined based on a set of main ideas, relationships can be sought when intermediate or detailed type concepts are present. As reported by Novak and Cañas (2006), cross-links often represent creative leaps on the part of the knowledge producer. Furthermore, according to Urban (1999, 2007), insights are not very likely if task relevant knowledge is missing. That is, insights are dependent on the availability, accessibility, and integration of knowledge representations, which are necessary and useful for a given task (importance of domain-specific knowledge on divergent thinking). Thus, the display of cross-links could also be impacted by the amount of domain-specific knowledge that students have access to for a particular topic. Quick perception and processing of information and data, and storage in a flexible, accessible memory network are presupposition for fluent, flexible and associational thinking (Urban, 1999, 2007). This re-iterates the point discussed in Chapter 2 around the importance of having access to domain-specific knowledge that is efficiently organised in long-term memory to allow more ‘thinking space’ for cognitive demanding tasks such as seeking relationships between sub-domains of knowledge within a topic. For the energy topic, an example is provided that demonstrates the different display of knowledge between the globally gifted and not gifted students to emphasise the importance of organisation of domain-specific knowledge on the display for cross-links (Figures 40 and 41). For the energy topic, the gifted students were more likely to display hierarchical categorisation and to display cross-links. Similarly, Austin and Shore (1993) found that the concept maps of experts were more likely to be connected and integrated compared to the concept maps of novices. The concept maps below show the algorithmic nature of one of the not gifted students compared to the more integrated display for a globally gifted student. Figure 40 highlights the algorithmic nature of the concept maps drawn by not gifted students and Figure 41 highlights the more hierarchical and interrelated nature of concept maps drawn by globally gifted students.
Figure 40. Pre-teaching science concept map for not gifted student (Student B).

Figure 41. Pre-teaching science concept map for globally gifted student (Student C).
This poses the question of whether gifted students are more able to seek out and find cross-links because they are more creative than their not gifted peers or whether they can do this because of the more organised nature of their knowledge. As mentioned by Munro (2012) and Urban (1999, 2007), gifted students are likely to show creative outcomes or divergent thinking. It is theorised that gifted students are able to think more ‘creatively’ and find the relationships that constitute the cross-links as a result of a number of reasons.

Firstly, the domain-specific knowledge base that gifted students possess allows them to generate the ideas and concepts that build an elaborate and differentiated network of meanings for the topic (Munro, 2012). The domain-specific schemata that are organised in an efficient way allows the student to automatise the knowledge (Sweller 1998; van Merrienboer & Sweller, 2005) and the automatisation of knowledge allows for the working memory to be a thinking space to reform, reshape and restructure knowledge (Urban, 1999, 2007). When domain specific knowledge does not allow for the automatisation of knowledge, students are less able to be flexible in their thinking. The restrictions that are present within working memory do not allow students to be flexible with ideas that they have not integrated into their long-term memory. Thus, gifted students are able to look for patterns in the knowledge that they have stored in their long-term memory. The flexibility in working memory allows them to be ‘creative’. They can use this resource to search for similarities between concepts and ideas. Their hierarchical networks are automatised and this automatisation allows for them to simultaneously activate different segments of knowledge, to “think about two or more patterns, rules, or general propositions at once” (Munro, 2012, pp. 9-10), and think about the semantic patterns that might indicate a relationship.

7.4 A Model of the Gifted Learning Capacity

In addressing Hypotheses 1 to 3, the learning capacity of gifted students can be described in terms of the novice-expert knower model. That is, prior to teaching, what did the knowledge of gifted students ‘look like’ with reference to the novice-expert knower model? The two knowledge characteristics that showed the most consistent results across both topics were the display of domain-specific knowledge and the display of big ideas; chunking of information through inferring broad semantic categories. The results showed that all globally gifted students across both energy and migration topics displayed big ideas at pre-teaching. This type of
knowledge organisation shows that the globally gifted students, given their exceptional verbal and nonverbal abilities were able to structure their knowledge according to overarching broad semantic categories. This is indicative of the big picture type thinking emphasised by Munro (2013) in which gifted students infer patterns from teaching information and infer ‘big ideas’ that synthesise the patterns.

Furthermore, the quality of globally gifted students’ propositions was demonstrated across both topics. The globally gifted students displayed more verbal propositions utilising the core concepts for both topics when compared to the not gifted students. The conclusion that can be drawn from this is that the globally gifted students had more domain-specific knowledge of the topics. This was demonstrated by their ability to not only generate valid propositions with the core concepts, but the propositions that were displayed showed their understanding of the concepts in a way that demonstrated an understanding that contextualised the propositions within the topic.

Overall, the characteristics of the expert knower were more prominent for gifted students within the science topic. The characteristics are displayed in Figure 42.

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*Figure 42. Summary of the gifted learning characteristics by types of giftedness across both topics.*

**7.4.1 Implications of gifted learning capacity on learning.** The organisation of knowledge into semantic hierarchies and categorisation of knowledge into big ideas demonstrates the students’ capacity to chunk information. This type of organisation has implications for further information processing with the highly organised knowledge or schemata in long-term memory. According to cognitive load theory (Sweller, 1988) this type of conceptual organisation, once automated, allows the student to utilise their thinking space (working
memory) for other tasks as the knowledge is highly developed in their long-term memory. This allows students to allocate their thinking space to other tasks as these concepts are activated or light up as a chunk of information as opposed to separate unlinked ideas. The more elaborated and differentiated knowledge base allows gifted students to generate the ideas and concepts that build a more elaborated and differentiated network of meanings for the topic (Munro, 2012). The domain-specific schemata are organised in an efficient way that allows the student to automatise the knowledge (Sweller 1998; van Merrienboer & Sweller, 2005) and the automatisation of knowledge allows for the working memory to be a thinking space to reform, reshape and restructure knowledge (Urban, 1999, 2007). When domain specific knowledge is not automatised, students are less able to be flexible in their thinking within that domain. The restrictions that are present within working memory do not allow students to be flexible with ideas that they have not integrated into their long-term memory. Thus, gifted students are able to look for patterns in the knowledge that they have stored in their long-term memory. The flexibility in working memory increases the opportunities for them to be ‘creative’ in terms of engaging in or displaying divergent thinking (Kaufman, Plucker, & Russell, 2011). They can use this resource to search for similarities between ideas. Their hierarchical networks are automatised and this automatisation allows for them to simultaneously activate different segments of knowledge, to “think about two or more patterns, rules, or general propositions at once” (Munro, 2012, pp. 9-10), and think about the semantic patterns that might indicate a relationship.

The processing of information described based on the gifted learning capacity is commensurate with the notion of excellence described by Ziegler et al. (2013) in terms of the repertoire of actions displayed by experts within their area of specialty. Ziegler and colleagues state that the actions of experts are more successful, more extensive, and experts act on the basis of the rich information storage. Furthermore, as more cognitive steps become automated the level of cognitive effort is reduced which allows for the cognitive resources to be available for problem solving. This coincides with the implications of the gifted learning capacity on learning, which emphasises the importance of the accumulation of domain knowledge and the cognitive capacity to problem solve once the knowledge can be accessed and retrieved more automatically (Sweller, 1998; van Merrienboer & Sweller, 2005).
The implications that the gifted learning capacity has on learning have been described in terms of the processing and storage of information in long-term memory. The differences in processing and storage of information between gifted and not gifted students likely stems from the processing capacity that the gifted students have, as well as the cognitive capacity more generally.

7.4.2 The development of intuitive theories. It is the unique cognitive experience that shapes the knowledge and thinking of gifted students in ways, which are different to not gifted students. According to Shavinina (2007), gifted individuals have a unique ‘intellectual’ picture of the world, which manifests from the unique cognitive experience that is the basis for their giftedness. This unique cognitive experience is developed through the individual’s conceptual structures, knowledge base and as part of this, their subjective mental space (thinking space). Furthermore, this unique experience results in the gifted individual seeing, understanding, and interpreting information differently from the not gifted. Their giftedness stems from characteristics of their learning and their ability to learn. Furthermore, based on eminence literature, Van Tassel-Baska (2008) described the gifted learner’s approach to learning as idiosyncratic and this approach requires a personalised approach when planning for differentiation. This description of ‘giftedness’ reflects the notion that the gifted student will develop knowledge that is unique and distinct to the knowledge of their not gifted peers. As stated by Ziegler and Phillipson (2013) and Shavinina (2007) the gifted student has a unique interaction with their environment. This interaction can be described as their functioning within a system as reported by Ziegler and Phillipson or in terms of their cognitive experiences as described by Shavinina. What these descriptions suggest is that gifted individuals interpret information in ways that differ from their not gifted peers. This could be defined as their intuitive theories (Munro, 2012).

The gifted students have the quality of displaying ‘expert’ understanding, not when compared with adult experts in the domain but with chronological-aged peers. Outcomes in a primary or secondary classroom context match the talent outcomes described by Gagne (2005). Gifted students move through the novice to expert knower trend more rapidly and in a self-initiated and focused way and using their broad-based thinking ability need much less practice (Munro, 2013). Students begin with a different ‘intellectual picture’ of the world when they approach a task, which includes these knowledge characteristics as described above. According
to Munro (2005) gifted students have more elaborate network of meaning units or propositions as shown in Figure 43. Student A has both more meaning units and a greater number of links. Imagine both students being exposed to the same information for this topic. Student A has more units of meaning for making sense of it. As well, this student can develop a broader understanding because the ideas are linked with other ideas, can chunk the information more efficiently, ‘put together’ more of this information into individual ‘bites’ or ‘chunks’, can come to an understanding more quickly, can operate more in a ‘big picture’ way, and can make wider links with existing knowledge and draw in a broader range of ideas. This is commensurate with the notion described by other researchers such as Shavinina and Ziegler in which the gifted student can interact with their environment in ways that differ to not gifted students. This can be explained partly by their learning capacity.


The gifted learning capacity can thus be interpreted as the unique intellectual picture that gifted students have on the world and serves as the basis for interpreting teaching information. However, this does not explain the different ‘intellectual pictures’ that students gifted in different domains might display and their subsequent knowledge representations.
7.5 Hypothesis 4

Verbally gifted students prior to teaching display more domain-specific knowledge (verbal propositions) and more semantically organised knowledge than nonverbally gifted students.

In evaluating Hypothesis 4, evidence for differences in the amount and organisation of domain-specific knowledge between verbally gifted and nonverbally gifted students was explored. It was hypothesised that verbally gifted students would display highly elaborated and differentiated conceptual networks (Munro, 2005). Porath (1996) described the strengths of the verbally gifted students in the way that they organised story plots. The verbally gifted students indicated elaborate conceptual structures and organised story plots in ways typical of children two years older. The story plots of the verbally gifted students indicated elaborate structures and their specific language abilities contribute to the richness and sophistication of their narratives. In comparison, nonverbally gifted students can have difficulty attending to details that are presented in isolation and may miss ‘easy’ concepts (Silverman, 2002, 2010). Furthermore, the verbal processing system manages abstract information in a sequential and successive manner whereas the nonverbal system manages abstract information in a synchronous, simultaneous manner (Branoff, 1998) and nonverbally gifted students tend to process information more slowly (Dixon, 1983; Silverman, 2002). These processing differences along with the verbal semantic strengths of verbal gifted students would indicate a different application and representation of knowledge for the given topics. Therefore, the different cognitive strengths of the verbally gifted the nonverbally gifted students would likely indicate differences in the representation and organisation of knowledge prior to teaching. The verbally gifted students were thus expected to display more verbal propositions and more semantic organisation in comparison to the nonverbally gifted students.

Domain-specific knowledge was assessed in terms of the number of valid propositions that students displayed using the ‘core’ concepts and the number of additional concepts that students displayed. Semantic organisation was assessed in terms of the hierarchical organisation of concepts and big ideas that students displayed.

7.5.1 Valid propositions. At pre-teaching, the verbally gifted students did not display more elaborated and differentiated conceptual networks than the nonverbally gifted students in terms of the number of valid propositions. This finding was contrary to the predictions made about the knowledge of verbally gifted students. The verbally gifted students displayed on
average 8.4 and 9.7 valid propositions for the energy and migration topics, respectively, compared to 9.1 and 11.4 for the nonverbally gifted students. The verbally gifted students displayed even fewer valid propositions when the context was taken into consideration, displaying on average 7 and 8.9 semantically valid propositions for the energy and migration topics, respectively, compared to 8.1 and 10 for the nonverbally gifted students.

7.5.2 Additional concepts. At pre-teaching, the verbally gifted students did not display more elaborated and differentiated conceptual networks than the nonverbally gifted students in terms of the number of additional concepts. The verbally gifted students displayed 9.8 and 6.7 additional concepts for the energy and migration topics, respectively, compared to 7.2 and 6.1 for the nonverbally gifted students. The differences across both topics were not sufficiently large enough to reach statistical significance.

7.5.3 Summary (domain specific knowledge). The findings for both topics were not consistent with the notion that verbally gifted students would display more domain specific knowledge of the topics than the nonverbally gifted students. According to Munro (2005), “Verbal knowledge that is gifted can be conceptualized as comprising verbal semantic networks that are more differentiated and elaborated than that which is not gifted. This leads to an enhanced ability to retrieve the meanings of verbal concepts and to reason about them and to make links between ideas that may be unexpected. Students gifted in this area are likely to have extensive vocabularies” (p. 156). Furthermore, according to Silverman (1989), students who are gifted only in the nonverbal areas of knowledge, the ‘gifted visual-spatial’ learning profile, are less likely to have access to the elaborated semantic network available to the verbally gifted students (Silverman, 1989). Thus, the research suggests that verbally gifted students are more likely to have more elaborated semantic networks and more extensive vocabularies than the nonverbally gifted students.

