Nurturing the desire to be challenged: a framework for sustaining the motivation to persist using metacognitive thinking in a senior secondary STEM environment.

Submitted by

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STATEMENT OF SOURCES

This thesis contains no material published elsewhere or extracted in whole or in part from a thesis by which I have qualified for or been awarded another degree or diploma.

No other person's work has been used without due acknowledgement in the main text of the thesis. The thesis has not been submitted for the award of any degree or diploma in any other tertiary institution.

All research procedures reported in the thesis received the approval of the Human Research Ethics Committee at Flinders University.

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ABSTRACT

This study examines the relationship between the need for metacognition, defined as one's thinking about thinking, when students engage in effortful cognitive activity and how it affects variables associated with resilience and motivation. Students completed measures of meta-cognitive use and motivation, before, during, and after completing units of work where meta-cognitive strategies were explicitly embedded.

This study was conducted to solve an existing problem at a particular school where a number of students, identified as high achievers, were not considering or persisting with the science and mathematics courses offered.

The same problem has been reported as a world-wide trend (Mather & Tadros, 2014) and a plethora of actions have been attributed as the possible cause (Dinham, 2011; Mather & Tadros, 2014; Rotigel & Fello, 2004). These studies were used to distil the common constructs and this study proceeded to explore *what* can be done to mitigate the trend at the school.

The action-research methodology presents a framework for understanding and discussing the role of metacognition when cognition becomes problematic; particularly the effect that metacognitive thinking has in maintaining motivation and persistence when cognitively advanced students are challenged and tempted by less demanding academic pathways.

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CHAPTER 1: INTRODUCTION

TEACHING AND LEARNING

Synonymous with education are two important processes, teaching and learning; both certainly effect the quality of education but only one of these processes is an essential outcome, learning. Interestingly when a problem is identified within the education process it is often the teaching that commands the focus of attention rather than the learning.

In the early 21st century, a problem was identified within the educational outcomes of many developed countries due to the changing nature of the labour force. The concern centred on the declining number of students that were electing to pursue school based subjects that led to engineering pathways (Lazarides & Watt, 2015; Mather & Tadros, 2014, p. 5) when research predicted that problem-solving occupations, (such as engineering), would be in great demand. Educational data predicted a shortfall in skilled practitioners to meet the predicted requirements (Prieto et al., 2011; X. Wang, 2013).

Articles reporting the declining student numbers enrolled in subjects leading to technology and problem-solving based careers often focused on the ‘teaching’ processes. An Australian study found that secondary school subjects leading to engineering were not being selected because they were “boring, difficult, not well taught, and students were not aware of their importance” (Murray, 2011, p. 229). A similar study in the United Kingdom, sampling 1500 students across multiple schools reported that a “perceived difficulty and lack of confidence … perceived dislike and boredom, and a lack of relevance” (M. Brown, Brown, & Bibby, 2008, p. 3) were major factors. A European study with the same focus found that students “regarded these subjects as difficult, having a high workload and fast progression …” (Bøe & Henriksen, 2013, p. 552).

Proposed solutions to the problem included making the subjects more tangible by organising excursions, better textbooks, more specialised teacher intervention, greater use of appropriate technology (Murray, 2011); reducing the complexity of the subjects and "increasing the enjoyment and excitement" (M. Brown et al., 2008, p. 16); have programs that better inform students of the pathways opened by these subjects; altering the courses so that they become broader and more inclusive of a greater range of motivations (Bøe & Henriksen, 2013).

Developed countries, acknowledging this as a worldwide trend, soon recognised the need for special government intervention in order to improve the teaching of mathematics and sciences, blending this with problem-solving strategies and technological knowhow (Lowrie, Downes, & Leonard, 2017). The emergence of STEM (Science, Technology, Engineering and Mathematics) education as a priority was resultant of government initiatives and funding. The United States introduced specialised STEM schools (Erdogan & Stuessy, 2015) and STEM programs quickly spread globally; most countries adopted STEM programs that were integrated within a whole school approach. Many of these STEM programs focused on a particular way of presenting the courses, the *teaching* aspect of education.

So, where does the 'learning' come into this educational focus?

Teaching and pedagogies are no doubt important, but these are processes controlled by teachers. Not all students respond to pedagogies favourably and not all teachers are willing to embrace change and move away from their comfort zone (Hertberg-Davis, 2009; Lewis, 2016). Current thinking suggests that students ought to have a voice and therefore have some control over their capability for success, (Cook-Sather, 2020; Mevarech & Fridkin, 2006). If we agree that this should be the case, then the learning process ought to be a focus and not an after-thought attached to any pedagogy.

