Thinking Skills and Creativity 15 (2015) 48–60

Contents lists available at ScienceDirect

Thinking Skills and Creativity

journal homepage: http://www.elsevier.com/locate/tsc

The impact of a cognitive acceleration programme in science on students in an academically selective high school

Grady Venville[a,*], Mary Oliver[b]

[a] University of Western Australia, Graduate School of Education, 35 Stirling Highway, Nedlands, WA 6009, Australia
[b] University of Nottingham, School of Education, Jubilee Campus, Wollaton Road, Nottingham NG81BB, United Kingdom

ARTICLE INFO

Article history:
Received 25 April 2014
Received in revised form
23 November 2014
Accepted 24 November 2014
Available online 2 December 2014

Keywords:
Cognitive acceleration
Thinking
Academically selective
Science
High achiever

ABSTRACT

This paper describes the impact of a thinking skills programme in science on the cognition of students in an academically selective high school. The research followed a sequential explanatory design with the collection and analysis of quantitative data in the first phase followed by the collection and analysis of qualitative data in the second phase. Participants were 582 Year 8 and Year 9 (ages 12–14) high school students and their science teachers from eight schools who participated in *Thinking Science*, a 2-year classroom intervention and teacher professional learning programme. The schools included one academically selective high school ($n = 144$) and seven non-academically selective schools ($n = 438$). Quantitative data were collected by Piagetian reasoning tasks administered to all students before and after the intervention. Qualitative data included interviews with the head of science and three participating science teachers from the academically selective school. Over the 2-year period, students from the academically selective school had a greater mean gain with a large effect size ($d = 0.995$) when compared with the control ($n = 120$) and when compared with other students who participated in the intervention with a medium effect size ($d = 0.687$). The qualitative data indicated that science teachers in the academically selective school were committed to the intervention and explained how they had changed their pedagogy as a result of the professional learning programme. More specifically, the teachers developed teaching strategies specific to the characteristics of their academically talented students that enabled them to participate in thinking activities such as metacognition and social construction. In conclusion, *Thinking Science* was a worthwhile intervention for all participating students, but particularly for students in the academically selective school where teachers were able to adapt their pedagogy and the approach to suit their students.

1. Introduction

The teaching and learning of thinking is becoming a more prominent aspect of educational policy and curriculum documents in a number of countries (Gallagher, Hipkins, & Zohar, 2012). For example, the European Commission's key competencies for lifelong learning is underpinned by themes including critical thinking and creativity (European Commission, 2007). The OECD's DeSeCo Project (OECD, 2005) recognises that individuals in today's world need to go well beyond the

* Corresponding author at: Graduate School of Education, University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia. Tel.: +61 8 64883811.
E-mail addresses: Grady.venville@uwa.edu.au (G. Venville), Mary.oliver@nottingham.ac.uk (M. Oliver).

http://dx.doi.org/10.1016/j.tsc.2014.11.004
1871-1871/

basic reproduction of accumulated knowledge and this requires "cognitive and practical skills, creative abilities and other psychosocial resources" (p. 8). Further, "individuals have to learn to think and act in a more integrated way" (p. 9). The Melbourne Declaration on Educational Goals for Young Australians (MCEETYA, 2008) acknowledged that successful learners "are able to think deeply and logically, and obtain and evaluate evidence in a disciplined way" (MCEETYA, 2008, p. 8). As a consequence of the Melbourne declaration, the first national curriculum in Australia, implemented in 2012, included seven general capabilities that are considered to be the skills, behaviours and attributes that students need to succeed in life in the 21st Century. One of these general capabilities is *critical and creative thinking*.

The Australian Curriculum recognises that "thinking that is productive, purposeful and intentional is at the centre of effective learning" (ACARA, 2012, p. 52) and requires teachers to explicitly teach and embed critical, higher order thinking and creative thinking throughout the learning areas. While teaching thinking is now an explicit and required goal of education in Australia, many teachers remain confused about what the teaching of thinking involves, how it might best be achieved and/or how it affects students' learning and achievement (Oliver, Venville, and Adey, 2011). This is an issue internationally, for example, Zohar, Degaini, and Vaaknin (2001) found that 45% of their sample of 40 Israeli teachers believed higher order thinking is inappropriate for low-achieving students. Prior to Israel's national curricular reform focussed on thinking, Gallagher et al. (2012) found that while "projects and local programmes have been quite successful, they have not succeeded in changing the bulk of teaching and learning... rather, such projects and programmes still exist as isolated pockets or 'islands' of exemplary teaching within a 'sea' of much more traditional schooling" (Gallagher et al., 2012, p. 139). Our own research and observations indicate that Gallagher et al.'s island metaphor can be applied to the current situation in Australia where there are examples of excellent practice with regard to the teaching and learning of thinking, but the vast majority of classrooms rarely incorporate activities designed to stimulate cognition in ways that will advance the students' thinking.

1.1. Research rationale

In order for the new Australian Curriculum to make a difference to students' education, evidence is required to support approaches to teachers' professional learning and curriculum development so that Australian children can genuinely become critical and creative thinkers. Two thinking programmes that have been implemented in Australian schools include the Philosophy for Children (P4C) programme (Lipman, 2003) and the *Thinking Science* cognitive acceleration programme originally developed in the UK by Adey, Shayer, and Yates (1989). The research reported in this paper was situated within the initial trialling of the *Thinking Science* cognitive acceleration programme in eight Australian schools. During the implementation of the *Thinking Science* cognitive acceleration programme in Australia, the authors noted contrasting views and opinions from school administrators and teachers with regard to students' levels of achievement and the teaching of thinking skills. On one hand, some educators suggested that a programme on thinking skills that improves cognition should be targeted at low ability students because it is likely to improve their achievement. On the other hand, other educators suggested that such a programme would only be suitable for academically talented students who would be more likely to cope with advanced thinking skills. We were surprised by such responses because evidence to date suggest that all students should be supported by, and can benefit from, excellent teaching and appropriate cognitive stimulation through the explicit teaching of thinking skills (Adey & Shayer, 1993; Adey, Robertson, & Venville, 2002). These contrasting opinions, however, stimulated the inquiry reported in this paper.

1.2. Research purpose

The purpose of this research was to explore the impact of the *Thinking Science* cognitive acceleration programme on the cognition of students in an academically selective school. In particular, we were interested in any change in the academically selective students' cognition compared with students who did not participate in the *Thinking Science* programme and also compared with students in non-academically selective schools who also participated in the *Thinking Science* programme.

1.3. Teaching thinking skills to high and low achieving students

Research shows that quality teaching is fundamental to student achievement (Hattie & Timperley, 2007; Louden, Rohl, & Hopkins, 2008; Rogers, 2007). According to the literature, characteristics of expert teachers include, but are not limited to, concern for students, passion, deep knowledge of the field, flexible instructional repertoires, respect (Matthews, 2009; Rimm, 2009; Van Tassel-Baska, MacFarlane, & Feng, 2006) as well as teaching practices that ensure individual progress (Diezmann & Watters, 2000) and emphasise higher order thinking (Louden et al., 2008). Importantly, good teachers challenge students, they teach skills of thinking and know their subject (Hattie, 2009). Research also has shown that students whose talents are exceptionally higher than their peers should have instruction, resources and activities corresponding to their talents (Feldhusen, 1998) and that school environments that make a difference to the learning of talented students provide opportunities for them to socialise and learn with students of similar achievement levels as well as opportunities to work with a wide range of peers (Gross, 2009; Rogers, 2007).