Further exploration of the cognitive characteristics of verbally gifted students provide some insight into possible explanations for the finding that verbally gifted students did not display more valid propositions for the provided concepts than the nonverbally gifted students. One possible explanation for the verbally gifted students not having displayed more valid propositions than the nonverbally gifted students or the not gifted students could be explained by the process of comprehension described by Munro (2005).
Munro (2005) reported that when reading, verbally gifted students may need to identify fewer of the concepts mentioned explicitly in a text than their not gifted peers to identify its context and comprehend at least some of its propositions. The more extensive existing networks of concepts that these students have may be sufficient to inform them of the context and the ideas likely to be mentioned. As a consequence, Munro (2005) suggested that the verbally gifted students need not invest attention in encoding most of the written words to identify the likely intended relationships between concepts in the text. Their existing knowledge would do this more rapidly. Across both topics (energy and migration) the verbally gifted students did not display more valid propositions on either measures of general validity and semantic validity than the nonverbally gifted students at pre-teaching.

The other element of elaborated and differentiated conceptual networks that was assessed included the number of additional concepts. The verbally gifted students did not infer significantly more additional concepts than the nonverbally gifted students. However, the biggest difference between the mean number of additional concepts for gifted and not gifted students was seen between the verbal and nonverbal gifted students. That is, the magnitude of the difference between the verbally gifted students and the nonverbally gifted students was greater than the magnitude of the difference between all other groups, without reaching significance. This would be expected given the nature of ‘verbal giftedness’ as described by Munro (2005) in which verbally gifted students are likely to have extensive vocabularies. This is consistent with the notion described by Porath (1996) who reported that verbally gifted students displayed narratives that were richer and more sophisticated than not gifted peers.

The nature of the concept-mapping task provides essential background to the interpretation of the finding that verbally gifted students did not display more valid propositions than the nonverbally gifted students. The task required students to display their knowledge of the topics after being given a list of concepts that would form the basis of the topic. The lists of concepts that were provided to students provided a context for interpreting the topic and activating their thinking for the topic. The assessment of proposition validity was based on students’ use of the concepts provided to them for each topic.

Given that the data showed verbally gifted students to be more likely to infer additional concepts than the nonverbally gifted students it could be interpreted that the verbally gifted students displayed large domain specific knowledge of the topic but without displaying
knowledge of the concepts that were being assessed specifically. As reported by Munro (2005) the verbally gifted students have verbal semantic networks that are highly elaborated and differentiated and these students have extensive vocabularies. However, the concept mapping task was assessing the students’ ability to organise a set of given concepts to determine whether students were able to represent the concepts in valid propositions. Although it is surprising that the verbally gifted students were unable to display more valid propositions using the provided concepts than the nonverbally gifted students, the nature of their semantic networks may provide insight into this finding.

To understand the nature of nonverbal giftedness, we return to the definitions of verbal and nonverbal intelligence, where the distinction was made between verbal and fluid reasoning. In particular, the definition of fluid reasoning provides insight into the nature of nonverbal giftedness: fluid intelligence or fluid reasoning is defined as the capacity to think logically and solve problems in a novel situation independent of acquired knowledge (Ferrer, O’Hare, & Bunge, 2009). Fluid intelligence refers to the processing of information and the ability to reason with the aim to understand relationships and abstract propositions (Stankov, 2000).

The ability to reason with the aim to understand relationships and abstract propositions when presented with a list of concepts and a context in which the concepts can be understood, it provides context for which to interpret the higher display of proposition validity for nonverbally gifted students compared to verbally gifted students. The fluid analogising ability (Geake, 2008) allows the nonverbally gifted students to ‘see’ the relationships between concepts and the context in which the concepts are being presented.

The semantic activation theories (see Anderson, 1976; Anderson & Pirolli, 1984; Collins & Loftus, 1975), which support the idea that a cue word will activate schemata, might also provide context for interpreting the finding. The verbally gifted students have larger more extensive vocabularies than the nonverbally gifted students (Munro, 2005), but when provided with a list of concepts within a given context, failed to display more valid propositions using those lists of words than the nonverbally gifted students. The semantic networks of the verbally gifted students being highly elaborated and differentiated may lead to these students displaying knowledge that deviates from the core ideas presented in the teaching or assessment tasks. The activation of these highly elaborated and differentiated semantic networks without the ‘fluid analogising’ (Geake, 2008) component appears to result in these students displaying knowledge
of the topic that is extensive yet outside of the scope of measurement. These students displayed large concept maps with concepts and propositions that displayed activation of extensive ideas without focusing on the concepts that formed the basis of the topic. Figure 44 provides an example of this type of knowledge representation by a verbally gifted student for the science topic. The nonverbally gifted students used their nonverbal/spatial abilities to display knowledge of the topic using the list of provided concepts and the provided context to display more valid propositions than the verbally gifted students.

This is also consistent with the learning style of verbally gifted students described by Redding (1989). According to Redding, verbally gifted students are motivated to seek meaning and prefer to understand concepts and their implications. As a result, this can cause verbally gifted students to neglect the task or test in favour of the challenge of unpacking abstract ideas.

The spreading activation model (Collins & Loftus, 1975) describes the activation of concepts along the paths of a semantic network. This model provides a clear picture of the semantic relations between concepts and the interconnectivity of concepts within a semantic network. The spreading activation model proposes that the presentation of a word activates semantically related words. For example, the word *red* should strongly activate words that are semantically closely related such as *orange* and *fire* and should cause less activation of words such as *sunrises* and *sunsets*. The model assumes that when a concept is processed, activation spreads along the paths of a network and its effectiveness decreases as it travels outward. The activation of a second concept decreases the activation of the first concept and the semantic distance increases the further the activation travels along the paths.
Figure 44. Verbally gifted student’s knowledge of the energy topic showing the ‘spreading activation’ type knowledge.

Similarly, the semantic network model proposed by Anderson (1976) called ACT, was used to explain how knowledge is stored in a semantic network consisting of interconnected nodes, and activation can spread down network paths from active nodes to activate new nodes and paths. ACT model is an example of a spreading activation model in which the activation spreads throughout a semantic network. At each point in the network, the activation is divided among alternative links according to their relative strengths. Increasing the number of links therefore slows the spread of activation. A modified version of ACT uses subnodes to integrate related material in the semantic network (Reder & Anderson, 1980).
The semantic network models provide a framework for interpreting the activation of knowledge for students with varying degrees of conceptual knowledge for a topic. The example given for spreading activation model in which the concept of ‘red’ would activate the concept ‘orange’ demonstrates how knowledge is stored in semantic networks and activation of a concept will allow the activation of other semantically related concepts. If students are gifted in the verbal domain it would be predicted that their vocabulary for a given topic would be larger than a student who is not gifted verbally. Munro (2005) described the strengths of the verbally gifted student including extensive vocabularies and the capacity to identify the context and comprehend propositions from only a few of the concepts mentioned in a text. Furthermore, the Mill Hill Vocabulary Scale (Raven, 1994) used in the present study to identify verbally gifted students measures this type of verbal knowledge as it requires students to write definitions and select synonyms for a list of words. Thus, verbally gifted students have the potential for greater activation along semantic paths once concepts are presented for a given topic. Activation of related concepts along a semantic path would result in a display of knowledge that includes concepts that elaborate initial concepts further along a semantic path. This was seen for the verbally gifted students who were most likely to display additional concepts for both topics. The verbally gifted students were more likely to display their own concepts for the topic than the nonverbally gifted students and demonstrated fewer valid propositions than the nonverbally gifted students from the list of provided concepts.

Another way of assessing the representation of concepts was to measure the proportion of the overall concept map that was made up of concepts that were provided to students (to include on their concept map). The proportion of the overall displayed concepts that were the provided concepts for both topics showed that the verbally gifted students were most likely to display the highest ratio of additional concepts to provided concepts. For example, at pre-teaching only 54% of the concepts that comprised the verbally gifted students’ concept maps were from the list of provided concepts compared to approximately 61% for the nonverbally gifted students (Figure 45).

Similarly for the migration topic, at pre-teaching 66% of the concepts that comprised the verbally gifted students’ concept maps were from the list of provided concepts compared to 74% for the nonverbally gifted students. This highlights the difference between the verbally gifted and nonverbally gifted students in terms of the display of knowledge for the topics. Although the
groups did not differ significantly in the mean number of additional concepts, the verbally gifted
students may have extensive vocabularies and the ability to reason verbally. However, this does
not necessarily show that these students can demonstrate knowledge for a topic where the ability
to integrate a set of concepts coherently within a given context is necessary. Perhaps an
implication of this finding would be to scaffold the thinking of these students to focus on the
concepts that are central to the topic. It could be the case that these students are activating larger
chunks of information or ideas for the concepts that are presented. When the large chunks of
information are activated for these students they move along these semantic paths and display
knowledge that is representative of the spreading activation model. The ability to stop the
activation at a node and divert attention back to the concepts that are more central to the topic
could be the processing mechanism that could facilitate these students in terms of displaying
more valid propositions with the study concepts for the topics.

Figure 45. Proportion of overall concepts displayed on pre-teaching concept maps that were
concepts provided to students.

7.5.4 Hierarchical categories. Furthermore, the verbally gifted students displayed on
average 1.8 hierarchical categories at pre-teaching compared to 1.3 hierarchical categories for the
nonverbally gifted students. The mean difference was not large enough to reach statistical
significance. Furthermore, 79% of the verbally gifted students displayed hierarchical categorisation of energy concepts compared to 72% of the nonverbally gifted students at pre-teaching. For the migration topic, the verbally gifted students displayed on average 1.1 hierarchical categories at pre-teaching compared to 0.93 hierarchical categories for the nonverbally gifted students. The mean difference was not large enough to reach statistical significance. Furthermore, 71% of the verbally gifted students displayed hierarchical categorisation of migration concepts compared to 60% of the nonverbally gifted students at pre-teaching.

7.5.5 Big ideas. The verbally gifted students displayed on average 1.4 big ideas at pre-teaching compared to 1.6 big ideas for the nonverbally gifted students. The mean difference was not large enough to reach statistical significance. Furthermore, 74% of the verbally gifted students displayed big ideas with the energy concepts compared to 83% of the nonverbally gifted students at pre-teaching. For the migration topic, the verbally gifted students displayed on average 1.2 big ideas at pre-teaching compared to 1.1 big ideas for the nonverbally gifted students. The mean difference was not large enough to reach statistical significance. Furthermore, 79% of the verbally gifted students displayed big ideas with migration concepts compared to 67% of the nonverbally gifted students at pre-teaching.

7.5.6 Summary (semantic organisation). The findings across both topics are not consistent with the notion that verbally gifted students would display more semantic organisation than the nonverbally gifted students. According to Sak (2004) verbally gifted students can be more interested and adept at comprehending the global aspect of a phenomenon than nonverbally gifted students, who can be more interested in and adept at analysing critical parts of the phenomenon. This strengthens the notion that the nonverbally gifted students would be more likely to display cross-links as this demonstrates analysis of critical parts of the topic and verbally gifted students might be more likely to see ‘big picture’. The findings for the present study indicate that the ‘big picture’ thinking by verbally gifted students is not a general phenomenon and points towards a domain-specific trend. For example, for the migration topic, the verbally gifted students were more likely to display big ideas, however, for the energy topic; the nonverbally gifted students were more likely to display big ideas. Therefore, the global aspects of the topic, the big ideas, were more likely to be perceived by students with regard to the particular topic and the domain in which they were gifted. According to Munro (2013), the
capacity to see the big picture, to infer patterns and ‘big ideas’ from teaching, is one of the hallmarks of expert-type or gifted knowledge. However, the findings for the present study showed that students’ ability to infer patterns and display big ideas for the topics differed according to the specific topic and the domain of giftedness. The students gifted in the verbal domain were more likely to infer patterns from the teaching in the humanities topic whereas the students gifted in the nonverbal domain were more likely to infer patterns from the teaching in the science topic. This is consistent with the notion that students gifted in the nonverbal domain are more likely to show abilities within science topics and students verbally gifted are more likely to display abilities within the humanities (Ackerman, 1996; Lubinski & Benbow, 2006; Rolfhus & Ackerman, 1996).

In terms of hierarchical organisation of knowledge, although the differences were not large enough to reach significance, the verbally gifted students were more likely to display hierarchical categorisation across both topics. This is consistent with the verbal processing system described by Branoff (1998) who reported that the verbal processing system manages abstract information in a more successive sequential way than the nonverbal system, which manages abstract information in a synchronous simultaneous manner. Furthermore, the semantic organisation in terms of hierarchical categorisation displayed by verbally gifted students is consistent with Porath (1996) who described verbally gifted students’ story plots as organised and being comprised of elaborate conceptual structures. As reported by Munro (2012) this type of taxonomic hierarchical classification of concepts is a complex and sophisticated way of categorising and forming concepts and typical of expert-type knowledge representation. However, although being typical of expert-type knowledge representation, it appears to be typical of high verbal ability in particular, given the sequential processing of information that is attributed to verbal processing system (Branoff, 1998).

7.6 Hypothesis 5

Nonverbally gifted students prior to teaching perceive more interrelatedness of concepts than verbally gifted students.