This research centres on the act of learning. Its aim is two-fold. Initially to explore how the introduction and practice of meta-cognitive strategies effects a student's decision making when studies become more difficult, and success is not guaranteed. A subsequent aim explored is the relationship between a student's autonomy, using metacognition, and a student's motivation to persist despite difficulties.

There are some assumptions that this research is based on:

i) That given the opportunity students will embrace a greater autonomy in their learning, (Ames, 1992).

ii) All students that employ meta-cognitive strategies explicitly exercise more control over their own learning than students who do so passively, (that is, students unaware of meta-cognitive strategies), (Mevarech & Fridkin, 2006).

iii) That the degree of motivational influence that can be attributed to knowingly deploying meta-cognitive strategies can be measured within an organised structure like a classroom, (Mevarech & Fridkin, 2006).

The research is targeted at high achieving students enrolled in either the advanced middle school program or senior secondary mathematics and physics courses. Recent studies have shown that adolescents' academic motivation decline over time; their interests and attitude towards school, in particular in subjects like mathematics and the sciences, tend to deteriorate (Murray, 2011). This work focuses on 'successful' students that have previously shown aptitude in their middle school years but struggle in their secondary years, primarily due to poor meta-skills (Al-Harthy & Was, 2010). As opposed to hard skills, skills that are teachable, quantifiable, and needed to complete a task, or soft skills, personal qualities that allow for collaboration such as communication and teamwork, Meta skills are those abilities that enable a student to learn and build new skills faster. Meta skills include traits like self-awareness, empathy, self-confidence and resilience (Stephen, 2020).

The motivation for this research comes from two related incidents that have occurred over the last decade. Firstly, as a teacher of advanced learners I noted that not all students that excelled in their middle school science and mathematics classes did so in their senior secondary classes. Some of these students did not even consider choosing the subjects when they became optional. I wondered why? After all these students had demonstrated both the motivation and the required advanced thinking skills; was it our educational system? Is this related to the difference in pedagogy within senior education or perhaps stronger competing interests and demands? Why are only some of the students opting out of the secondary science and mathematics?

These questions turned from an interest to research when reading a work by Richard Mayer who in one of his articles wrote:

> Tom is working on a geometry problem that he has never seen before. He begins enthusiastically, but soon he runs into a dead end. Not knowing what to do he quits saying "we haven't had this yet." Why did Tom fail? Perhaps he lacked the cognitive tools he needed, such as basic geometry knowledge. We give him a short test of basic geometry and find that he is highly knowledgeable, so we rule out cognitive factors as a source of failure. This leaves two other possibilities – metacognitive and motivational factors may be involved (Mayer, 1998, p. 61).

In that single passage I recognised the issue that had perplexed me. The excerpt was a micro-scenario of what I saw happening over a greater span of time and with a greater number of students. The illumination garnished from Richard's words provided a twist in my own thinking; perhaps it was not 'teaching' I needed to focus on, perhaps what was important was the 'learning' – the metacognition and the motivation. The students who have always achieved high grades 'run into a dead end'. They have proven cognitive ability, however, not knowing what to do, they quit with the excuse "this subject does not hold my interest anymore".

The camouflage is pedagogy but underneath the façade that mimics a link to a teaching style is agency. Pedagogy *is* important but its relevance is often over-stated, in my opinion.

Student agency can overcome what a teacher lacks in an extensive knowledge of pedagogical practice (Bruning, Schraw, Norby, & Ronning, 1990). A teacher's lack of enthusiasm cannot thwart a student's desire to succeed if the student has control of the learning.

The idea that some people are apt to adjust their thinking to negotiate motivation and solve problems is not new; seventy years ago, Max Wertheimer asked, why is it that some people, when they are faced with problems, get clever ideas, make inventions, and discoveries? What happens and what are the processes that lead to such solutions? "What occurs when, now and then, thinking really works productively? What happens when, now and then, thinking forges ahead? What is really going on in such a process?" (Wertheimer, 2020, p. 36).

Although Wertheimer did not conclusively answer these questions, his interviews with Albert Einstein and other notable thinkers of the time provided insights that inspired others to take up the challenge of responding. Their work forms the basis of the meta-skills that sit alongside an individual's cognition and are explicitly evoked when cognition becomes problematic (Segal, Chipman, & Glaser, 1985; Sternberg, 1998; Weiner, 1986).

So why this particular research and how is it different to the vast amount of research which has already been undertaken?