The press in Australia recently reported that "results flatline for top students" (Topsfield, 2013, p. 1) based on the findings of a major study in the state of Victoria. Griffin, Care, Francis, Hutchinson, and Pavlevic (2012) found that in both literacy and mathematics, primary school teachers were much more successfully able to initiate teaching strategies for low achieving students to improve their learning outcomes over 6 months than they were for high achieving students. The higher order skills or competencies in literacy included students being able to infer, evaluate, interpret, make judgements and use multiple pieces of information (Griffin et al., 2012). Griffin et al. speculated that there is a "national and systemic problem of a lack of teaching strategies or resources to encourage higher ability students to improve or progress at a rate commensurate with their ability" (p. 13). One of the underpinning reasons that Griffin et al. suggested for this lack of ability of teachers to appropriately stimulate high achieving students was because state and federal governments focused on 'closing the gap' between low and high achieving students, rather than improving the learning outcomes for students at all levels of the achievement spectrum. Similarly, McGaw (2008) pointed out that if Australia wants to improve on international tests, Australian educators must focus not only on improving low performing students' achievement but also on improving high performing students' achievement.

We speculate that the findings described above resonate with a defining feature of the Australian cultural characteristic referred to as of the 'Tall Poppy Syndrome'. Australia has an unspoken national ethos and profound respect for humility and loathing of egoism. The metaphor of a tall poppy represents people who demonstrably exploit their talents and the widespread cultural view that the tall poppies that make a show of themselves, have to be cut down, criticised and aligned with the majority (Feather, 1989). In the discussion of the findings we return to this sociocultural idea of a tall poppy and explore whether Australian educators may be influenced by a cultural cringe and loathing of high achievement.

In contrast with the Griffin et al. (2012) findings from Australia, previous research conducted in California and Michigan in the USA indicated that teachers of high achieving students are more likely to emphasise higher order processes than teachers in classes of low achieving students (Raudenbush, Rowan, & Cheong, 1993). Further, Warburton and Torff (2005) showed that the majority of the teachers in their study in the US state of New York believed that critical thinking activities were more effective for high achieving students than for low achieving students. These researchers did not mention whether they found any teachers who thought that low achieving students had more to gain through the teaching of thinking skills as we found in our discussions with Australian teachers. These studies indicate speculation and confusion with regard to the level of achievement of students and the suitability of thinking skills programmes amongst teachers and educators. There are, however, a small number of studies that provided empirical data directly related to this issue that we discuss in the following paragraphs.

Zohar and Peled (2008) assessed the effects of explicit teaching of metastrategic knowledge, on gains of 41 low and high achieving 5th Grade students in Israel. Metastrategic knowledge was defined as general knowledge about cognitive procedures of higher-order thinking skills and strategies (e.g. classification, causality, argumentation, hypothesising, evaluating). Tasks included two computerised simulation activities over nine teaching sessions on seed germination, for example, that allowed the students to plan experiments with several variables looking for causal relationships and drawing conclusions. The findings showed that the explicit teaching of metastrategic knowledge positively affected both low and high achieving students, but the low achieving students required a longer period of time than the high achieving students to reach their top score. Another finding was that the low achieving students in the experimental group outperformed the high achieving students in the comparison group by the end of the teaching sessions. The researchers were unable to make conclusions about whether the low achieving students made greater gains than high achieving students because of a ceiling effect on the tasks used.

In an overview of the findings from the original *Thinking Science* cognitive acceleration project, Adey and Shayer (1993) tested whether the students who showed the highest pre-/post- cognitive gains were those with either a low or high pre-score. They were interested to see if there was any indication that the students with low pre-intervention scores "had much to make up" or those with a high pre-intervention score could be "thought to be ready" for the cognitive stimulation through the thinking activities (p. 23). Adey and Shayer concluded that the high gainers came from a wide distribution of pre-intervention test scores and that this was supported by an absence of any correlation between starting level and gain. Similarly, results from a large study with a cognitive acceleration intervention with more than 470 Year 1 (5 and 6 year old) pupils in inner London (Adey et al., 2002), showed no relationship between cognitive gains over the single year of the intervention and pre-intervention cognitive score or achievement level in either language or number.

An exploratory case study we conducted in a low socioeconomic, regional high school where only 8% of the graduating students typically go on to university, showed that there are considerable benefits of teaching thinking to low achieving students (Oliver, Venville, & Adey, 2012). The case study students started the 2-year intervention at a lower mean cognitive level compared with the comparison students who did not participate in the programme. Findings showed, however, that the case study students made greater cognitive gains over the period of the intervention as indicated by a Science Reasoning Task with a medium effect size (Cohen's $d = 0.47$). Boys showed greater gains than girls. Further, independent national and state testing indicated that the intervention in the case study school resulted in participating students having significantly greater mean gains in achievement in science compared with all other students in the state with a small effect size (Cohen's $d = 0.21$), but not in reading, spelling and numeracy. Consistent with Zohar and Peled (2008), however, the final mean scores for cognition and science achievement from the case study students in the low socioeconomic school were still well below the final mean scores of the comparison group, indicating that while the overall gains by these students was significant, they probably needed more time compared with the control students to reach their full potential.

1.4. Significance of the research

The findings from the studies reported above seem to indicate advantages for all types of students through the explicit teaching of thinking skills. However, we found no studies that specifically investigated the teaching and learning of thinking skills within an academically selective school context. This research addresses this gap in the literature by specifically focusing on the outcomes for students of the teaching of thinking in an academically selective school. The findings are of interest to educators and researchers interested in the teaching and learning of thinking skills as well as those interested in the education of academically talented students. The educational significance of this research is that it provides data that will allow educators to answer questions about whether it is worth the time, expense and effort of teaching thinking skills to students specifically chosen for their academic talents to attend a selective school. It provides insight into educational questions about whether academically selected students already have advanced levels of cognition compared with other students; whether a thinking skills intervention makes a worthwhile difference at that high end of the educational spectrum; and, whether the context of an academically selective school makes a difference with regard to the teaching and learning of thinking skills compared with high achieving students in non-selective schools.

In engaging in this study, we have considered the argument that by investigating academically selected students, there may be an assumption that these students' higher levels of academic achievement and higher levels of cognition indicates a better state compared with students not in an academically selective school. Bourdieu offers a profound critique of *bourgeois* educational systems through his theory of social and cultural reproduction in education (Morrow & Torres, 1995). Morrow and Torres (1995) analyse the close link between educational reproduction and class reproduction and argue that education systems often perpetuate differences in educational status and in social class. While we were interested in the impact of a cognitive acceleration programme on students in an academically selective school, this was a practical approach to a contextual problem identified in Australia that we hoped would provide educational direction to the educators with whom we work. As Engeström (1999) explains:

> The underlying relativistic notion is that we should not make value judgments concerning whose cognition is better or more advanced – that all kinds of thinking and practice are equally valuable. Although this liberal stance may be a comfortable basis for academic discourse, it ignores the reality that in all domains of societal practice value judgments and decisions have to be made every day. People have to decide where they want to go, which way is up (Engeström, 1999, p. 26).