7.6.1 Cross-links, energy topic. At pre-teaching for the energy topic, the nonverbally gifted students did not display more interconnected conceptual networks than the verbally gifted students. The nonverbally gifted students displayed on average 1.3 cross links compared to 0.9
cross-links for the verbally gifted students. This difference was not sufficiently large enough to reach statistical significance. However, when the proportion of students who displayed cross-links was assessed, larger differences were seen between the nonverbally and verbally gifted students. It was found that 78% of nonverbally gifted students displayed cross-links on their concept maps at pre-teaching compared to less than half (47%) of verbally gifted students. Thus, nonverbally gifted students were more likely to display conceptual networks that displayed interconnectivity and integration of concepts than the verbally gifted students.

7.6.2 Cross-links, migration topic. At pre-teaching for the migration topic, when the mean number of cross-links per student was measured, the nonverbally gifted students did not display more interconnected conceptual networks than the verbally gifted students. The nonverbally gifted students displayed on average 0.7 cross-links compared to 1.4 cross-links for the verbally gifted students. Furthermore, contrary to the findings from the energy topic, the nonverbally gifted students were less likely to display at least once cross-link when compared to the verbally gifted students. Only 40% of the nonverbally gifted students displayed cross-links at pre-teaching compared to 57% of verbally gifted students for the migration topic.

7.6.3 Summary (interrelatedness of concepts). The findings from the energy topic are commensurate with the notion that visual-spatial learners perceive the interrelatedness of the parts of a situation (Silverman, 2010). As described by Silverman (2010), students gifted in the nonverbal domain are characterised by high abstract reasoning abilities, understanding of complex relations and systems and are able to grasp metaphors and analogies. These students have particular strengths in the ability to discover relationships (Mann, 2005). Furthermore, differences have been highlighted in the way verbally and nonverbally gifted students perceive information and make judgments (Sak, 2004). Verbally gifted students can be more interested and adept at comprehending the global aspect of a phenomenon than nonverbally gifted students, who can be more interested in and adept at analysing critical parts of the phenomenon. This strengthens the notion that the nonverbally gifted students would be more likely to display cross-links as this demonstrates analysis of critical parts of the topic.

However, the findings were inconsistent across the two topics. Nonverbally gifted students were not found to be more likely or adept at displaying this analysis of critical parts for both topics. One possibility for this could be linked with the notion stated by Silverman (2013) that visual-spatial learners are more likely to see the ‘big picture’ before they learn details. For
the energy topic, a larger proportion of the nonverbally gifted students displayed cross-links and
big ideas than the verbally gifted students. For the migration topic, a larger proportion of the
verbally gifted students displayed cross-links and big ideas than the nonverbally gifted students.

As mentioned in previous chapters, the ‘big ideas’ represent broad semantic categories inferred
by students to organise concepts into semantic hierarchies or big (global-type) ideas. Thus it
appears that the comprehension of the global aspects of a phenomenon such as big ideas of a
topic could be linked to the ability to analyse critical parts of the phenomenon such as the cross-
links between ideas in a topic. The ability to identify and define cross-links could depend on the
extent to which students can grasp the global aspects or ideas for the topic for which they are
studying. Furthermore, the globally gifted students were more likely than students gifted in a
single domain to display cross-links at pre-teaching for both topics. This suggests that the
interaction between verbal and nonverbal ability is beneficial in the identification of cross-links
or more novel relationships between concepts.

Another possibility that stems from the findings is the notion of domain-specificity for
the types of giftedness across topics. The nonverbally gifted students were more likely to display
cross-links for the science topic whereas the verbally gifted students were more likely to display
cross-links for the humanities (migration) topic. The differences across the topic could have
resulted from domain differences in ability for the given topics. According to Trickett and
Trafton (2007), a student who has superior visual-spatial ability is able to create mental
representations of complex ideas and then mentally manipulate those representations, which is a
skill that is needed for creative productivity and theory development in the STEM domains. This
idea has been emphasised by Silverman (2010) who has reported that one of the areas of
particular strength for students gifted in the nonverbal domain is in science. In a longitudinal
study of mathematically precocious youth (SMPY study), Lubinski and Benbow (2006) found
that those individuals who majored in physical science had higher mathematical, verbal and
spatial abilities compared to students studying in other areas. Furthermore, students who majored
in humanities scored high on verbal ability but low on mathematical and spatial ability. Thus,
students who studied humanities had relatively higher verbal ability but lower mathematical and
spatial ability compared to students with other majors. These findings demonstrate that
differences in cognitive abilities or areas of ‘giftedness’ correlate with areas of students’
particular interest, strength, or aptitude. This finding is commensurate with the work of Rolfhus
and Ackerman (1996) who developed a battery of self-report measures to assess individual differences across a number of knowledge domains covering areas such as physical and social science, art, history and literature. When assessing the relationship between spatial and verbal ability across the knowledge domains, the results showed positive correlations between spatial ability and knowledge domains such as engineering, calculus, geometry and physics and significant correlations between verbal ability and the arts and humanities. Thus, spatial and verbal abilities showed varying correlations across knowledge domains (Ackerman, 1996).

This provides further framework for interpreting the results that showed differences in the likelihood that students displayed more interconnected knowledge across the two different topics. The nonverbally gifted students were more likely to display interconnected knowledge structures for the science topic and the verbally gifted students were more likely to display interconnected knowledge for the humanities topic.

**7.7 Elaborating and Modifying the Model of Gifted Learning Capacity**

The observed differences between the knowledge characteristics of verbally and nonverbally gifted students did not match the predicted differences in Hypotheses 4 and 5. Specifically, the magnitude of the differences in some cases was not as great as predicted. In addressing Hypotheses 4 and 5, the different learning capacity of verbally gifted compared to nonverbally gifted students can be described in terms of the novice-expert knower model. That is, prior to teaching, how did the knowledge of verbally gifted and nonverbally gifted students differ with reference to the novice-expert knower model? In the model of the gifted learning capacity described earlier, the two knowledge characteristics that showed the most consistent results across both topics were the display of domain-specific knowledge and the display of big ideas; chunking of information through inferring broad semantic categories. The results showed that all globally gifted students across both energy and migration topics displayed big ideas at pre-teaching. This type of knowledge organisation shows that the globally gifted students, given their exceptional verbal and nonverbal abilities were able to structure their knowledge according to overarching broad semantic categories. However, differences were found between verbally gifted and nonverbally gifted students for these characteristics.

One finding that must be integrated into the gifted learning capacity is the domain-specificity phenomenon for the science and humanities topics that was found. Although one of
the features of the gifted learning capacity for the globally gifted students was the display of big ideas and cross-links, this was not consistent for verbally gifted and nonverbally gifted students. The verbally gifted students were more likely to display big ideas and cross-links for the humanities topic whereas the nonverbally gifted students were more likely to display these characteristics for the science topic. Therefore, the cognitive capacity of the students gifted in a single domain produced different knowledge representations.

In terms of predicted differences between verbally and nonverbally gifted students although the differences did not reach statistical significance, the verbally gifted students displayed more additional concepts across both topics and were more likely to display hierarchical categorisation across both topics. Therefore, overall, in terms of the knowledge characteristics that comprise the ‘expert knower’, the verbally gifted students are more likely to display knowledge that reflects the expert-type thinking. However, it should also be noted that general conclusions about the knowledge of gifted students should not be made without reference to firstly the domain in which the student is gifted and the domain of study. This is consistent with the notion of domain-specificity for giftedness in which students display advanced conceptual networks in some subject areas but not necessarily across subject areas universally (Munro, 2013).

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*Figure 46. Difference in the learning characteristics by types of giftedness (verbal or nonverbal) across both topics at pre-teaching.*
7.8 Hypothesis 6

*The knowledge of gifted students post-teaching is characterised by more domain-specific knowledge (verbal propositions) than the knowledge of not gifted students.*

The first three hypotheses were assessed to determine the extent to which gifted students’ *prior knowledge* was characteristic of the expert knower in terms of the elaboration and differentiation of their conceptual networks, the efficiency and completeness of knowledge representations, and the extent to which they displayed interconnected knowledge. The findings showed that the characteristics of the expert knower were more likely to be displayed by gifted students. The current section follows from the previous sections and investigates whether the post-teaching knowledge differed for gifted and not gifted students in similar ways to the pre-teaching knowledge; according to the novice-expert knower model.

7.8.1 *Valid propositions, energy topic.* Immediately after the teaching and two weeks after the teaching the trends remained the same for the number of valid propositions displayed using the fifteen provided concepts for the energy topic; the highest mean number of valid propositions was displayed by globally gifted students, followed by nonverbally gifted students. The magnitude of the difference between the globally gifted and not gifted students increased across the two post-teaching assessments phases. Two weeks after the teaching, the globally gifted students displayed approximately four more valid propositions than the not gifted students (*p* < .05). The nonverbally gifted displayed approximately two more valid propositions than the not gifted students two weeks after teaching but the difference was not statistically significant. The students gifted in the verbal domain displayed a comparable number of valid propositions to the not gifted students.

7.8.2 *Valid (semantic) propositions, energy topic.* When the propositions were assessed to determine whether the students displayed an understanding that demonstrated context specific (semantic) validity for the provided energy concepts, the globally gifted students displayed more valid propositions at both post-teaching phases than the not gifted students. Immediately after the teaching, the globally gifted students displayed approximately four more valid propositions using the provided concepts (*p* < .01). Two weeks after the teaching, the difference remained, where globally gifted students displayed approximately four more valid propositions than the not gifted students (*p* < .05). The students gifted in the nonverbal domain displayed approximately two more semantically valid propositions when compared to the not gifted students, however the
difference was not statistically significant. The students gifted in the verbal domain only displayed a comparable number of semantically valid propositions to the not gifted students.

7.8.3 Valid propositions, migration topic. The results for the migration topic followed a similar trend to the energy topic. The globally gifted students displayed the highest mean number of valid propositions, followed by the students gifted in the nonverbal domain. Immediately after the teaching, the globally gifted students demonstrated approximately three more valid propositions using the seventeen provided study concepts than the not gifted students. The difference was not sufficiently large enough to reach statistical significance. However, following the two-week delay, the difference between the globally gifted and not gifted students increased to more than four valid propositions, which was significant (p < .05). The students gifted in a single domain did not display more valid propositions than the not gifted students. However, following the two-week delay, the differences between the students gifted in a single domain and the not gifted students increased. The gifted students displayed a greater continuation of learning compared to the not gifted students and this is depicted in Figure 47.

7.8.4 Valid (semantic) propositions, migration topic. When the context specific validity of the concepts was assessed, the differences between the gifted and not gifted students remained. The globally gifted students displayed approximately four more semantically valid propositions than the not gifted students immediately after the teaching, however the difference was not sufficiently large enough to reach statistical significance. Following the two-week delay, the difference between the globally gifted and not gifted students increased to five valid propositions (p < .05). The difference of five semantically valid propositions highlights the difference in domain-specific knowledge for the topic that the globally gifted students displayed following the teaching and two-week delay. Furthermore, the continuation of learning was visible for the semantic validity of the propositions using the provided concepts. All three gifted groups displayed a higher mean number of semantically valid propositions when comparing their scores from immediately after the teaching to after the two-delay. That is, the gifted students continued to learn, following the two-week delay. This is consistent with the findings of Zimmerman et al. (2011) who found an increase in students’ content knowledge using concept mapping from pre to post instruction. The not gifted students however were the only group that displayed fewer semantically valid propositions two weeks after teaching compared to the assessment immediately following the teaching.
7.8.5 Additional concepts, energy topic. As the final measure of domain-specific knowledge, it was also hypothesised that gifted students display more additional concepts than not gifted students post-teaching. Similar to findings at pre-teaching, the verbally gifted students displayed approximately three more additional concepts than the not gifted students immediately after the teaching and approximately two more additional concepts two weeks after the teaching, however the differences were not sufficiently large enough to reach statistical significance. The

Figure 47. Continuation of learning from post-teaching phase T2 to post-teaching phase T3.
globally gifted students and the nonverbally gifted students displayed a comparable number of additional concepts to the not gifted students at both post-teaching assessment phases.

As was seen at pre-teaching, the gifted students only tended to display more additional concepts if they were gifted in the verbal domain only. This is commensurate with the notion that verbally gifted students have extensive vocabularies (Munro, 2005).

**7.8.6 Additional concepts, migration topic.** Although the globally gifted students displayed more valid propositions using the provided study concepts for the topic, the verbally gifted students displayed the most number of additional concepts. It was hypothesised that gifted students would display more additional concepts than not gifted students at post-teaching phases. Similar to the trend seen at pre-teaching, the globally gifted students displayed the least number of additional concepts at both post-teaching assessments. The students gifted in a single domain and the not gifted students all displayed a comparable number of additional concepts at post-teaching phase T2. However, following the two-week delay (phase T3), the verbally gifted students displayed the most additional concepts, similar to the trend observed at pre-teaching. The difference between the verbally gifted and not gifted students of approximately 2.5 additional concepts was not statistically significant.