Relevance is subject to a time and place. As this research is undertaken many communities are deliberating on the lack of authentic problem solvers produced by our schools. "To succeed in this increasingly competitive economy, all students, not just a few, must learn how to communicate, to think and reason effectively, to solve complex problems, to work with multidimensional data and sophisticated representations, to make judgments about the accuracy of masses of information, to collaborate in diverse teams, and to demonstrate self-motivation" (Pellegrino, Chudowsky, & Glasser, 2001, p. 22). A focus on producing solutions require thinkers who are able to scaffold their own cognitive processes rather than repeat what they have learnt. Thinkers who can invoke their meta-skills at will to enhance, regulate, and progress their cognitive efforts. The motivation for this research, therefore, is the desire to develop a learning environment in which students are able to use their meta-cognitive and self-regulatory strategies at will, become more responsible for their own discoveries and learning, and ultimately, their own career paths; when the systems challenge them they have the ability to become problem-solvers rather than give up.

THE RESEARCH SITE

The research site for this action-research is a boys Catholic school in the city of Adelaide. It caters for students from reception to Year 12; at the time of writing' it has a population of about 1100 students. Being in the centre of the capital city it draws from a diverse range of socio-economic groups varying in ethnicity, religion, economic status, and parental education. This variety makes it an ideal environment to test out the basic premise of the action-research. In the second chapter, 'The Research Context' a more detailed discussion of the action-research school ensues.

IDENTIFICATION OF THE RESEARCH QUESTIONS

The research examines the role that metacognition may play in student autonomy and agency, therefore affecting student decision making. Motivation and resilience are monitored within the context of discrete subjects as opposed to a generalised version of these qualities. There are three essential questions that this action-research needs to report on:

1. Within a pedagogical framework *how* can the value that a student holds for a subject be increased? (Constructs)
2. *How* can we best shape the actions that develop the constructs responsible for a student's motivation and sense of fit within the subject? (Pedagogy)
3. *How* does the student's use of metacognitive reasoning better inform these constructs and therefore, value, persistence, and motivation within the context of a challenging environment?

PURPOSE OF THE RESEARCH

The study explores how students, who have been identified by the school as potential high achievers, use meta-cognitive strategies to make career altering decisions about science and mathematics courses. This study is particularly interested in those students that face challenges within these courses. The keystone idea within this work is that students who have control over their own learning are more likely to successfully problem solve the challenges they experience and ultimately persist with the subjects (Sternberg, 1998).

A secondary, but none-the-less important, purpose of this study is to act on similar observations reported by the school, that a number of the identified high achievers in middle-school are not realising their aims and potential when they enter their senior secondary years. It is hypothesised that there may be a link between a lack of the explicit use of meta-cognitive reasoning and employment of self-regulatory strategies, by these students, and their under-achievement.

DESIGN OF THE RESEARCH

This research followed an action-research methodology with the purposeful intent of effecting the learning environment. Participants for this research were from the researcher's classes. It was a longitudinal research based over three years encompassing students at the start of their secondary journey through to students who had completed their final year. The participants had the following common qualities:

- They were enrolled in either advanced middle school courses (developed for high achievers), or Stage 1 / Stage 2 Science and Mathematics courses.
- They had been identified (by the school) as students with advanced cognitive skills for their age.
- The focus students had found their courses problematic in some respect and are considering of opting out.

It was initially expected that about 6 – 12 students from a group of 50 students within the focus classes might experience some form of difficulties. It is these students that formed the focus group.

Data collection methods used in the action-research will include

- Focus group interviews to illicit why students have chosen to study these particular mathematics and science subjects.
- Class based surveys, before and after the intervention, to gauge changes in meta-cognitive and self-regulatory strategic knowledge.
- Collection of assessments, work samples, and teacher feedback to show both problems and progress.
- Exit interviews with students who have decided to opt out of the courses with a particular focus on motives and motivation.

All participants were volunteers.

As action-research, discussed in chapter 4, it examines students at an instant in time, recognises a problem, selects appropriate variables, and defines a measure which was indicative of a desired change (Nasrollahi, 2015). The desired outcome was already known, and the study looked to examine the variables which were likely to result in the outcome.

If the desired outcome was not achieved the ‘action’ was altered; the variables themselves, or their application, were subject to re-thinking; the action re-designed and re-applied. All the changes were accompanied by close reading of the subject voices; actions were based on concepts well documented in the literature (Creswell, 2014a).

SIGNIFICANCE OF THE RESEARCH

The significance of the study rests on the conviction that the best bridge that links a student with innate ability to resilience and perseverance in the face of mediocrity is metacognition. Metacognitive practises provide agency and self-determination which in turn influences learning rather than teaching. Students can control learning whereas teaching is largely controlled by teachers, institutions, community, and policy.