2. Methods

2.1. Research context

Each Australian state and territory is responsible for the education delivered in the state, and as a consequence, each state has a different approach to the education of high ability students (Seaton, Marsh, Yeung, & Craven, 2011). There is considerable variability with some states and territories providing in-school classes for high ability students while other states provide academically selective schools and others a combination of both in-school classes and academically selective schools.

The academically selective school that is the focus of this paper is centrally located in the capital city of one Australian state. The school's website states that the school "combines its strong and relevant traditions with a well-defined ethos and mandate to provide a differentiated curriculum that develops the skills and abilities of academically gifted students". Selection of students for entry into this academically selective school is based on the results of the Academic Selective Entrance Test coordinated by the state Department of Education for all gifted and talented programme applicants. The test includes individual assessments in the areas of mathematics and science, language, writing and non-verbal reasoning. (http://det.wa.edu.au/curriculumsupport/giftedandtalented/detcms/navigation/parents/how-to-apply-for-gifted-and-talented-programs/). At the time this paper was written, the Australian Government Myschool website (http://www.myschool.edu.au) reported that in 2013 the school had total enrolments of 1003 students in Year 8–Year 12 (girls: 458; boys: 545) with 23% having a language background other than English. There was 74.1 full time equivalent teaching staff. The school Index of Community Socio-Educational Advantage (ICSEA) was 1257. (The average ICSEA for all schools in Australia is 1000 with a standard deviation of 100.) Based on their ICSEA score, 89% of students in this school were classified as being in the top quarter of Australian students. From 2008 to 2013, Year 9 students at this school performed substantially above students in other Australian schools and substantially above or above students in schools from statistically similar socio-educational backgrounds in the National Assessment Program Literacy and Numeracy (NAPLAN).

2.2. Research design

The research followed a sequential explanatory design with the collection and analysis of quantitative data in the first phase followed by the collection and analysis of qualitative data in the second phase (Creswell, 2009). Participants were the students in eight schools participating in the 2-year *Thinking Science* cognitive acceleration intervention including students in one academically selective school that was the focus of the research.

The research question that drove the data analysis was:

What is the magnitude of the effect (if any) of the *Thinking Science* cognitive acceleration intervention on the academically selective school students' levels of cognition compared with:

(a) age-matched students who did not participate in the intervention?
(b) non-academically selective school students who participated in intervention?

Phase 1 of the research was designed as a quasi-experiment with three groups of students. The Academically Selective School Group included 144 students from the participating school who undertook the *Thinking Science* programme. Two comparison groups were used. For part (a) an age matched cohort who did not participate in the *Thinking Science* programme (Comparison Group A, $n = 120$), for part (b) non-academically selective school students who did participate in the *Thinking Science* programme (Comparison Group B, $n = 438$).

2.3. Theory base and description of the Thinking Science cognitive acceleration intervention

The *Thinking Science* cognitive acceleration intervention is a well-established Piagetian-based higher order thinking skills programme initially developed in the United Kingdom by Adey et al. (1989). Details of the theoretical base, practical approach of the programme, and the research outcomes are outlined by Adey and Shayer (1993, 1994) and Shayer and Adey (2002). In summary, the theoretical origins of *Thinking Science* are based on the writings of Piaget and Vygotsky. Piaget held the view that individuals mature biologically and that this process enables higher order thinking. In contrast, Vygotsky had the view that higher order thinking originates from human culture, therefore, development follows learning (Rosa & Montero, 1990). While these positions on development and learning seem contradictory, the developers of the *Thinking Science* intervention have long held the view that both perspectives inform the nature of pedagogy that impact not only on learning, but on cognition and development (Shayer, 2003).

The classroom intervention involves 30 thinking lessons that are implemented by science teachers over a period of 2 years when students are in Years 7–9. Students are required to participate in a thinking lesson instead of a regular science lesson about every 2 weeks. The lessons draw on Piagetian schemata of formal operations, for example, variables, proportionality, probability, correlation, formal models, and equilibrium (Adey & Shayer, 1994). Each lesson incorporates five important pedagogical strategies including concrete preparation, cognitive conflict, social construction, metacognition, and bridging. The three aspects of cognitive conflict, social construction, and metacognition are considered to precipitate the "mental work" (Adey & Shayer, 1993, p. 7) required by students to accelerate their cognition and the principal means by which the long-term, far-transfer effects of the intervention are achieved (Adey & Shayer, 1993).

The notion of cognitive conflict is considered to be one mechanism of development identified during the 1980s by scholars working within the Piagetian framework (Tudge, 1990). Cognitive conflict is a pedagogical tool that results in students being surprised with a phenomenon because their observations are inconsistent with expectations based on their current ways of knowing and thinking. It is designed to make students reconsider their current understandings and to be more receptive to different explanations and ways of thinking about a problem. Tudge (1990) claimed that research based on cognitive conflict showed that social interaction between peers who bring different ideas to the conflict problem is "a highly effective means of inducing cognitive development" (Tudge, 1990, p. 159). Moreover, Tudge argued that such peer collaboration is synonymous with the Vygotskian notion of more competent peers supporting development in the zone of proximal development. More recent research from a sociocultural perspective emphasises the importance of language and interaction between peers as a cultural and psychological tool in classroom contexts and indicates that such interaction can influence the development of children's reasoning (Mercer, 2010). Finally, metacognition is a very advanced form of self-regulation when students become aware of, and are able to, reflect on, manage, and manipulate their own learning through conscious and deliberate mental action. Researchers have demonstrated connections between metacognition and critical thinking (Magno, 2010), problem solving (Lai, 2011), and persistence (Martinez, 2006) that indicate the importance of metacognition to cognitive development.

The research reported in this paper resulted from the implementation in Australia of the cognitive acceleration programme, in this country called *Thinking Science Australia* (http://www.education.uwa.edu.au/tsa) in collaboration with the late Philip Adey, one of the original developers of the *Thinking Science* programme. This programme involved the adaptation of the *Thinking Science* materials to the Australian school context and professional development for science teachers in eight schools including one academically selective school that is the focus of the research reported in this paper. Over the course of 2 years, the science teachers from the eight schools participated in 6 days of professional development away from school. In the initial, 2-day workshop, teachers were introduced to the teaching materials, activities and the theoretical underpinnings of the programme. Programme leaders modelled lessons during the workshop, and these were then 'unpacked' to identify the different principles. Teachers were encouraged to plan together, between and within schools, sharing ideas and resources. Opportunities also were provided for team teaching, in-class coaching and peer observation. This particular model of professional development was adapted from Adey, Hewitt, Hewitt, and Landau (2004).