**7.8.7 Summary (additional concepts).** The hypothesis that gifted students would display more domain-specific knowledge of the topic at post-teaching phases can be assessed in terms of the quality of the propositions and in terms of the amount of knowledge displayed for the topic. In terms of the amount of knowledge displayed for the topic, the verbally gifted students were most likely to infer additional concepts to demonstrate their understanding of the topic about human migration. However, when considering the quality of the propositions displayed using the provided concepts, which formed the basis of the teaching, the globally gifted students and students gifted in the nonverbal domain only displayed more knowledge of the topic. These students were able to demonstrate an understanding of the concepts that formed the central ideas within the topic. The globally gifted students in particular were able to demonstrate that they understood the concepts within the context in which the concepts were presented. Immediately after the teaching, the globally gifted students displayed fourteen of the seventeen concepts in semantically valid propositions. Two weeks later, the globally gifted students displayed on average almost fifteen of the seventeen provided concepts in semantically valid propositions.
7.8.8 Summary (domain-specific knowledge). Given exposure to the same teaching, the gifted students were more likely to display domain-specific knowledge for the topics. Furthermore, the gifted students were more likely to display a bigger increase in knowledge of the topics at the assessment phase two weeks after teaching. The difference across both topics could be explained in part by the differences in the abilities of verbally gifted and nonverbally gifted as described by Ackerman (1996). The nonverbally gifted students displayed more continuation of learning compared to the verbally gifted students in science topic and the verbally gifted students displayed more continuation of learning in humanities topic. This is commensurate with the notion that students gifted in the verbal domain show particular strengths in the arts and humanities whereas students gifted in the nonverbal and spatial domains have particular strength in the physical sciences (Ackerman, 1996; Benbow & Minor, 2006).

In terms of the number of valid propositions that students displayed at post-teaching phases, it was found that the globally gifted students displayed more domain-specific knowledge of both the energy and the migration topics than the not gifted students. This finding was more pronounced following the two-week delay. The larger knowledge base for the topics for the globally gifted students is commensurate with the notion of the expert knower and previous findings in both the expertise and giftedness research where the knowledge base of experts and gifted students is larger than that of novices or not gifted students (Glaser & Chi, 1988; Kalyuga, Ayres, Chandler, & Sweller, 2010; Song & Parath, 2005; Steiner & Carr, 2003; Sternberg, 1998; Subotnink & Jarvin, 2005; Sweller, Clarkm, & Kirschner, 2010).

The globally gifted students displayed an understanding of both topics that was more characteristic of an expert-type understanding than the not gifted students. In terms the knowledge displayed for both topics, the gap between globally gifted and not gifted students increased two weeks after teaching indicating that the gifted students continued learning to a greater extent compared to the not gifted students. This could be a result of their increased knowledge at pre-teaching which assisted these students in making links with the teaching more easily than the not gifted students (Ausubel, 1968; Munro, 2005; Reif, 1984).

In terms of the students who were gifted in a single domain, the amount of domain-specific knowledge that these students displayed at post-teaching can be understood in the following ways. Overall across both topics, the verbally gifted students were more likely to display additional concepts, especially following the two-week delay; however, these students
did not display more knowledge of the topics in terms of displaying an understanding of the central concepts being assessed in the topic when compared to the not gifted students. Overall, the differences between the students gifted in a single domain and the not gifted students were not as evident as the differences between the globally gifted and the not gifted students. Across both the science and humanities topics, being gifted in both verbal and nonverbal domains (globally gifted) was associated with a greater display of verbal propositions than being gifted in a single domain or neither domain.

7.9 Hypothesis 7

The knowledge of gifted students post-teaching is more semantically organised than the knowledge of not gifted students.

It was hypothesised that the gifted students would display more semantic organisation of the topics following the teaching when compared to the not gifted students. This was assessed through the measures of hierarchical categorisation of concepts and the inference of big ideas to organise and represent ideas in broad semantic categories.

7.9.1 Hierarchical categories, energy topic. Immediately after the teaching the globally gifted students and the students gifted in the verbal domain displayed approximately two hierarchical categories compared to one hierarchical category for the not gifted students. The differences were not sufficiently large enough to reach statistical significance. The nonverbally gifted students displayed approximately the same number of hierarchical categories as the not gifted students. Two weeks after the teaching, similar patterns were seen in the mean number of hierarchical categories displayed by each group, with the globally gifted students and the students gifted in the verbal domain displayed approximately two hierarchical categories compared to one hierarchical category for those students gifted only in the nonverbal domain and the not gifted students.

When assessing the likelihood that students within each group displayed hierarchical categories or not, immediately after the teaching, more than three quarters of the globally gifted students and the verbally gifted students displayed hierarchical categorisation of concepts. Approximately half of the students gifted in the nonverbal domain only and the not gifted students displayed at least some hierarchical categorisation of concepts immediately after the teaching. The differences between the gifted groups and not gifted students were not statistically
significant. After the two-week delay, the globally gifted students and the verbally gifted students were more likely to display hierarchical categorisation than the not gifted students (p < .05). All of the globally gifted students displayed hierarchical categorisation of concepts after the two-week delay. Although the difference between globally gifted and not gifted students did not reach statistical significance, the display of hierarchical categories by all globally gifted students demonstrates that this type of semantic organisation is characteristic of the globally gifted students’ knowledge structures.

**7.9.2 Hierarchical categories, migration topic.** Immediately after the teaching no differences were found between the gifted groups and the not gifted students in terms of the mean number of hierarchical categories displayed. Fewer hierarchical categories were displayed overall for the migration topic when compared with the energy topic, which resulted in less differentiation between the groups. Two weeks after the teaching the globally gifted students displayed the highest mean number of hierarchical categories however no differences were found between the gifted and not gifted groups.

When assessing the likelihood that students within each group displayed hierarchical categories or not, immediately after the teaching, approximately three quarters of the students gifted in a single domain displayed at least some hierarchical categorisation of concepts. Approximately two thirds of the globally gifted students displayed hierarchical categorisation of concepts whereas just over half of the not gifted students displayed at least some hierarchical categorisation of concepts immediately after the teaching. The differences between the gifted and not gifted groups were not sufficiently large enough to reach statistical significance. However, the data show that immediately after the teaching, the students gifted in either or both domains were more likely to organise concepts into semantic hierarchies with a more abstract concept being differentiated into superordinate concepts. After the two-week delay, consistent with the findings from the energy topic, all of the globally gifted students displayed hierarchical categorisation of concepts. Also consistent with the energy topic was the decrease in the proportion of verbally gifted students who displayed hierarchical categorisation of concepts from assessment phase T2 to assessment phase T3. That is, following the two-week delay, less of the verbally gifted students displayed hierarchical categorisation. They (verbally gifted students) were the least likely to display hierarchical categorisation two weeks after the teaching after
having been the most likely, along with the nonverbally gifted students immediately after the teaching.

7.9.3 Big ideas, energy topic. Immediately after the teaching the globally gifted and verbally gifted students displayed more big ideas than the not gifted students (p < .05). Following the two-week delay, the nonverbally gifted students displayed more big ideas than the globally the not gifted students (p < .05). Following the two-week delay, the nonverbally gifted students displayed more big ideas than the not gifted students (p < .05). The nonverbally gifted students displayed on average approximately two big ideas compared to less than one for the not gifted students. The globally gifted and verbally gifted students did not display significantly more big ideas than the not gifted students.

When assessing the likelihood that the groups displayed big ideas, it was found that immediately after the teaching all of the globally gifted students displayed big ideas. Compared to the not gifted students, the globally gifted were more likely to display big ideas immediately following the teaching (p < .01). Furthermore, immediately after the teaching, the students gifted in a single domain displayed were more likely to display big ideas compared to the not gifted students (p < .05).

Although the globally gifted students did not display more big ideas than the not gifted students following the two-week delay, when assessing the likelihood that big ideas were displayed, all of the globally gifted students displayed big ideas. When compared to the not gifted students, the globally gifted students were more likely to display big ideas two weeks after the teaching (p < .05). The nonverbally gifted students were also more likely to display big ideas two weeks after the teaching when compared with the not gifted students (p < .05). The verbally gifted students were no more likely to display big ideas two weeks after teaching than the not gifted students.

7.9.4 Big ideas, migration topic. Immediately after the teaching the globally gifted students displayed more big ideas than the not gifted students (p < .05). After the two-week delay, the trend remained the same with the globally gifted students displaying the highest mean number of big ideas. The magnitude of the difference between the globally gifted and the not gifted students was not sufficiently large enough to reach statistical significance (p = .074).

When assessing the likelihood that students displayed big ideas immediately after the teaching, it was found that the globally gifted students were more likely to display big ideas than
the not gifted students (p < .01). All of the globally gifted students displayed big ideas immediately after the teaching compared to approximately half of the not gifted students. The students gifted in a single domain were no more likely than the not gifted students to display big ideas immediately after the teaching. Two weeks after the teaching, it was found that the globally gifted students were more likely to display big ideas than the not gifted students (p < .01). All of the globally gifted students displayed big ideas two weeks after the teaching compared to less than half of the not gifted students. The students gifted in a single domain were no more likely than the not gifted students to display big ideas immediately after the teaching.

7.9.5 Summary (semantic organisation). It can be said that the display of big ideas was characteristic of the globally gifted students. A similar pattern was observed across both energy and migration topics with all of the globally gifted students displaying big ideas at both post-teaching assessment phases. This type of organisation demonstrates the ‘chunking’ of information by these students. Instead of displaying knowledge that is more linear and algorithmic, these students displayed chunks or categories of ideas that were more closely related semantically. This is consistent with the early findings from Chi et al. (1981) who demonstrated a major difference between the knowledge of experts and novices. They showed that experts in physics classified categories according to the major physics principles as opposed to the more specific problems. This type of classification is consistent with the findings in the present study where the globally gifted students in particular were more likely to display knowledge of the topics using broad semantic categories or ‘big ideas’. The display of big ideas at post-teaching phases is also consistent with Munro (2013) who noted that gifted students organise and reorganise the ideas, which comprise their new understanding in more complex ways than students who are not gifted. Furthermore, Munro also noted that these students recognise and infer the main idea(s) within the information more rapidly than their not gifted peers. The more rapid inference of main ideas described by Munro emphasises the difference between gifted and not gifted students in the display of big ideas at post-teaching phases where all of the globally gifted students were able to demonstrate this.

Following the two-week delay across both topics it can be said that the globally gifted students displayed knowledge that was organised into more efficient and complete representations. The globally gifted students were the only group where all students displayed hierarchical categorisation and big ideas across both topics. The inference of big ideas along with
the increased number of hierarchical categories displayed by globally gifted students demonstrates that the efficiency and completeness of knowledge representation is comprised of both nonverbal and verbal skills. This is consistent with previous findings that found expert-type knowledge to be more efficiently organised (Austin & Shore, 1993; de Jong & Fergusson-Hessler, 1996; Gobbo & Chi, 1986; Larkin, McDermott, Simon, & Simon, 1980; Sternberg, 1998) and commensurate with the expert-knower model of giftedness (Munro, 2010, 2012). Scruggs and Cohn (1983) described the difference between gifted and not gifted students in terms of the rate at which the gifted students acquire and retain information. They concluded that the assimilation of information by gifted learners was somewhat ‘different’ when compared to not gifted learners. Perhaps, this difference could be attributed in part to the semantic organisation of knowledge by gifted students.

Austin and Shore (1993) found that high performing students represented their knowledge differently from low performing students in college physics. This suggests that the thinking of high performing students may provide some insight into the progression from novice to expert. According to Tashman (2013) it is not only the superior knowledge of experts that leads to better performance than novices, but the superior organisation of that knowledge. Ziegler in his Actiotope Model of Giftedness suggests that persons capable of excellent accomplishments are better able to steer the expansion of their action repertoire. A possible example of the ability to steer one’s expansion of their action repertoire could be through the efficient organisation of knowledge as mentioned by researchers such as Tashman (2013) and Berliner (1994).

The display of hierarchical categorisation of concepts and big ideas across both topics for the globally gifted students in commensurate with the notion of gifted students’ ability to organise and reorganise their knowledge and understanding in more complex ways as proposed by Munro (2013). Munro also reported that gifted students reorganise their knowledge by inferring big ideas more rapidly than their not gifted peers. Given that all globally gifted students displayed hierarchical categorisation of concepts and big ideas for both topics two weeks after the teaching; this could be interpreted as the more rapid semantic reorganisation of knowledge in comparison to the not gifted students, consistent with Munro (2013) and the notion of ‘difference’ described by Scruggs and Cohn (1983).
The semantic hierarchical nature of the concept maps drawn by gifted students indicates the type of organisation in long-term memory that is symbolic and indicative of expert-type knowledge structures. The hierarchical structures represented in the concept maps of gifted students show that the gifted students were able to prioritise the main ideas within a given topic and infer logical patterned understanding that reflects expert type understanding of a topic (Munro, 2010, 2012). This could be explained in part by the increase especially for some students to display more hierarchical categories following the two-week delay. This delay allowed time for students to integrate the taught ideas into their existing knowledge and organised this new knowledge in a way that fit with prior existing knowledge. The two-week delay was a time for restructuring knowledge. Zimmerman et al. (2011) found that students did not show any difference in the hierarchical structure from pre to post instruction. One possible explanation was that the students may not have actively integrated the new knowledge into their existing conceptual framework (Novak & Gowin, 1984).

7.10 Hypothesis 8
The knowledge of gifted students post-teaching is characterised by more interrelatedness of concepts than the not gifted students.

It was hypothesised that the gifted students display more interrelatedness of concepts for the topics following the teaching when compared to not gifted students. This was assessed through the measure of cross-links on students’ post-teaching concept maps.