Table 1
An overview of the schools that participated in the *Thinking Science* intervention.

School	Sector	Location	ICSEA[a]	Students (n = 582)	Teachers (n = 62)
School 1	Public	Rural	946	68	6
School 2	Public	Rural	946	27	4
School 3	Public	City	984	62	7
School 4	Public	City	952	32	5
School 5	Public	Regional	969	94	9
School 6	Catholic	City	1187	91	9
School 7	Catholic	City	1000	64	8
School 8 (academically selective school)	Public	City	1257	144	14

[a] Index of Community Socio-Educational Advantage; average 1000, SD 100.

2.4. Participants

Data were collected in eight high schools (seven non-academically selective high schools and one academically selective) whose administration and science teachers volunteered to participate in the *Thinking Science* intervention. The data collection involved a total of 582 students (438 in the non-academically selective schools and 144 in the academically selective school) when they were in Year 8 and Year 9 (ages 12–14) over the 2-year period when *Thinking Science* was implemented in their science lessons (Table 1). Only twice tested students from each school were included in the data set. Published data with control and experimental groups have previously been made available for researchers to use for comparative purposes (Adey & Shayer, 1990). We drew on these data as an age matched cohort of Year 8/9 students (Comparison Group A) who did not participate in the *Thinking Science* intervention to gauge the effect of the intervention on the academically selective school students.

2.5. Methods of data collection and analysis

Phase 1 data collection utilised Piagetian-based Science Reasoning Tasks (SRT) to determine students' level of cognitive development before and after the *Thinking Science* intervention. SRT tests are a well-documented, validated measure to gauge the cognitive level of students (Shayer, Adey, & Wylam, 1981). The SRT data were analysed using Rasch scaling so that a fine estimate of a person's level of cognition can be converted directly into a decimal score on a scale ranging from early preoperational (1) to mature formal operational (10) with a standard error of about 0.4 (Adey & Shayer, 1993). The SRT (volume and heaviness) was administered to all Year 8 students prior to the implementation of the intervention and a different SRT (equilibrium and balance) was administered on completion of the full programme at the end of the 2nd year. The test was administered by teachers in their science classes and the test papers were scored by independent researchers. Test scores for the academically selective group and the comparison Groups A and B were compared statistically using a general linear model repeated measure analysis (ANOVA) to determine the interaction between the two independent variables of time (pre- and post-intervention) and participation in the thinking intervention for Comparison Group A, and time and attendance at an academically selective school for Comparison Group B. Cohen's effect size (d) was used to quantify the differences between the groups as suggested by Allen and Bennett (2008), p. 120 using comparisons of gain scores. Using Cohen (1988) conventions as a guide, d of 0.20 can be considered small, a d of 0.50 is medium, and a d of 0.80 is large (Cohen, 1988).

Phase 2 data collection involved an individual interview with the head of the department of science as well as a focus group interview with three participating science teachers from the academically selective school. Some of these data have already been reported (Oliver et al., 2012). The purpose of the interviews was to ascertain the participants' reflections on the implementation of the intervention, the successes and challenges and well as their insights into the effect of the programme on participating teachers and students. Both interviews were audio recorded and fully transcribed. The interviews were analysed through repeated listening to the audio recordings as well as repeated reading of the transcripts to isolate themes and ideas that were relevant to the research question and confirmed and/or provided insight into the quantitative data as well as themes and ideas that disconfirmed the quantitative data (Creswell, 2009). Excerpts from the transcripts were selected to include in this paper to illustrate emergent themes. Three methods were used to enhance the rigour of the qualitative data analysis, (1) researcher triangulation, (2) member checking, and (3) a search for confirming and disconfirming evidence as elaborated in the following paragraph.

The initial analysis and development of themes from the qualitative data collection were completed independently by the first author and then provided to the second author for reanalysis and reflection as a form of researcher triangulation (Patton, 2015). The second author had spent considerable time in all participating schools making classroom observations and interacting with the participating teachers and students during the *Thinking Science* intervention and hence her experiences were valuable to provide an informed perspective to the qualitative data analysis (Patton, 2015). The initial analysis of the qualitative data by the first author resulted in a number of small-grained themes. The second wave of analysis that involved the second author resulted in some of the initial small-grained themes being coalesced into three major themes of higher

Table 2
Pre/post-test mean scores, mean gains and effect sizes for the Academically Selective School Group, Comparison Group A and Comparison Group B.

	n	Pre-test mean (SD)	Post-test mean (SD)	Mean gain (SD)	Effect size of mean gain (Cohen's *d*)
Academically Selective School Group (+intervention)	144	6.23 (0.94)	7.89 (1.20)	1.65 (1.30)	
Comparison Group A (no intervention)	120	6.17 (1.03)	6.64 (1.36)	0.46 (1.09)	0.995
Comparison Group B (non-academically selective school students + intervention)	438	4.98 (0.35)	5.22 (2.04)	0.99 (0.21)	0.687

abstraction that are reported in the findings. Once the three major themes had been identified, a post hoc search of the raw interview data was conducted for evidence that either confirmed or disconfirmed the three major themes (Patton, 2015). As expected, considerable evidence was found to support the themes. Moreover, one small excerpt from the focus group interview was found that did not support the second theme and this is provided in the results below.

The first full draft of the paper was provided to the science head of department (HOD) and vice principal of the participating academically selective school for member checking and feedback (Patton, 2015) prior to submission for review. In particular, we were interested to know whether the HOD and vice principal considered that the three themes captured their perceptions of the use of the *Thinking Science* cognitive acceleration programme within their school. Both the HOD and the vice principal provided feedback that the themes and general ideas presented in the draft paper were consistent with their perceptions and this signalled to the researchers that the analysis of the qualitative data was sufficiently refined. The vice principal requested minor changes to the title of the paper and that a small part of the text from the presentation of the qualitative data be removed because it did not match her recollection of events. The HOD agreed that these changes were appropriate. As a consequence, minor changes were made to the paper. In the view of the authors, these minor changes did not affect the main findings and themes reported in the results.

3. Results

In this section, the quantitative results from Phase 1 of the research are presented first. The qualitative data from the Phase 2 interviews are then presented to provide possible explanations and insights into the trends evident in the quantitative findings.

3.1. *Phase 1 quantitative results*

While the students in the academically selective school started the programme with cognition levels slightly higher than students in both comparison groups, their mean gains of 1.65 (SD 1.30) compared with the mean gain for the Comparison Group A (non-participating students) of 0.46 (SD 1.09) and Comparison Group B (participating students not in the academically selective school) of 0.99 (SD 0.21) demonstrate the effect of participating in the structured thinking lessons over the 2 years (Table 2). It is evident that the students in the academically selective school who participated in the *Thinking Science* intervention not only outperformed the comparison group who did not participate in *Thinking Science* with a large effect size ($d = 0.995$), but also students who did participate in *Thinking Science* in other, non-academically selective schools ($d = 0.687$) with a medium effect size (Table 2). Overall, the quantitative findings indicate that the *Thinking Science* intervention improved all participating students' cognition significantly but had an even more significant effect on the students in the academically selective school.

3.2. *Phase 2 qualitative findings*

Analysis of the interviews resulted in three themes that provided possible explanations for the trends evident in the quantitative findings. These themes were: (1) school commitment, (2) a shift to thinking pedagogy, and (3) recognising and meeting the specific needs of students. Each of these themes is presented below and illustrated with excerpts from the interviews with the head of department of science (HOD) and the three participating science teachers from the academically selective school. Three assertions based on the data that correspond with the themes are provided.

3.2.1. *Theme 1: School commitment*

The first theme that emerged from the interview data was that the school was very committed to the intervention programme and to developing thinking skills within their students. The head of the science department (HOD) described the commitment of the school to the programme with full administrative support and all science teachers and the technician being involved in the professional development programme. One teacher explained that she found the *Thinking Science* package of lessons very helpful in terms of being able to teach thinking.

> HOD: Every staff member went through training, including the technician, it's an important part of the process. . . Any new members of staff were PD'd as we went along, and had to attend training; two units in the first year, then another two days training later, and observations. . . The key is the professional development of the teachers.

> Teacher M: Teachers in general find teaching thinking and generating resources for thinking lessons quite hard. It's out of the box. And having these lessons prepared for them really, really helps. Teaching a thinking lesson is a hard lesson to plan.

The head of science and science teachers recognised a number of practical challenges with regard to implementation of the programme including the time needed to coordinate the programme, continuing to fit it into the curriculum, and conventions such as desks set up in rows, that were impediments to students working in groups.

> HOD: We are convinced by [the data generated by] this program, but then it gets squeezed because we need to deliver the curriculum and other programs; it puts pressure on the *Thinking Science* program.

> Teacher M: There's the practical side of things, which is just the sheer logistics of doing it, the layouts of the worksheet, and then there's the pedagogy. I can see the challenges really were about the logistics, and now we're getting on to the actual teaching of it.

The findings under this first theme indicate the commitment the school had to the *Thinking Science* intervention but also showed that the participating science teachers recognised the logistical challenges of establishing such a programme in their school. These findings are summarised in Assertion 1.

Assertion 1: The academically selective school was committed to incorporating the *Thinking Science* intervention into the curriculum. Teachers recognised the logistical challenges that this created and devised ways of addressing these challenges.

3.2.2. Theme 2: Shift to thinking pedagogy

The second theme that emerged from the interview data was that the participants identified a shift in their pedagogical approach to something one teacher described as 'seeing the process of the students' thinking'. The head of science explained that his science staff initially found it challenging to focus on the process of thinking as the main objective of the lessons, rather than the students learning some specific content knowledge in science. He said that teachers found it difficult not to tell the students the answers, to get them to work through the problems themselves, and for teachers to come to terms with the idea that not every lesson has to come to a scientific conclusion. The teachers also recognised this shift in their pedagogy.

> HOD: *Thinking Science* is more about the program than the [science knowledge] outcome. Some of the teachers get caught up on outcomes. The science teachers found that hard. They want to end the process but it's not about that.

> Teacher M: I think it's a greater focus on thinking, in other words, I'm doing these lessons purely for thinking, not to teach them any real content.

> Teacher A: What can happen is we can get locked in or caught up in the delivery of the curriculum to the point that we don't make enough space to bring in the strategies that we all fundamentally agree with.

Some teachers were able to describe how this shift in pedagogy materialised in their classroom approach. For example, Teacher A discussed his approach to homework.

> Teacher A: In physics. . . very often if you get the right answer at the end, you get your two marks, full stop. When I set them homework, I don't always give them the full marks [for the right answer]. . . I'm always saying I want to see the process of your thinking to how you arrived at that. They get a little bit cross about that from time to time. And I'll say there will be marks in your homework for how you got there. And they say, well it's the right answer, so isn't that all that matters? Whereas if you're drawing out their thinking, that's the challenge.

Another teacher talked about 'creating a space to allow time for the students' thinking'.

> Teacher N: I think it's creating space to allow time for their thinking, it's kind of a comment I made earlier is that often when kids answer, now we'll say to them, 'Well why do you think that? What does everybody else think?', so it leads to better discussion. By asking the question, 'What does everybody else think?', I find that what happens is that kids think, 'Oh, that may not be the right answer', so it gives them kind of a space to think, 'Well maybe my answer is valid, then'. And I find that is a good approach.

This teacher also reflected on and recognised teachers' body language during classroom activities and how it had to change to accommodate the new pedagogy.

> Teacher N: I think there is a tendency to give it away a little bit with our body language when someone says the answer that you agree with; kind of your head is already starting to nod and you're, 'Ahh I need to stop that!' So, or you're shaking your head, and I think it's a question of holding back and not... saying, 'Oh that's an interesting point, I wonder what you guys think, what do you think?' and then getting more than one view, 'I know I agree with that', 'Ok, can you explain why you agree with that?'

The same teacher relayed an anecdote that demonstrated a shift in pedagogy that allowed the students the time to think and how that had a remarkable outcome on the lesson.

> Teacher N: Last year there was a really good example, I can't remember the specifics of the example, but basically the whole class bar one student thought one thing, and this one student thought something else. So I said, 'well what do you think?' By the end of the lesson they all agreed with that one student, so that was really helpful in terms of the cognitive conflict because it got them to change the way they were thinking which was good because you could say, 'Well don't just think that just because you've got a consensus with the majority that that necessarily is the right answer', which then set the platform for the next time round.

There was some evidence from the interviews that was inconsistent with this theme of a shift in pedagogy in that one teacher said that he felt that he had always been able to teach students to think.

> Teacher M: Right from the first day I taught, I always wanted the kids thinking, rather than doing, just get them thinking before they start doing or copying down notes and stuff like that.

The collective findings under the second theme show that overall, the *Thinking Science* programme resulted in teachers perceiving a change to their pedagogy, for example, providing their students with the space and time to think and requiring students to show their thinking in their homework. The teachers recognised that through these strategies they could 'see the process of their students thinking'. These findings are summarised in Assertion 2.

Assertion 2: The teachers in the academically selective school recognised and provided examples of changes to their pedagogy that enabled them to 'see the process of their students' thinking'.

3.2.3. Theme 3: Recognising and meeting the specific needs of students

When asked specifically about the suitability of this particular programme of thinking lessons for students in an academically selective school, the head of science said that one of the challenges was to set the lessons at the right level for high achieving students and that this can best be done by focusing on the social construction and metacognitive aspects that usually happen in the latter half of each lesson.

> HOD: [The students generally respond] very positively, some of them I would say do think that the lessons are below their level, but the key to the first few years is about training the staff. Once the staff have got it, they then start to realise the thinking, and then they focus more on the second part of the lesson and they get into that deeper thinking.

The head of science explained his view that some high achieving students are good at memorising and absorbing information, and one of the strengths of this programme is that it forces these students to apply their understandings:

> HOD: In the part of the lessons where you get that cognitive conflict, they still think they're right, but we say 'what is the evidence showing you?' Their mind shifting from their concrete ideas to being open to other ideas has proved to be quite an interesting experience for some of those students. What gifted kids can be very good at is absorbing the information but the application of that understanding can be more difficult for them.