7.10.1 Cross-links, energy topic. The results showed that immediately after the teaching, the verbally gifted students displayed the highest mean number of cross-links. The difference between verbally gifted and not gifted students was not large enough to reach statistical significance. Furthermore, immediately after the teaching, no differences were found between the globally gifted and nonverbally gifted with the not gifted students. Two weeks after the teaching the difference between the verbally gifted and not gifted students increased and the verbally gifted students displayed more cross-links than the not gifted students (p < .01). The globally gifted students and the students gifted in the nonverbal domain only displayed on average approximately one more cross-link than the not gifted students two weeks after the teaching. The differences were not sufficiently large enough to reach statistical significance. The nonverbally gifted students were the group who displayed an increase in the mean number of
cross-links displayed from following the two-week delay. Furthermore, the differences between all three gifted groups and the not gifted students increased following the two-week delay. The results for the energy topic differ from the findings of Zimmerman et al. (2011) who found no difference in the number cross-links displayed from pre to post instruction citing that the students were unable to increase their integrative ability to link two different sections of their concept maps. The present study shows that it was only the not gifted students who were unable to increase the number of cross-links from pre-to-post instruction.

In terms of the likelihood that students included cross-links, immediately after the teaching, no differences were found for the proportion of students within each group who displayed cross-links. Approximately two-thirds of the students from each group displayed cross-links immediately after the teaching. Following the two-week delay, the proportion of students displaying cross-links increased for the three gifted groups and decreased for the not gifted students. The verbally gifted students (p < .01), globally gifted (p < .05) and nonverbally gifted (p < .05) were more likely than the not gifted students to display cross-links two-weeks after the teaching. Almost three quarters of globally gifted and nonverbally gifted students displayed cross-links two weeks after teaching whilst more than ninety percent of verbally gifted students displayed cross-links two weeks after the teaching. These findings are commensurate with the notion that expert knowledge is characterised by more connected and interrelated knowledge structures (Mintzes, Wandersee, & Novak, 1997). In comparison, approximately one-third of the not gifted students displayed cross-links two weeks after teaching. The proportion of not gifted students who displayed cross-links immediately after the teaching was almost halved following the two-week delay having decreased from 64% to 39%.

7.10.2 Cross-links, migration topic. The results showed that immediately after the teaching no differences were found between gifted and not gifted students in the mean number of cross-links displayed. The nonverbally gifted students displayed the highest mean number of cross-links and the verbally gifted students displayed the lowest mean number of cross-links. Two weeks after the teaching no differences were found between gifted and not gifted students in the mean number of cross-links displayed. The verbally gifted students displayed the highest mean number of cross-links, almost one more than the not gifted students. The verbally gifted students were the only group that displayed an increase in the mean number of cross-links following the two-week delay. The globally gifted, nonverbally gifted and not gifted students all
displayed a decrease in the mean number of cross-links displayed following the two-week delay. The results for the migration topic are consistent with the findings of Zimmerman et al. (2011) who found no difference in the number cross-links displayed from pre to post instruction citing that the students were unable to increase their integrative ability to link two different sections of their concept maps.

Immediately after the teaching more approximately half of the globally gifted and not gifted students displayed cross-links. The nonverbally gifted students (73%) were most likely to display cross-links immediately after teaching. The difference in the proportion of nonverbally gifted and not gifted students was verging on statistical significance (p = .06). Following the two-week delay the verbally gifted students were more likely to display cross-links than the not gifted students (p < .01). The proportion of not gifted students displaying cross-links two weeks after the teaching decreased to one-third of students (33%). The proportion of not gifted students who displayed cross-links immediately after the teaching decreased from 50% to 33% following the two-week delay.

7.10.3 Summary (interrelatedness of concepts). The display of cross-links demonstrated the student’s capacity to identify relationships across hierarchies or networks of knowledge on the concept maps. Overall for the energy topic, following the two-week delay, the gifted students were more likely to display concept maps that were more interconnected than the not gifted students. Although gifted students displayed more interconnected and integrated concept maps immediately after teaching than not gifted students, the differences increased between the gifted and not gifted students following the two-week delay. Across both energy and migration topics it is notable that the proportion of not gifted students displaying cross-links decreased from immediately after the teaching to two weeks after the teaching. Following the delay, the not gifted students were less likely to display knowledge that was interconnected.

In their study of problem solving in science using concept maps to assess students’ knowledge, Zimmerman, Maker, Gomez-Arizaga, and Pease (2011) found no difference in the number cross-links displayed from pre to post instruction citing that the students were unable to increase their integrative ability to link two different sections of their concept maps. However, some notable differences between the Zimmerman et al. (2011) and the present study should be considered. First, their study assessed students post teaching at one time point whereas in the present study, students were assessed at two time points post teaching. In the present study,
differences were notable between the two post teaching phases. Furthermore, the Zimmerman et al. (2011) study did not assess differences in the knowledge characteristics of students with different ability levels. In the present study, differences were seen across each assessment phase between gifted groups and not gifted students. Furthermore, the measurement of cross-links in the Zimmerman et al. study did not take into account the proportion of students who displayed at least some cross-links and used only the mean number of cross-links at pre and post teaching. In the present study, differences were seen between gifted and not gifted groups in terms of the proportion of students who displayed cross-links at different assessment points. The findings from the present study thus show some results, which differ from the findings of Zimmerman et al. (2011).

The display of cross-links on students’ concept maps at both post-teaching assessments showed varying results across the two topics. It was hypothesised that the gifted students would display knowledge at both post-teaching assessment phases that was more interconnected than not gifted students. Across both topics, the biggest differences were seen two weeks after the teaching with the differences between not gifted and verbally gifted students increasing.

At both post-teaching phases across both topics, the proportion of verbally gifted students displaying cross-links was greater than the proportion of nonverbally gifted students displaying cross-links. Furthermore, the likelihood that the verbally gifted students displayed cross links increased at each assessment phase across both topics. As the students progressed further through the assessment phases, the verbally gifted students were more likely to identify relationships and connections between concepts within the topic. Their knowledge was becoming more interconnected at each assessment phase for both topics. The likelihood that the nonverbally gifted students would display cross links did not deviate substantially from pre-teaching to two weeks after teaching. That is, the level of interconnectedness displayed at pre-teaching for the nonverbally gifted students was reflective of the level of interconnectedness that these students displayed two weeks after teaching.

Cross-links often represent creative leaps on the part of the knowledge producer (Novak & Cañas 2008). The display of cross-links demonstrates a relationship that the learner has perceived between different segments or semantic paths within their display of knowledge for the topic. As described in Chapter 3, the componential theory of creativity (Urban, 1991) and
Cognitive Load Theory (CLT) highlight the importance of domain-specific knowledge in the construction of creative ideas and problem solving.

CLT describes how large amounts of domain-specific knowledge structures that are hierarchically organised allow for automatic processing. This automatic processing reduces the load on the thinking base, which is restricted by the minimal resources that are available in working memory. Thus, an increase in domain-specific knowledge enables the learner to use the thinking space for problem solving rather than retaining information that is not yet readily available in their memory structures. This idea is emphasised by Urban (1991) in his componential theory of creativity when suggesting that thinking space is vital in the development of creative ideas (divergent thinking) by allowing the learner to be flexible in their thinking and to be able to reformulate, redefine and reconstruct information as part of the creative process.

The idea presented by Urban (1991) proposes that an essential component of creativity is the domain knowledge for a topic and the capacity to engage in divergent thinking depends on the accessibility of knowledge that a student has within a specific domain. Therefore, the increase in cross-links for verbally gifted students at each phase might coincide with their ability to continually build or extend their verbal propositions for the topics. This is consistent with the notion of the verbally gifted learner presented by Munro (2005). Furthermore, this could be supported by the finding that in the present study the verbally gifted students were the group who displayed on average the highest number of additional concepts across both topics.

### 7.11 Model of Gifted Knowledge – Post-teaching

The results across the two topics post-teaching show that the knowledge of the gifted students was displayed in terms of characteristics of the expert-knower to a larger extent for the science topic, which is consistent with the display of knowledge at pre-teaching.

For the science topic, post-teaching the globally gifted students were more likely than the not gifted students to display more organised knowledge and more integrated and interconnected knowledge. The globally gifted students also displayed more valid propositions displaying more domain-specific knowledge of the science topic. The students gifted in a single domain showed fewer characteristics of the expert-knower. The verbally gifted students were more likely than the not gifted students to display organised knowledge in terms of hierarchical categorisation of concepts and interconnected knowledge. The nonverbally gifted students were more likely than
the not gifted students to display organised knowledge in terms of big ideas and interconnected knowledge.

Following teaching for the humanities topic, the globally gifted students displayed knowledge that was most characteristic of the expert-knower. The globally gifted students were more likely than the not gifted students to display more organised knowledge and more integrated and interconnected knowledge. The globally gifted students also displayed more valid propositions displaying more domain-specific knowledge of the humanities topic. The students gifted in a single domain showed fewer characteristics of the expert-knower. In fact, the nonverbally gifted students displayed knowledge for the humanities topic that was no more characteristic of the expert-knower than the not gifted students. The verbally gifted students were more likely than the not gifted students to display interconnected knowledge.

It is difficult to describe a model of gifted knowing without both differentiating between domains in which students are gifted and also the topics in which they will be display their knowledge. This is consistent with the notion of domain-specificity of giftedness in which students differ in the knowledge areas or subjects in which they are gifted (Munro, 2013). The notion of domain-specificity relates not only to the subject area in which gifted students show advanced conceptual networks but also to the irregularity of cognitive representations across those subject areas. For example, verbally gifted students were more likely to display integrated knowledge for the humanities topic whereas the nonverbally gifted students were more likely to display integrated knowledge for the science topic. Thus, the cognitive domains in which students were gifted correlated with different knowledge characteristics across subjects and differing levels of subject area performance. Furthermore, the knowledge characteristics that were displayed at pre-teaching appeared to remain consistent across the learning phase. It is thus important to consider the impact of prior knowledge on learning and how the learning capacity of gifted students might impact their learning outcomes.

7.12 Impact of Prior Knowledge on Learning Outcomes.

The knowledge displayed at pre-teaching was predictive of the knowledge displayed at both post-teaching phases. High positive correlations were found between the outcome measures of students’ knowledge characteristics at pre-teaching and post-teaching (Table 32, Chapter 6). As reported by Munro (2005) students with a more elaborate network of meaning units and links
between those meaning units for a given topic prior to teaching are more likely to form a broader understanding of the topic. This was found to be the case in the present study when examining the correlations between the outcome measures at post-teaching phases with outcomes at pre-teaching. The number of valid propositions displayed at pre-teaching was correlated significantly \((p < .01)\) with the number of valid propositions displayed at both post-teaching assessment phases. The positive correlation demonstrates a significant relationship between students’ learning capacity and their learning outcomes following the teaching. The diagrams showing growth across assessment phases for the number of valid propositions displayed shows that the gifted students consistently displayed more valid propositions than the not gifted students. However, the rate of increase did not differ between groups.

In terms of how this informs Hypotheses 6, 7, and 8, gifted students structured more science and history propositions from the core concepts than the not gifted students. The gifted students were more able to use domain specific concepts more effectively. Therefore, this points to the gifted students having a larger network of meanings in which they could draw on during the teaching. This is consistent with the notion expressed by Munro (2005) detailed in the model of the gifted learning capacity that gifted students have more elaborate network of meaning units or propositions. Revisiting the diagrams used to illustrate the gifted learning capacity, Figure 43 displayed two examples of students’ networks of meaning. The first student (Student A) had both more meaning units and a greater number of links between the meaning units. Imagine both students being exposed to the same information for a topic. Student A would have more units of meaning for making sense of additional information that is presented. Furthermore, this student could develop a broader understanding because the ideas are linked with other ideas, can chunk the information more efficiently, ‘put together’ more of this information into individual ‘bites’ or ‘chunks’, can come to an understanding more quickly, can operate more in a ‘big picture’ way, and can make wider links with existing knowledge and draw in a broader range of ideas. Thus, the learning capacity for a topic has direct implications for future learning.

7.12.1 Implications for the classroom. Therefore, when interpreting the capacity that students have to achieve ‘excellence’ or to display expert-type knowledge, there are multiple factors that should be considered. According to Heller, Perleth, and Lim (2005) the time that is spent in active learning should not be considered to be exclusively responsible for attaining excellence or expertise within a specific domain, as described by Ericsson in his construct of
deliberate practice. For example, it has been suggested that some children have a genetic potential to learn more easily, earlier, faster than others, to learn more complex and more abstract schemata than others and to remember and retrieve information better than others (Feldhusen, 2005). Given opportunities to engage in advanced cognitive and learning activities earlier than typical age-grade experiences, the genetic potential of these precocious children interacts with the stimulating experiences, producing learning and school achievements at above-average or extremely high levels (Wachs, 1992). There is abundant evidence that children who are gifted, as evidenced by their high IQs, and who enjoy their parents’ and teachers’ rich nurturance, develop superior abilities and achieve at much higher levels than do those who are not gifted (Ericsson, 1996; Benbow, Lubinski, & Buchy, 1996; Terman & Oden, 1959; Bloom, 1985; Holohan & Sears, 1995; Simonton, 1997). They learn rapidly and get far ahead of age mates and thus may be seen as precocious (Feldhusen, 2005). However, the diagrams (Students A and B) demonstrate the differences in units of meaning that represent the knowledge differences that exist between students who are gifted in terms of their knowledge or understanding for a topic. One way to assess students’ capacity to achieve ‘excellence’ within the classroom is through identifying their learning capacity for specific topics and their knowledge representations which includes their intuitive theories about the topic (Munro, 2013).