> HOD: I think that's [metacognition] the bit that I hear them [the teachers] talking about the most. After the classes they'll say that their students were struggling with a concept but when they really got them to dig through and think about it, that's when it was interesting to see. Part of that is evaluating what they're doing. It's the students' accountability of their answer; makes them think about why they said their answer, and why they thought that. So it's again going to that deeper level.

While the head of science said that most of the participating students worked well during the group work, he conceded that the teachers in this school needed to be creative to involve some high achieving students who typically didn't like working in groups.

> HOD: For most students it [social construction in group work] works really well. There are always some that are independent workers and they struggle in groups because they can't get across what they know. And some students are socially inept. They are outstanding students, but they don't work well in groups and don't like working in groups, so you need to think of clever ways to involve them by asking their opinion in a group scenario.

Two teachers also explained their views on the challenges of facilitating group work with gifted and talented students and provided insights into their thoughts that gifted students often tend to want to hide any apparent lack of knowledge and want to showcase what they know. According to the participating teachers, these tendencies underpin the challenges of group work with gifted students.

> Teacher M: So, how do they solve cognitive conflict in groups? By arguing about who's right, you know. But essentially what they do is they solve, straightaway. If they're stuck, they ask me. The others where it doesn't make sense to them, they avoid it. Because they're with other kids who are obviously flying through this, they tend to avoid it, in other words, 'I don't really want to do this because I don't get it'.

> Teacher N: One of the things about the kids, and it may be true for other kids as well, but particularly gifted kids, is they have a tendency to want to show off what they know, and so because of that, group work means that they're sharing in the contribution of the group, rather than what they, individually, want to show. So that can sometimes be problematic. And it becomes particularly problematic when a kid in the group says, 'no, I'm right', and another one says, 'no, I'm right', because they're used to that individual work.

It was evident in the interviews that while the teachers in the academically selective school recognised the challenges of getting gifted and talented students to work in groups, they also had developed strategies to overcome these issues. For example one teacher explained:

> Teacher N: What I found was that if you made the point that everyone has to contribute, and then when I would go round the groups, you can say to them, 'Alright, that's really good hearing that from you, but what does this person over here think? Oh you had an interesting point'. And I think that's where the teacher management or the classroom management comes in when you're working with those groups.

The interview with the head of science indicated that he felt that the main strengths of the programme developed within the academically selective school were the development of the teachers' questioning skills so that they could include metacognition into their pedagogical approach.

> HOD: It's about the questioning style. . . Instead of giving the answers they are spreading the questions around rather than spoon-feeding the students the answers. So in that sense it's developing more autonomous learners.

The teachers also recognised the importance of questioning and using higher order, or what he referred to as 'extension' questions to challenge the academically gifted students in this school.

> Teacher A: I think sometimes there are further extension questions that we probably need to ask within the context of the lessons that we're doing, certainly the earlier lessons. So I think again that comes down to sort of just having that, and I know Teacher M and I have talked about this and she does ask those further extension questions. I think that's the challenge for us, with the sort of students that we're working with.

The findings under this third theme indicate that the teachers in the academically selective school recognised the specific characteristics and needs of their academically talented students. For example, they recognised the high level of achievement of their students meant they often could solve problems quickly and their need for extension, they recognised problems some students had with group work, and they recognised their tendency to be good at memorising and absorbing information but not necessarily at application of that knowledge. The findings also indicate that the teachers were able to describe how they had accommodated these specific characteristics with strategies that enabled them to participate in the important aspects of the *Thinking Science* programme such as metacognition and social construction. For example, teachers described improved questioning techniques, specific classroom management strategies, ensuring that all students have the opportunity and are encouraged to contribute and making sure they are accountable for their answers. These findings have been summarised in Assertion 3.

> Assertion 3: Teachers described strategies they had developed to enable higher order thinking, metacognition and social construction specifically appropriate to the characteristics of their academically talented students.

4. Discussion

The findings from this study were consistent with findings internationally that the explicit teaching of thinking skills was beneficial for students from all schools participating in the intervention (Adey et al., 2002; Zohar & Peled, 2008). Specifically in response to the research question, however, the magnitude of the effect of the *Thinking Science* cognitive acceleration programme on the academically selective school students' levels of cognition compared with students who did not participate in the *Thinking Science* cognitive acceleration programme was indicated by a large effect size ($d = 0.995$). Using Cohen (1988) conventions as a guide, d of 0.20 can be considered small, a d of 0.50 is medium, and a d of 0.80 is large. Hattie (2009), p. 7 recently suggested that an effect size of 1.0 is equivalent to "advancing children's learning by 2–3 years". The results from this research, therefore, show that over the 2 years of the intervention, the students in the academically selective school advanced their cognition by considerably more than the control students who did not participate in the programme and, according to Hattie, this can be considered to be similar to advancing these students schooling by about 2 years beyond what the control students were able to achieve. So in effect, over the 2 years of the intervention they were able to achieve what it would have taken the control students at least 4 years, if not more, to achieve. While these findings are quite outstanding in the spectrum of educational interventions examined by Hattie, it is important to consider the question about whether this effect was more or less for students in the academically selective school compared with students in conventional schools.

The magnitude of the effect of the *Thinking Science* cognitive acceleration programme on the academically selective school students' levels of cognition compared with non-academically selective school students who participated in the *Thinking Science* cognitive acceleration programme was indicated by a medium effect size ($d = 0.687$). This indicates that the effect for the students in the academically selective high school was over and above the effect for students in other schools who participated in the programme.

The findings presented in this study are seemingly inconsistent with the findings of Adey and Shayer (1993) who concluded that the high gainers in their study in the UK came from a wide distribution of pre-intervention test scores and that there was no correlation between starting level and gain. While Adey and Shayer did include a range of schools from different socioeconomic status with students from a range of achievement levels, they did not specifically include an academically selective school and/or examine the effects of the *Thinking Science* intervention on students in this specific type of environment. The contrast in findings between our study and Adey and Shayer's study, therefore, indicate that there was something about the academically selective school environment that resulted in the intervention having an enhanced effect on students who participated in the programme in this context. The qualitative findings from the interview with the staff members of the school provided some insight into the implementation of the programme in the academically selective environment.

The interview findings indicated that the implementation of the programme in the case study school was comprehensive and well-supported with all science teachers and the technician attending professional development, and in-class coaching supporting the development of the teachers' thinking pedagogies. A number of challenges were acknowledged by the teachers including fitting the programme into a crowded curriculum, organising the coordination of the programme, and arranging the classrooms to accommodate the group work for social construction. Further, teachers found it challenging to adjust their pedagogy to focus more on the students' thinking processes and less on the science content outcomes during the lessons. It is important to note these issues could be relevant in any school, not just an academically selective school.

More specifically with regard to high achieving students in an academically selective school, the interview data revealed the teachers' view of the importance of setting the lessons at the right level to challenge these students (Hattie, 2009), in particular through the social construction and metacognitive aspects of the lesson. The head of science reflected that many of the students in this school are excellent at absorbing information, which in science often supports achievement on assessments such as tests and exams. He further noted that applying their knowledge and reflecting on their own thinking and dialogue with others is where the lessons tended to become challenging. The teachers found that the *Thinking Science* lessons made the students more accountable for their ideas, because they had to think at deeper levels and explain why they had given a particular answer. The head of science also said that because some of the academically selected students do not like participating in group work, the teachers at this school had to be creative to facilitate the social construction aspects of the *Thinking Science* intervention lessons. This finding is consistent with research that shows the importance of socialisation and learning with students of similar achievement levels for academically talented students (Gross, 2009; Rogers, 2007).

The qualitative findings and reflections from the academically selective school science staff provide possible insight into the effects of the intervention with the students in this school. We speculate that because the students started with higher levels of cognition, beyond students in the other schools that participated in the intervention, the science teachers developed their thinking pedagogies to challenge the students at higher levels of thinking. It is possible, therefore, that the science teachers in this school may have developed higher skill levels than teachers in other schools, in particular, advanced skills at questioning and facilitating social construction and metacognition. It also is possible that teachers in other schools, where students started at lower levels of cognition on average, were not compelled to develop their pedagogies to such a degree because the cognitive conflict inherent in each lesson and less probing questioning skills were sufficient to stimulate the cognition of many of the non-academically selected students.

Griffin et al. (2012) found that in both literacy and mathematics, primary school teachers were more successfully able to initiate teaching strategies for low achieving students than they were for high achieving students. Griffin et al. speculated on the reasons why teachers in their study were less able to suggest strategies for developing students' higher order capabilities including that they may lack the confidence or the language to articulate their strategies or they simply do not know how to intervene with students who already work at higher order levels. We further speculate that the *Thinking Science* intervention in this study provided the science teachers in the academically selective school with specific strategies, such as appropriate questioning skills for social construction and metacognition, that could be used within the thinking lessons to stimulate the cognition of the high achieving students in their classes. This explanation is consistent with Vygotskian notions of the zone of proximal development that high quality interactions with the teacher and peers is the way that development occurs and findings in the literature that metacognition supports critical thinking (Magno, 2010), problem solving (Lai, 2011) and persistence (Martinez, 2006), thus invoking development.

The professional development programme, that involved all science teachers in the school and the laboratory technician, provided common language that enabled the teachers and other staff to reflect on and discuss the challenges they came across and the strategies they used to address the challenges. We suggest that through the professional learning the process of challenging students with higher order thinking was normalised and became an accepted and even expected strategy within the school. This normalisation in the context of the academically selective school possibly addressed the 'Tall Poppy Syndrome' evident in Australian culture that we suggested may have contributed to the problems identified by Griffin et al. (2012) and McGaw (2008). The evidence suggests that Australian teachers often are not able to extend and challenge high achieving students in ways that enable them to develop to their full potential. The findings from this study showed that within this academically selective school environment, and through the *Thinking Science* intervention, the teachers were able to implement strategies that stimulated the cognition of their high achieving students and resulted in accelerated cognition.

4.1. Limitations

This study is limited in that it was conducted in one academically selective school and it is inappropriate to generalise the findings. However, the importance of this study is that it gives insight into a specific case and this insight may be transferable to other schools in similar contexts. Further research that more deeply explores the teaching of thinking skills in academically selective environments and non-academically selective environments may give greater insight into the pedagogies and strategies that are suitable for students at different points in the cognition spectrum.

4.2. Implications

The implications for this research are relevant to how Australian schools respond to data that show that Australian teachers are not adept at challenging and supporting the learning of high achieving students (Griffin et al., 2012; McGaw, 2008). The implications are probably similar in other countries where teachers find teaching thinking skills to high achieving students challenging. An important implication is that academically selective school environments may have an advantage with regard to teaching thinking skills because teachers in this environment may be better able to concentrate on developing their pedagogy relevant to the academic skills and needs of their students. Moreover, the findings indicate that high quality questioning, as well as activities and pedagogy that stimulate social construction and metacognition are key activities for stimulating academically talented students' thinking skills and cognition.

Most importantly, the findings from this research support the egalitarian ideal that teaching higher order thinking is appropriate for all students. Our research, together with the research reported in the introduction to this paper, provides growing evidence that regardless of a students' baseline cognition, with appropriate, well-designed pedagogy that is tailored to their specific needs, it is likely that they will benefit from lessons on higher order thinking. We endorse Engeström's (1999) argument that all kinds of thinking are equally valuable; however, in the reality of educational systems and schools, educators have an obligation to make appropriate decisions about how they can best help their students to participate in levels of cognition beyond those with which they first came into their classroom.

5. Conclusion

The findings of this study indicated that the effect of the *Thinking Science* intervention was greater for the participating students in the academically selective school compared with both students who did not participate in the intervention and students who did participate in the intervention but were not in an academically selective school. The commitment of the academically selective school to the programme and the science teachers' change in pedagogy to facilitate activities that were particularly helpful to stimulate the thinking capacity of academically gifted and talented students were found to have contributed to the success of this programme.

Acknowledgements

This research was supported by a grant from the Australian Research Council (DP1093877). The ideas presented in the paper are those of the authors and not the funding body. We acknowledge the late Professor Philip Adey whose wisdom and encouragement over the years of this research were invaluable. The time and commitment from the administration, teachers, and students of the participating schools, in particular the academically selective school that was the focus of this research, is very much appreciated.

References

ACARA Australian Curriculum, Assessment and Reporting Authority. (2012). *General capabilities in the Australian Curriculum*. Canberra, Australia: Author. http://www.australiancurriculum.edu.au/GeneralCapabilities/General%20capabilities.pdf Accessed 25.01.12

Adey, P., Hewitt, G., Hewitt, J., & Landau, N. (2004). *The professional development of teachers: Practice and theory*. Dordrecht: Kluwer Academic Publishers.