Ziegler and Phillipson (2012) reported that the evidence is clear in demonstrating the variance in individual pathways for achieving exceptionality and the unique interactions that each individual has with the environment results in different outcomes. Excellence is attributed to those individuals who negotiate these interactions successfully. Furthermore, some learners may be more likely to construct effective actions more successfully. For example, Ziegler, Vialle, and Wimmer (2013) used the example of how an individual’s IQ, although not an explanation for their effective actions, can be interpreted as an indicator of an effective repertoire of actions. Therefore, it is plausible that some students will be more likely to develop an effective repertoire of actions in the classroom context given differences in cognitive ability. This would contribute to the unique interactions that gifted individuals experience in the classroom.

Part of these unique interactions that individuals have with the environment could thus be the ways in which gifted students ‘see the world’. This notion is consistent with the idea stated by Shavinina (2007), who proposed that gifted individuals have a unique ‘intellectual’ picture of
the world, which manifests from the unique cognitive experience that is the basis for their giftedness. This unique cognitive experience is developed through the individual’s conceptual structures, knowledge base and as part of this, their subjective mental space, or thinking space. Furthermore, this unique experience results in the gifted individual seeing, understanding, and interpreting information differently from their not gifted peers. Their ‘giftedness’ stems from characteristics of their learning and their ability to learn. This description of ‘giftedness’ reflects the notion that the gifted student will develop knowledge that is unique and distinct to the knowledge of their not gifted peers, shaped not only by their innate abilities, but also by the environment in which they learn.

Given that the knowledge of gifted students will be shaped by the environment in which they learn, appropriate differentiation might allow these students to develop more breadth and depth of knowledge. As reported by Van Tassel-Baska (2008) differentiation in its simplest form in based on the differences with respect to precocity and complexity of gifted students with their not gifted peers and thus differentiation stems from being responsive to these differences. Therefore, in order to effectively differentiate for gifted students it is necessary to continually define what the precocity and complexity looks like within the classroom context and to recognise this within the learning capacity of gifted students across subject areas. The present study provides a basis for identifying gifted students’ learning capacity within the context of the classroom.
CHAPTER 8
IMPLICATIONS AND CONCLUSION

8.1 Contributions of the Present Study

The aims of the present study were to explore the extent to which gifted students displayed a learning capacity that comprised the characteristics of the expert-knower and the extent to which students gifted in different domains differed in their display of knowledge characteristics. Furthermore, the present study aimed to assess the extent to which gifted students displayed learning outcomes that were characteristic of the expert-knower following teaching.

The issue presented as the rationale for the present study was framed around the lack of differentiation in regular classrooms for high ability students. It was noted that differentiation for high ability students is not a common practice in regular classrooms (Hertberg-Davis, 2009) and many gifted students have abilities that are not easily recognised within the context of the school curriculum (Wallace, 2000). This issue results in teachers being unable to create opportunities to promote the development of students’ skills and abilities within the classroom. It was suggested by Wallace that appropriate educational provision within the classroom is necessary in order to encourage students to reveal their skills, abilities and understanding. Further attributed to this lack of differentiation within the classroom was the suggestion that the decline in Australia’s literacy and numeracy scores in international assessments could be attributed to a lack of provision for the extension of high achieving students within the classroom.

Investigators such as VanTassel-Baska and Stambaugh (2005) and Munro (2011, 2012) reported that one of the main reasons for the lack of differentiation for gifted students was teachers’ lack of professional knowledge about what giftedness looks like in the classroom. Thus building teachers’ professional knowledge of what giftedness looks like in the classroom context was pivotal in the process of differentiation for gifted learners. In order to build professional knowledge of what giftedness looks like in the classroom, it is necessary to find tools that can assess and distinguish the knowledge of gifted learners in comparison to their not gifted peers. Concept mapping was used in the present study to address this issue and the findings
demonstrated that this tool could be used in order to facilitate the process of identifying gifted students’ skills and abilities within the classroom and within the curriculum.

The present study has shown that gifted knowledge can be represented and observed using concept mapping as a tool to monitor students’ knowledge for the topics that they are learning. The present study demonstrated that students gifted in both verbal and nonverbal domains (globally gifted) displayed a learning capacity for both science and humanities topics that was characteristic of the expert knower to a larger extent than students gifted in a single domain. The present study also showed that students gifted in a single domain indeed displayed a learning capacity that showed varying representations of the expert knower and this could be attributed to the different cognitive profiles that these students have. The study also showed that the knowledge that students displayed post-teaching, their learning outcomes, were highly correlated with the characteristics of their learning capacity displayed at pre-teaching.

A number of implications have stemmed from the findings of the present study and are outlined in the following section.

8.2 Implications of the Present Study

8.2.1 The Importance of assessing gifted learning capacity. The identification of students’ learning capacity allows teachers to focus on how gifted students link ideas and provides an alternative to the use of intelligence measures for identification. The focus is on the quality of the knowledge of these students. The present study demonstrated that students differed in their capacity to generate propositions about the topics that they would study and to link ideas within the topics. Furthermore, the study also demonstrated that students differed in their capacity to display higher-level knowledge organisation. The present study showed that students’ learning capacity was highly correlated with their learning outcomes following teaching. The advanced knowledge development or complexity of knowledge can be described in terms of the efficient organisation and interrelatedness of ideas within the display of knowledge. As mentioned by Gobbo and Chi (1986) the structures of knowledge become more cohesive and integrated as children acquire expertise within a domain of study. Given that the cohesion and integration of knowledge were the characteristics of knowledge that showed the most inconsistencies across the two different topics, for all groups/types of gifted students, it is important that teachers can identify this prior to teaching, in order to facilitate the knowledge
acquisition and development for students who do not form expert-type knowledge characteristics spontaneously. Furthermore, given that students gifted in different domains display different learning capacities it is important for teachers to be aware of these differences in order to identify the pathways for students to develop their knowledge.

Students develop their intuitive theories of a topic by using their learning capacity to generate ideas and possibilities for the given topic. Therefore, it is vital for teachers to be aware of the intuitive theories that students are developing for the topics that they are teaching, and that these intuitive theories stem from students’ capacity to generate ideas based on their current knowledge, learning capacity, and picture of the world. The role of working memory is also important to consider when interpreting a student’s learning capacity. Working memory is the workspace that handles the encoding, retention, and retrieval of information and this relies on an intersection with long-term memory or long-term knowledge base (Gilhooly & Logie, 1998). Students with a gifted learning capacity can thus draw on their knowledge (stored in long-term memory) more easily and flexibly given its storage in a more efficient and complete way as demonstrated by the findings in the present study.

8.2.2 Domain-specificity for describing cognitive characteristics for gifted students.

The literature supported the notion that students differ in their knowledge areas or domains in which they are gifted (Munro, 2013) and that gifted students display advanced conceptual networks in some subject areas or domains; they do not show advanced development universally. An example of this could be a student who is creatively gifted in music. This student will likely have enhanced conceptual-abstract knowledge of music, rich bank of elaborated music experiences and can think in ways that allows them to construct creative music outcomes (Munro, 2013). To further elaborate this idea, students gifted either verbally, nonverbally, or globally, will display differing levels of development in terms of knowledge complexity for different topics of study. This provides further evidence that giftedness is domain-specific, but further to that, students who display giftedness in one or multiple cognitive domains may display more advanced knowledge development in some topics within the classroom whilst showing less advanced knowledge development in others.

The present study demonstrated that students gifted in a single domain displayed knowledge representations that were not consistent with those students who were gifted in multiple domains. Furthermore, the present study also demonstrated that students gifted in the
nonverbal domain were more likely to show advanced knowledge development for the science topic and students gifted in the verbal domain were more likely to show advanced knowledge development for the humanities topics. This coincides with research that attributed nonverbal or spatial abilities with strengths in the physical sciences and verbal abilities with humanities and social sciences (e.g. Benbow & Minor, 1990; Benbow, Lubinski, & Suky, 1996). The findings of the present study thus support the notion of domain-specificity for giftedness and provide descriptions of what the knowledge of gifted students across different domains of giftedness might look like in the classroom context.

These findings support the verbal-nonverbal distinction such as that described by Clark and Paivio (1991) where learners have access to two main systems when encoding information; verbal and nonverbal systems. If teachers can be aware of the different characteristics of verbally and nonverbally gifted students, they can differentiate teaching according to the most proficient ways in which students can encode new information. For example, teaching procedures could cue nonverbally gifted students to recode their imagery knowledge into verbal propositions in order to match more effectively with the verbal teaching information (Munro & Howes, 1998).

8.2.3 Using the novice-expert knower model to facilitate differentiation in the classroom. The current study provides a model to begin to unpack and describe the knowledge of gifted learners. According to Hertberg-Davis (2009), differentiation for high ability students in regular classrooms is infrequent. Munro (2011, 2012) in a review of the reasons for the lack of differentiation for gifted and talented students reported that the lack of differentiation could be attributed to teachers’ lack of knowledge of either or both gifted learning and the associated pedagogy and relevant curriculum. This finding was based on the work of Van Tassel-Baska and Stambaugh (2005) who found that teachers lack the relevant pedagogical knowledge and teaching skills for gifted and talented students. Furthermore, Wallace (2000) attributed the lack of differentiation for gifted and talented students to the difficulties in knowing how to integrate this into the school curriculum.

Research has demonstrated that differentiation that is designed to advance gifted students’ learning for a unit of study can enhance their learning of higher order skills within specific content areas (Van Tassel-Baska, 2008). Furthermore, Van Tassel-Baska also reported that when curriculum is designed to match students’ preferred cognitive strengths, teachers can predict or anticipate what students’ knowledge might look like given different cognitive
strengths. This coincides with Munro (2012) who suggested that the identification of the thinking that underpins the knowledge transformation for the novice to expert knower transition provides teachers with a tool to infer how gifted and talented student might interpret and construct an understanding of regular curriculum topics.

As discussed in the present study, the novice-expert knower model of giftedness (Munro, 2012) describes the similarities between an expert and gifted understanding. The present study presents evidence to suggest that the model should incorporate differences according to different types of giftedness. Some knowledge characteristics were shown to remain across gifted types however other characteristics were found to be specific to the type of gifted ability. As described by Shavinina (2007), the gifted students have a different cognitive picture that is represented in ways that reflect expert-type understanding. This is a product of their learning capacity that differs from their not gifted peers. Given that the present study demonstrated that students gifted in a single domain displayed unique patterns of knowledge representations, the novice-expert knower model should reflect these differences.

8.2.4 Concept maps provide a useful schematic tool for identifying and representing gifted knowledge as characterised by the novice-expert knower model – implications for teaching practice.

As stated in chapter three, no studies had previously used concept maps to assess the cognitive characteristics of gifted students, and the different ways in which knowledge is represented and organised according to different types of giftedness. It was proposed that given that the models of giftedness explored for the current study stemmed from the expertise literature, concept maps would be an appropriate tool to assess the knowledge of gifted students. The results of the current study have demonstrated the utility of concept maps to describe gifted knowledge and to differentiate between domains of giftedness.

The present study found that gifted students displayed knowledge that was more characteristic of the expert-knower in a number of ways. This was assessed through students’ knowledge representations using concept maps. This reiterates the findings that demonstrated the effectiveness of concept mapping for differentiating between the knowledge of experts and novices (Marshall, 1995; Mintzes et al., 1997; Vanides et al., 2005; West et al., 2000; Williams, 1998) given that the expert-knower model uses the expert performance approach as a framework to describe gifted knowledge. Thus, concept mapping could be a useful tool for teachers to assess
the extent to which students have developed ‘expert-type’ understanding of topics within the school curriculum.

Furthermore, the consistency between knowledge representations for gifted and not gifted students across time is consistent with prior research that found the majority of students constructed concept maps with consistent structure over time (Vanides et al., 2005). The knowledge characteristics assessed at pre-teaching were highly correlated with the knowledge characteristics at post-teaching phases, suggesting that concept mapping is an appropriate tool for tracking or mapping students’ knowledge across a teaching phase. As stated by Novak & Cañas (2006), concept maps illustrate a learner’s cognitive structure for a specific topic or domain and study and the cognitive structure reveals the learner’s conceptual understanding and thus insight into the developmental potential for that topic of study. The present study illustrated the potential use of concept mapping for providing insight into the developmental potential for gifted students across different topics. That is, teachers could use concept mapping to assess students’ domain specific knowledge of a topic prior to teaching, in order to assess their ‘developmental potential’ for that topic.

The use of concept mapping in the present study also illustrated the potential for this tool to identify changes in students’ knowledge from pre-to-post-teaching. This was consistent with the findings of Edwards and Fraser (1983) who reported that concept mapping was an effective method of identifying relevant knowledge before or after instruction. The findings of the present study also provide evidence and justification for the effectiveness of concept mapping for assessing and understanding a students’ thinking about a topic and thus could be a beneficial tool for formative assessment (Black & William, 1998).

The present study also supports the notion that concept maps are a direct method of analysing the organisation and structure of a learner’s knowledge within a particular domain (Mintzes et al., 1997; Novak & Gowin, 1984; Williams, 1998). This was supported in the present study by the findings that showed different knowledge representations across the two topics for students gifted in different domains. The unique representations across topics showed that students can differ in the representation of knowledge for different topics, showing more advanced development or expertise in certain topics or domains.

Concept maps are a direct method of looking at the organisation and structure of an individual’s knowledge within a particular domain and gives insight into the fluency and
efficiency with which the knowledge can be used (Williams, 1998). It was proposed in the present study that the notion of ‘difference’ as stated by Scruggs and Cohn (1983) could be understood in terms of the semantic organisation of knowledge by gifted learners. The use of concept mapping can identify the instances when students display this type of semantic organisation, which can lead to more efficient assimilation of information into their existing knowledge. Therefore, in terms of teaching practice, concept maps can provide teachers with a method of identifying students’ level of conceptual understanding. This can be used to inform teaching practices to scaffold appropriately the content within a topic.