Adey, P., & Shayer, M. (1990). Accelerating the development of formal thinking in middle and high school students. *Journal of Research in Science Teaching*, *27*(3), 267–285. http://dx.doi.org/10.1002/tea.3660270309

Adey, P., & Shayer, M. (1993). An exploration of long-term far-transfer effects following an extended intervention program in the high school science curriculum. *Cognition and Instruction*, *11*(1), 1–29.
Adey, P., & Shayer, M. (1994). *Really raising standards: Cognitive intervention and academic achievement*. London, UK: Routledge.
Adey, P., Shayer, M., & Yates, C. (1989). *Thinking Science: Student and teachers' materials for the CASE intervention*. London: Macmillan.
Allen, P., & Bennett, K. (2008). *SPSS for the health and behavioural sciences*. South Melbourne: Thompson.
Adey, P., Robertson, A., & Venville, G. (2002). Effects of a cognitive acceleration programme on Year 1 pupils. *British Journal of Educational Psychology*, *72*, 1–25.
Cohen, J. (1988). *Statistical power analysis for the behavioural sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.
Creswell, J. W. (2009). Research design: Qualitative. In *Quantitative and mixed methods approaches* (3rd ed.). Los Angeles: Sage.
Diezmann, C., & Watters, J. (2000). An enrichment philosophy and strategy for empowering young gifted children to become autonomous learners. *Gifted and Talented International*, *15*(1), 6–18.
Engeström, Y. (1999). Activity theory and individual and social transformation. In Y. Engeström, R. Miettinen, & R.-L. Punamäki (Eds.), *Perspectives on Activity Theory* (pp. 19–37). Cambridge, UK: Cambridge University Press.
European Commission. (2007). *Key competencies for lifelong learning: European reference framework*. http://ec.europa.eu/dgs/education_culture/publ/pdf/ll-learning/keycomp_en.pdf Downloaded 25.01.12
Feather, N. T. (1989). Attitudes towards the high achiever: The fall of the tall poppy. *Australian Journal of Psychology*, *41*(3), 239–267.
Feldhusen, J. F. (1998). Programs for the gifted few or talent development for the many? *Phi Delta Kappan*, *79*(10), 735–739.
Gallagher, C., Hipkins, R., & Zohar, A. (2012). Positioning thinking within national curriculum and assessment systems: Perspectives from Israel, New Zealand and Northern Ireland. *Thinking Skills and Creativity*, *7*(2), 134–143.
Griffin, P., Care, E., Francis, M., Hutchinson, D., & Pavlevic, M. (2012). The influence of teaching strategies on student achievement in higher order skills, school improvement: What does research tell us about effective strategies. In C. Glascodine, & K.-A. Hoad (Eds.), *Proceedings of the Australian Council of Educational Research (ACER) Research conference series* Camberwell, Victoria, (pp. 77–85). August, ACER.
Gross, M. (2009). Friendships. In B. A. Kerr (Ed.), *Encyclopedia of giftedness, creativity and talent* (Vol. 1) (pp. 361–364). Los Angeles: Sage.
Hattie, J. C. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*. London: Routledge.
Hattie, J. C., & Timperley, H. (2007). The power of feedback. *Review of Educational Research*, *77*(1), 81–112.
Lai, E. R. (2011). Metacognition: A literature review. *Person Research Report*,. Retrieved from www.pearsonassessments.com/reserach
Lipman, M. (2003). *Thinking in education* (2nd ed.). New York: Cambridge University Press.
Louden, B., Rohl, M., & Hopkins, S. (2008). *Teaching for growth: Effective teaching of literacy and numeracy*. Perth, Australia: Wren Press. http://www.uwa.edu.au/__data/assets/pdf_file/0005/615686/TFG_Final_Report.pdf Accessed 25.04.14
Magno, C. (2010). The role of metacognitive skills in developing critical thinking. *Metacognition Learning*, *5*, 137–156.
Martinez, M. E. (2006). What is metacognition? *Phi Delta Kappan*, 696–699.
Matthews, M. S. (2009). Gifted learners who drop out: Prevalence and prevention. In L. V. Shavinina (Ed.), *International handbook of giftedness* (Vol. 1) (pp. 527–536). New York: Springer.
MCEETYA Ministerial Council on Education, & Training and Youth Affairs. (2008). *Melbourne declaration on educational goals for young Australians*. http://www.mceecdya.edu.au/verve/_resources/national_declaration_on_the_educational_goals_for_young_australians.pdf Accessed 25th
McGaw, B. (2008). How good is Australian school education? In S. Marginson, & R. James (Eds.), *Education, science and public policy: Ideas for an education revolution* (pp. 53–77). Carlton, Victoria: Melbourne University Publishing.
Mercer, N. (2010). The analysis of classroom talk: Methods and methodologies. *British Journal of Educational Psychology*, *80*, 1–14.
Morrow, R. A., & Torres, C. A. (1995). *Social theory and education: A critique of theories of social and cultural reproduction*. Albany, NY: SUNY Press.
OECD. (2005). *The definition and selection of key competencies: Executive summary*. http://www.deseco.admin.ch/bfs/deseco/en/index/02.parsys.43469.downloadList.2296.DownloadFile.tmp/2005.dskcexecutivesummary.en.pdf Accessed 25.01.12
Oliver, M., Venville, G., & Adey, P. (2012). Effects of a cognitive acceleration program in a low socio-economic high school in regional Australia. *International Journal of Science Education*, *34*(9), 1393–1410.
Patton, M. Q. (2015). *Qualitative research and evaluation methods* (4th ed.). Thousand Oaks, CA: Sage.
Raudenbush, S. W., Rowan, B., & Cheong, Y. F. (1993). Higher order instructional goals in secondary schools: Class, teacher and school influences. *American Educational Research Journal*, *30*(3), 523–553.
Rimm, S. (2009). Underachievement. In B. Kerr (Ed.), *Encyclopedia of giftedness, creativity and talent*. Los Angeles: Sage (pp. x–x).
Rogers, K. (2007). Lessons learned about educating the gifted and talented: A synthesis of the research on educational practice. *The Gifted Child Quarterly*, *51*(4), 382–397.
Seaton, M., Marsh, H. W., Yeung, A. S., & Craven, R. (2011). The big fish down under: Examining moderators of the 'big-fish-little-pond' effect for Australia's high achievers. *Australian Journal of Education*, *55*(2), 93–114.
Shayer, M. (2003). Not just Piaget, not just Vygotsky, and certainly not Vygotsky as an alternative to Piaget. *Learning and Instruction*, *13*, 465–485.
Shayer, M., & Adey, P. (2002). *Learning intelligence: Cognitive acceleration across the curriculum from 5 to 15 years*. Buckingham, UK: Open University Press.
Shayer, M., Adey, P., & Wylam, H. (1981). Group tests of cognitive development-ideals and a realization. *Journal of Research in Science Teaching*, *18*, 157–168.
Topsfield, J. (2013, Thursday, January 10). *Results flatline for top students*. The Age.
Tudge, J. (1990). Vygotsky, the zone of proximal development and peer collaboration: Implications for classroom practice. In L. C. Moll (Ed.), *Vygotsky and Education: Instructional Implications and Applications of Sociohistorical Psychology* (pp. 155–172). Cambridge, UK: Cambridge University Press.
Van Tassel-Baska, J., MacFarlane, B., & Feng, A. X. (2006). A cross-cultural study of exemplary teaching: What do Singapore and the United States secondary gifted class teachers say? *Gifted and Talented International*, *21*(2), 38–46.
Warburton, E., & Torff, B. (2005). The effect of perceived learner advantages on teachers' beliefs about critical-thinking activities. *Journal of Teacher Education*, *56*, 24–33.
Zohar, A., & Peled, B. (2008). The effects of explicit teaching of metastrategic knowledge on low- and high- achieving students. *Learning and Instruction*, *18*(4), 337–353.
Zohar, A., Degaini, A., & Vaaknin, E. (2001). Teachers' beliefs about low-achieving students and higher order thinking. *Teaching and Teacher Education*, *17*(4), 469–485.