Novak (2006) reported that one of the values of concept maps is that when children construct their own concept maps for a question or problem in any domain, they reveal with considerable specificity what is their developmental potential for the topic of study. Thus we are provided with a clear view of “what the learner knows” and we can design instruction to build upon this. This is consistent with the notion of intuitive theories that has been presented in the present study. Given that concept maps represent explicitly a child’s knowledge structure along with idiosyncrasies that develop with each child’s unique experiences (Edmondson, 2000), concept mapping can be a useful tool in identifying students’ intuitive theories for the topics that are being taught. One possible advantage of using concept mapping to identify students’ learning capacity and subsequent ‘intuitive theories’ includes the ease at which this procedure can be undertaken for teachers. Furthermore, concept mapping can be embedded in the topics that are taught within the curriculum. This helps teachers to see what the gifted learners know in an open-ended way that can be controlled by providing students with a context. Seeing what gifted learners know can facilitate the process of differentiation by forming reasonable expectations about what students might be able to achieve within a given topic.

Thus, the findings from the present study illustrate that concept mapping can be a useful tool for identifying gifted learning capacity and identifying the transition from novice to expert type thinking within the classroom context. Furthermore, in terms of teaching practice, concept mapping could be utilised as a method of pre and post teaching assessment. At the pre assessment phase, the use of concept mapping procedures can inform teachers about the breadth and depth of students’ domain specific knowledge. In terms of developing professional knowledge about what gifted knowing looks like, concept mapping could also be used to facilitate this process. Teachers could benefit from identifying and interpreting cognitive
characteristics that demonstrate an ‘expert-type’ understanding according to the characteristics assessed in the present study.

8.2.5 Implications for policy.

Following the recent inquiry into the provision of gifted education in Victoria, a number of policy recommendations were made. Three recommendations in particular focused on the identification and subsequent learning opportunities, in particular, curriculum differentiation for gifted students. These recommendations stated that:

- Processes for identifying all gifted students should be embedded in the education system
- Every gifted student in every Victorian classroom in every Victorian school should be provided with personalised learning opportunities to meet his or her individual needs
- All Victorian teachers should have a thorough understanding of giftedness and have the support they need to confidently and competently cater for gifted students in their classrooms, in particular through the use of curriculum differentiation

In order to support these recommendations, future policy and educational provision for gifted and talented students should focus on an explicit foundation that demonstrates how these students know, think and learn. The findings from the present study support the use of the ‘novice to expert knower’ model to contribute to this foundation.

In order for curriculum differentiation to occur, teachers must be provided with an explicit model of how gifted students know, think, and learn within the context of the classroom. Thus, policy should focus on teachers’ need to develop knowledge about the quality of gifted students’ knowledge, as well as its quantity, using the ‘regular student understanding’ as a reference point (Munro, 2013) as demonstrated with the novice to expert knower model. This reinforces the current notion that rather than talking about ‘extent’ or ‘level of giftedness’ in terms of the proportion of the population showing ‘gifted’ knowledge the focus should be on the quality and complexity of knowledge or understanding constructed. As noted by Munro (2013), this is particularly relevant to teachers as they deal with students’ knowledge and understanding on a daily basis. This approach would not only facilitate the identification of gifted knowing and thinking within the classroom context, but would allow teachers to differentiate the curriculum based on students’ learning capacity and their

The practice of curriculum differentiation therefore relies upon teachers’ capacity to interpret gifted knowing and thinking. That is, before teachers can differentiate learning for
‘gifted students’, they need to know and see what gifted knowledge looks like within the context of the school curriculum. As discussed widely in this thesis, this idea was emphasised by Wallace (2000) who reported that teachers had difficulty in differentiating the curriculum for gifted and talented students. Figure 48 describes this as a process where teachers are less able to recognise what constitutes a gifted learning capacity when their knowledge of how gifted students think is not sufficient. This has direct implications not only on teachers’ ability to differentiate, but also teachers’ opportunities to differentiate. As a result, students who display a gifted learning capacity for a specific topic will be less likely to develop their knowledge of the topic into talented learning outcomes.

![Figure 48. Cycle of seeing gifted knowing and thinking in the classroom.](image)

Policy should therefore emphasise the acceptance of a model such as the novice to expert knower model that allows teachers to see instances of gifted knowing and thinking within the context of the school curriculum, using the regular student understanding as a reference point. Furthermore, identification procedures such as concept mapping should be utilised in order to identify discipline specific knowledge. As reported in the previous section on the utility of concept mapping, Edwards and Fraser (1983) reported that concept mapping was an effective method of identifying relevant knowledge before or after instruction. The findings of the present study also provide evidence and justification for the effectiveness of concept mapping for
assessing and understanding a students’ thinking about a topic and thus could be a beneficial tool for formative assessment (Black & William, 1998).

This approach to identification and differentiation will support teachers in recognising the multiple ways in which students can display gifted knowledge. It will allow teachers to recognise the level of ‘expertise’ that students can show and will help teachers to see the ‘discipline-specific’ nature of giftedness. Furthermore, this approach will help teachers to have a greater awareness of what to look for in the students’ learning outcomes to recognise and describe instances of gifted knowing and thinking within regular curricula guidelines. This approach to policy would ultimately promote the differentiation of curriculum from a learning perspective and could lead to the embedding of effective differentiation practices into the regular classroom.

8.3 Limitations of the Present Study

8.3.1 Factors of learning that underlie the acquisition of knowledge. The novice-expert knower model provides a rationale and framework for describing knowledge that is typical of gifted students. However, this model does not provide a framework for interpreting the likelihood that students will display certain knowledge or acquire knowledge dependent upon other non-cognitive factors. For example, Gagne’s DMGT Model includes non-cognitive factors that underlie the notion of giftedness or talent. Furthermore, Ziegler’s actiotope model of giftedness includes the environment as part of the system that facilitates the development of excellence. The conceptual framework for the present study however focused solely on the cognitive aspects of knowledge. It is important to acknowledge that indeed there are other internal and external factors that contribute to the development and acquisition of knowledge and in the novice to expert knower transition.

The conception of giftedness based on the novice-expert knower model focuses on the cognitive factors as they relate to identifying gifted knowledge in a way that is practical for the classroom setting. In further explaining this position, a different conception of giftedness is examined. Subotnik, Olszewski-Kubilius, and Worrell (2012) propose a model of moving from ability to eminence. In this model they include delimiters and enhancers. The delimiters include low motivation, unproductive mindsets, low level of psychological strength, and poor social skills. These delimiters can restrict the development from ability to eminence in a specific domain. On the contrary the enhancers such as optimal motivation, productive mindsets,
developed psychological strength, developed social skills, and opportunities taken, can all contribute to the development from ability to eminence.

These delimiters and enhancers certainly are important factors when describing a model of giftedness, but when viewing giftedness through a knowledge-based model, for the purpose of a classroom assessment of the gifted learner’s knowledge, the assessment changes. The psychosocial factors that contribute to the development of giftedness are not required to make an assessment of that gifted learner’s conceptual development in a specific domain. However, this does not suggest that the underlying factors that contributed to the development of that conceptual knowledge are not considered. In terms of describing the knowledge it is not possible to do that without an understanding of those psychosocial factors, but in terms of practicality in the classroom, the ‘output’ is what is required to gain an immediate insight into the level of understanding.

There are various factors that contribute to the acquisition and development of knowledge. A graphical representation of knowledge must be viewed as the ‘end product’ of a complex system of factors all contributing to the learner’s knowledge. This approach is based on identifying what learners require in order to learn effectively. The factors include; a purpose for the learning, the outcomes of the learning, what the learner knows about the topic (prior knowledge), seeing a pathway to the goal, investing positive emotion into the learning, individual learning style, self-efficacy and seeing progress being made in the learning (Munro, 2003). These are all parts of a student’s knowledge acquisition process and the current study can only pertain to assessing a limited type of knowledge; in particular, that which can be expressed through verbal propositions on a concept map.

The various factors that contribute to the development of knowledge and understanding as described by Subotnik, et al., (2012) are consistent with models of giftedness described in chapter two. For example, the DMGT (Gagne, 2004) emphasises the developmental path from giftedness to talent that begins with the student’s cognitive capacity within a specific domain and the talented output that is influenced by extraneous non-cognitive factors such as culture, motivation, and so forth.

The present study thus cannot claim to provide teachers with a tool that can describe the range of factors that will lead to the actualisation of abilities and knowledge acquisition.
However, it can provide teachers with a tool to interpret what students know about a topic in a way that resembles the interactions between teachers and students in a regular classroom.

**8.3.2 Impact of classroom environment.** Following limitation one, the impact of gifted students’ classroom environments were not assessed in the present study. In models such as the Munich Model of Giftedness (Heller, Perleth, & Lim, 2005) and Gagne’s DMGT (2004), external moderators such as teachers and educational institutions impact on the transformation of innate abilities or gifts into talented outcomes. Therefore, a student’s classroom environment can potentially impact on their development from gifted to talented and could also impact on a student’s willingness to display their ‘gifted learning capacity’. This is further emphasised by Ziegler and Phillipson (2012) who stated that individuals’ pathways for achieving exceptionality vary depending on the unique interactions that they have with their environments. Thus, it is important to acknowledge that the present study could not ascertain the type of unique interactions that students perceived within their classrooms and how this could potentially have impacted on their displays of knowledge.

**8.3.3 Reduction in sample size.** Another limitation of the present study was the sample size, in particular the sample size for the gifted groups. Following the three assessment phases the overall sample was reduced to N=76 for the energy topic and N=67 for the migration topic. For the statistical analysis that was conducted to assess changes across time, only students who completed all sessions could be included in the analysis. Therefore, the sample size was reduced due to the number of students who were absent during any of the sessions. The time constraints of the participating schools did not allow for students who were absent to participate in sessions at alternative times. A number of factors impacted on the absence of students. For example, at one particular school, the sessions took place at the same time as inter-school sport activities. Therefore, students who took part in the sporting activities were absent for at least one of the sessions.

Furthermore, unlike most other study areas, the study of expertise or giftedness has a number of unique limitations. In particular, the study of expertise can be limited by the fact that the number of experts is, by definition, small (Baker, Cote, & Abernethy, 2003). The criterion for being ‘gifted’ in the present study was limited to those students who achieved scores in the top 10th percentile for the given cognitive assessments. Therefore, the restricted nature of the definition of ‘gifted’ makes the establishment of large sample sizes with strong statistical power
difficult. For the present study, the reduction in sample size was not anticipated at the beginning of the data collection phase. Given the restriction based on the top 10\textsuperscript{th} percentile criteria and the subsequent loss of participant numbers, the analysis was conducted with fewer than ideal numbers. This was noted in the results section and findings were interpreted accordingly.

8.4 Suggestions for Further Research

Further research could adopt similar methods as the present study across a larger range of topics within the classroom setting. This could contribute in determining whether the differences found across topics in the present study can be attributed to some underlying factor within science and humanities and whether this extends across domains of giftedness. Furthermore, further research could assess the impact of differentiated instruction that is tailored towards students’ learning capacity for a given topic. Subsequent assessment of students’ depth and breadth of knowledge and transition from novice to expert type thinking could be explored.

Further research could also explore the non-cognitive factors that can facilitate the novice-expert knower transition and the talent development process. As stated, Gagne (2004, 2005) emphasises that the developmental path from giftedness to talent is influenced by extraneous non-cognitive factors. Therefore, further research that examines the impact of non-cognitive factors on students’ development of the expert-knower characteristics could provide further relevant pedagogical implications that have relevance for teachers.

8.5 Conclusion

In order for schools to cater more appropriately for gifted students it is necessary that teachers build professional knowledge about what gifted knowing and thinking looks like within the context of the classroom and school curriculum. The novice-expert knower framework provides teachers with a set of criteria for which they can do this. The present study demonstrates that the learning capacity of gifted students differs according to the different domains in which the students are gifted. Therefore, this provides a basis for interpreting gifted knowing based not on a general set of criteria that constitute giftedness but on more specified criteria according to domains of giftedness including verbal and nonverbal domains. The present study also demonstrates that teachers can use the novice-expert knower framework to anticipate or infer the types of understanding gifted and talented students might form of a topic. Teachers
could use this approach to plan differentiation for regular classroom topics in order to give students who display a gifted learning capacity the opportunities to form the high ability understanding (Munro, 2013).

Therefore, the present study has demonstrated that concept mapping has the potential to be used as a tool to identify the cognitive characteristics that gifted students display when displaying their knowledge of science and humanities topics. These cognitive characteristics provide teachers with an insight into the level of thinking and understanding that students have engaged in within the specific context of the topic that is being taught. This insight can facilitate the process of differentiation for gifted learners within the classroom context.

Furthermore, the key idea that must be considered following this research is the professional knowledge that teachers have in relation to gifted knowledge. The findings from the present study can help teachers understand what gifted knowledge ‘looks like’ in order to ‘see’ instances of gifted thinking within their classrooms. Only after recognition of gifted knowing within the classroom can teachers begin to help these highly able students to develop their knowledge appropriately and achieve to their full potential.
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"How do grade 5 students show what their knowledge looks like?"

Hello! My name is Joe Santoro. I am a student at the University of Melbourne. I am doing a project to find out how people your age show what their knowledge looks like. When I finish my project it will be part of my degree, called a PhD. My supervisor, Dr John Munro, helps me with my research project. We both work in the Graduate School of Education.

Your school principal and your teacher have given me permission to send you this letter to tell you a bit about my research project. Once you have read the letter you can decide if you would like to take part. You should talk to your parents about the project too.

If you want to be part of the project, I would ask you to complete a few different tasks. Most of the tasks are just like doing your normal school work. You and all the other people from your class who are taking part would do all of the tasks in a normal classroom. The tasks that I will ask you to do will be just like normal work that you do in class. Some children will also be asked to do a short 3-minute interview with me about what you learnt in class. If you are chosen to do the interview, I will record what you say so that I can listen to it and write down exactly what you said. I will be there to explain about the different tasks and to answer any questions that you might have. If you don’t know an answer, or you don’t want to answer a question, that’s fine and you can choose to stop being part of the project at any time.

The project will have nothing to do with your school report or your grade for any of your subjects. I just want to see how different children show what they understand about the things they are learning in class.

After the project is over, I will lock all the information I have collected away safely in the Graduate School of Education for 5 years. I have to do this because it is a University rule. After that my supervisor will destroy them.

Remember, you don’t have to take part unless you want to. If you have any questions you should talk to your teacher or a parent. If they don’t know the answer to your question, they can contact me, or my supervisor, or the Research Ethics Office at the University for you.

If you want to be part of my project, and your parent(s) agree, please sign your name on the next page where it says “student”, and get your parent or guardian to sign as well.

Thanks for reading my letter.

Joe Santoro

Dr. John Munro (Supervisor)    Mr. Joe Santoro (PhD Student)
ph. 8344 0953    ph. 9035 4841
email: jkmunro@unimelb.edu.au    email: jsantoro@student.unimelb.edu.au
PLAIN LANGUAGE STATEMENT

Project: "Knowledge representation for high ability learners"

Introduction
The school that your child attends has been asked to participate in our research project. The aim of the study is to investigate the knowledge representation of high ability learners. The Human Research Ethics Committee at The University of Melbourne has approved this project. We would like to invite your child, along with the other Grade 5 children in the school, to participate in this project.

Recent reviews of the literacy, science and mathematics knowledge of Australian students have indicated that schools in Australia tend not to cater very well for high ability learners. We, Mr Joe Santoro and Dr John Munro, are researching some of the characteristics that might help to identify high ability learners. Mr Joe Santoro is planning to use the data as part of his PhD thesis at the Melbourne Graduate School of Education.

What will my child be asked to do?
Should you give permission for your child to participate, your child would be asked to contribute to the project in a number of ways. First we would ask your child to complete two different tasks, which assess general learning ability. These tasks will be conducted as group tasks, not on a one-to-one basis. Second, we would ask your child to complete three different brief tasks before they learn a topic in class. The tasks would look at what they already know about the topic that they are going to be taught. The tasks would all stem from work that is based on the Australian National Curriculum. Third, we would ask your child to complete another brief task, to show what they know about the topic after having completed the learning task. Furthermore, some children (about 20%) would be randomly selected and asked to participate in a brief interview of about 5 minutes, so that we can get a more detailed picture of what they learnt in the topic. With your permission, the interview would be tape-recorded so that we can ensure that we make an accurate record of what your child says.

The scores on the tasks that will be completed as part of the research project will not be used in any assessments by your child's teacher or by the school.

How will my child's confidentiality be protected?
We intend to protect your child's anonymity and the confidentiality of your child's responses to the fullest possible extent, within the limits of the law. Your child's name and all the information collected from the tasks will be kept in password-protected computer files. In the final report, your child, if selected for an interview, will be referred to by a pseudonym. We will remove any references to personal information that might allow someone to guess your child's identity. The data will be kept securely in the Melbourne Graduate School of Education for five years from the date of publication, before being destroyed.

Will participation prejudice my child in any way?
Please be advised that your child's participation in this study is completely voluntary. Should you wish for your child to withdraw at any stage, or to withdraw any unprocessed data you have supplied, you are free to do so without prejudice. All of the tasks that your child will do and the scores that they get will be handled in the strictest confidence.

Where can I get further information?
Should you require any further information, or have any concerns, please do not hesitate to contact either of the researchers on the numbers given below. Should you have any concerns about the conduct of the project, you are welcome to contact the Executive Officer, Human Research Ethics, The University of Melbourne, on ph: 8344 2073, or fax: 9347 6739.

How do I agree for my child to participate?
If you would like your child to participate, please indicate that you have read and understood this information by signing the accompanying consent form and returning it to your child's teacher.

Dr. John Munro (Supervisor)                          Mr. Joe Santoro (PhD Student)
ph: 9344 0983                                          ph: 9345 4841
email: jkmunro@unimelb.edu.au                          email: jsantoro@student.unimelb.edu.au

Melbourne Graduate School of Education
The University of Melbourne VIC 3010 Australia
T: +61 3 8344 8285  F: +61 3 8344 8529  W: www.education.unimelb.edu.au
APPENDIX B
CONSENT FORM

CONSENT FORM

PROJECT TITLE: Knowledge representation for high ability learners
Graduate School of Education, University of Melbourne

Dr John Munro from the Graduate School of Education, University of Melbourne, and Mr. Joe Santoro are researching some of the factors, which can be used to understand high ability learning. Mr. Santoro is planning to use the data as part of his PhD thesis at the Graduate School of Education, University of Melbourne.

The factors we are investigating include how much prior knowledge students have before being taught a topic in class, the student’s understanding of how concepts are related to one another for a topic, and the student’s understanding of how the ideas they have learnt all fit together.

I understand that:

- My child will be asked to complete a number of different tasks in these areas
- My child may be asked to conduct a short interview, which will be audio-taped
- The tasks will be spread out across the remainder of the 2013 school year
- My child’s participation is voluntary
- All tasks completed by my child and the scores they receive will get handled with the strictest confidence
- The scores on the tasks will not be used in any assessments by my child’s teacher or school
- My child will not be identified in any written material developed from the research project
- All data will be destroyed after a minimum period of 5 years
- Once signed and returned the consent form will be retained by Dr John Munro and Mr. Joe Santoro

I give permission for my child to be part of the research carried out by Dr John Munro and Mr. Joe Santoro.

Name of student ...........................................

Signature ............................................. Date .............................................
(Student participant)

Signature ............................................. Date .............................................
(Parent/Guardian)

HREC: 133927a.1, Date: 17/12/15; Version: 1

Melbourne Graduate School of Education
The University of Melbourne Victoria 3010 Australia
T: +61 3 9344 6205 F: +61 3 9344 6520 W: www.education.unimelb.edu.au
APPENDIX C
EXAMPLE OF DEFINITIONS THAT INFER THE CONTEXT FOR THE ENERGY TOPIC

Electricity: A source of energy (electrical)

Transfer: The transfer of energy from one form to another. The process of energy transfer e.g. chemical energy transfers to electrical energy

Work: Energy as the capacity for doing work.

People: Users or consumers of energy.

Sun: A source of energy e.g. provides solar power.

Petrol: A source of energy for cars e.g. chemical energy.

Tired: Lacking energy

Food: A source of energy for people e.g. kilojoules.

Household appliances: Consuming or using energy e.g. use electricity.

Fossil fuel: As a source of (non-renewable) energy.

Pollution: A result of burning non-renewable energy sources (i.e. petrol, gas).

Heat: A source of energy.

Cars: Consuming energy (petrol, gas, electricity etc.) or producing energy (movement, mechanical, kinetic).

Engine: Energy provider for car or vehicle or machine. Transfer chemical to kinetic energy.
APPENDIX D
EXAMPLE OF DEFINITIONS THAT INFER THE CONTEXT FOR THE MIGRATION TOPIC

**Movement:** Movement of people around the world.

**People:** People as migrants, migration involving people.

**Country:** E.g. “people move countries”.

**World:** E.g. “people move around the world”.

**Africa:** Country in the world where people migrate to and/or from; the birthplace of humans.

Human migration began out of Africa.

**Aborigines:** Originated in Africa and part of early human migration.

**Australia:** Home to the Aborigines; country with history of migrants; country sought after by migrants.

**Lake Mungo:** Place where Aborigines migrated; aboriginal site; related to lifestyle.

**Lifestyle:** Reason for migration; outcome of migration; related to people.

**Boat:** Mode of transport for migrating.

**Europeans:** Early migrants; First Fleet and/or Captain Cook; related to people as migrants.

**Water:** Reason for migration e.g. people need clean/fresh water; water as ocean (e.g. obstacle for early migrants such as ocean crossing).

**Food:** Reason for migration e.g. people need food to survive.

**Ice age:** Reason for early human migration; impact on lifestyle; climate impact.

**First Fleet:** Historical example of migration; people that migrated such as the Europeans.

**Asylum seekers:** People that migrate; current example of migration.
APPENDIX E

TABLES OF MEAN SCORES FOR KNOWLEDGE CHARACTERISTICS

Table 1

*Mean Number of Valid Propositions for Science Topic*

<table>
<thead>
<tr>
<th>Ability group</th>
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<th>Post-teaching</th>
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*Mean Number of Semantically Valid Propositions for Science Topic*

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*Mean Number of Additional Concepts for Science Topic*

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*Mean Number of Hierarchical Categories for Science Topic*

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Table 5

*Mean Number of Cross-Links for Science Topic*

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Table 6

*Mean Number of Big Ideas for Science Topic*

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<td>1.30</td>
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**Mean Number of Valid Propositions for Humanities Topic**

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**Mean Number of Semantically Valid Propositions for Humanities Topic**

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### Table 9

**Mean Number of Additional Concepts for Humanities Topic**

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<td>14</td>
<td>3.11</td>
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<td>3.33</td>
<td>4.92</td>
<td>15</td>
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<td>1.63</td>
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*Mean Number of Hierarchical Categories for Humanities Topic*

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Table 11

*Mean Number of Cross-Links for Humanities Topic*

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Table 12

*Mean Number of Big Ideas for Humanities Topic*

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APPENDIX F
DIFFERENCES IN USE OF SPECIFIC CONCEPTS

Tables 1 to 4 provide the data for students’ use of the list of provided concepts across each of the assessments phases. Table 1 displays the data for globally gifted students, Table 2 displays the data for nonverbally gifted students, Table 3 displays the data for verbally gifted students, and Table 4 displays the data for the not gifted students.

Table 1
*Use of provided list of concepts across assessment phases for globally gifted students*

<table>
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<th>Post-teaching (T3)</th>
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<td>1.00</td>
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<td>0.30</td>
<td>0.55</td>
<td>0.50</td>
</tr>
<tr>
<td>people</td>
<td>0.80</td>
<td>0.89</td>
<td>0.88</td>
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<tr>
<td>household appliances</td>
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<td>0.77</td>
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<td>0.89</td>
<td>1.00</td>
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<td>0.67</td>
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<td>1.00</td>
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<td>0.61</td>
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Table 3

*Use of provided list of concepts across assessment phases for verbally gifted students*

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<td>people</td>
<td>0.53</td>
<td>0.65</td>
<td>0.69</td>
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<td>0.23</td>
</tr>
</tbody>
</table>
Table 4

*Use of provided list of concepts across assessment phases for not gifted students*

<table>
<thead>
<tr>
<th>Concept</th>
<th>Pre-teaching (T1)</th>
<th>Post-teaching (T2)</th>
<th>Post-teaching (T3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>energy</td>
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<td>0.93</td>
<td>1.00</td>
</tr>
<tr>
<td>transfer</td>
<td>0.12</td>
<td>0.02</td>
<td>0.18</td>
</tr>
<tr>
<td>work</td>
<td>0.24</td>
<td>0.36</td>
<td>0.33</td>
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<tr>
<td>people</td>
<td>0.53</td>
<td>0.69</td>
<td>0.82</td>
</tr>
<tr>
<td>household appliances</td>
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<td>0.60</td>
<td>0.64</td>
</tr>
<tr>
<td>cars</td>
<td>0.73</td>
<td>0.86</td>
<td>0.76</td>
</tr>
<tr>
<td>food</td>
<td>0.33</td>
<td>0.40</td>
<td>0.64</td>
</tr>
<tr>
<td>tired</td>
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<td>0.40</td>
<td>0.39</td>
</tr>
<tr>
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<td>0.67</td>
<td>0.70</td>
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<tr>
<td>fossil fuel</td>
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<td>0.31</td>
<td>0.33</td>
</tr>
<tr>
<td>electricity</td>
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<td>0.64</td>
<td>0.79</td>
</tr>
<tr>
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<td>0.62</td>
<td>0.73</td>
</tr>
<tr>
<td>sun</td>
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<td>0.45</td>
<td>0.67</td>
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<tr>
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<td>0.48</td>
<td>0.48</td>
</tr>
<tr>
<td>engine</td>
<td>0.31</td>
<td>0.36</td>
<td>0.48</td>
</tr>
</tbody>
</table>
The use and impact of energy in everyday life

This is the front cover of a book. What do you think the book is going to be about? Look closely at the pictures and think about what they might tell us about the book.
The human journey: Australia
and human migration

This is the front cover of a book.
What do you think the book is going to be about?
Look closely at the pictures and think about what they might tell us about the book.
Author/s: Santoro, Giuseppe Franco

Title: Gifted knowledge: What does it look like?

Date: 2016

Persistent Link: http://hdl.handle.net/11343/92243

File Description: Gifted Knowledge: What does it look like?