Meta-cognitive skills are often contributors to final outcomes but are rarely explicitly taught within the context of a subject. Students who lack time management skills or who fail to prioritise tasks are significantly likely to underperform (Kuyper, van der Werf, & Lubbers, 2000). A lack of motivation and procrastination may have little to do with actual subject knowledge, yet they are major contributors to the stress and failure that school students experience. As educators we 'teach' the content but not the meta-cognitive skills, consequently some of our most able students are often caught in a downward spiral of poor choices and strategies. Without the development of self-regulatory skills, it is a spiral which is difficult to escape.

Therefore, it is expected that this inquiry will have the following specific implications for the teaching profession, as it

- Affirms the idea that meta-cognitive strategies are an essential part of any *teaching* program.
- Demonstrates that student agency, promoted by the explicit teaching of meta-cognitive skills, is a key component in addressing motivation and persistence, particularly in senior secondary students who are being challenged by their courses.
- Generates a framework in which the concept of learning can be discussed and understood in terms of metacognition as well as cognitive ability.

By centring this research on students' learning rather than a teacher's teaching (pedagogy), this project addressed a gap in the research whereby much research has been completed associating *student failure* with poor metacognition, however, talented students don't tend to fail and as a result do not get noticed as they progress at a comfortable 'competent' level by choosing not to take up the higher challenges (Kipnis & Hofstein, 2006). Meta-cognitive knowledge is seldom tested; it is not explicitly part of any curriculum, and consequently rarely forms part of any diagnosis as to why students under-preform in their senior studies and then opt for subjects other that the mathematics and sciences. *A link between talented students not being practiced in explicit metacognition and their reluctance to choosing STEM pathways may exist and is worth further exploration.*

LIMITATIONS OF THE RESEARCH

There are several limitations that are evident in this research. The work does not explicitly define the schooling process, and this allows for strong arguments contesting that pedagogy and teaching may be key processes that *lead* to learning:

> "The more we take "learning" out of context and put it, cleanly and abstractly, into an institutional framework and ask students to perform in isolation, the less possible it is to learn. This now universal system of institutionalized schooling not only destroys joy and curiosity, and creates dropouts and failures, winners and losers." (Blum, 2016, p. 3)

Whilst these counter views are acknowledged and mentioned in the literature review, greater emphasis has been placed on the literature that values learning and self-regulatory development to advance the discourse on the importance of metacognitive strategies in the schooling process. This bias towards schooling as a process of personal growth rather than a process of socialization for the betterment of society does not detract or limit from the study.

Modern theories of learning tend to emphasise over-arching ideas which include mind-sets and psychological attitude (Dweck & Yeager, 2019). These are important and have, no doubt, a profound effect on learning however metacognition prefaces these psychological states (Leslie, 2021, p. 103). Nonetheless such attitudes may be attributed to learning biases' and could provide limitations, if untested.

There were limitations within the process of selecting the students in the research. The research focused on a number of students at three different year levels and followed their journeys over a three year period. These students had been identified as advanced learners from several different sources including diagnostic testing, parent information, teacher recommendations, and school records; ultimately there was subjectivity involved and it was difficult to ascertain whether the students had possessed high cognitive ability or were very hard workers. The process of student selection was adopted so that the sample consisted of only academically motivated boys; there was no guarantee that motivation was a consequence of the student's advanced cognitive processes. The motivation could have been extrinsic, such as parental expectations.

The fifty students monitored, from which approximately twelve students were closely followed represented 8% of the total students. There were 92% of students of whom the question of the validity of this research needs to be asked. However, the literature clearly demonstrated that the greater a students level of cognition the greater the stakes when failure is perceived (Johnson, 2000; Olenchak, 1999), therefore the findings have a greater significance to the sample chosen by the research. Irrespective, the size and very specific nature of the sample is a limitation.

Finally, this is a qualitative action-research. In such a study the researcher is an active part of the work. The aim was to change the environment to obtain certain outcomes. Given this, the role of the researcher generated potential limitations. Proper protocol (Creswell, 2014a) needed to be strictly followed to avoid bias. Transparent processes needed to be followed when creating questions, giving participants a voice, allowing for flexibility, defining the aim and parameters of the research, and being open-minded with the data presented for analysis.

Since this was action research completed at a very specific location with a unique set of students there exists a limitation on how the work can be used to make generalisations in other similar scenarios.

DEFINTIONS

Secondary Student:

In South Australia, where this research has taken place, a secondary student is a person studying courses within years spanning from 7^{th} to the 12^{th} years of education. At the College these are students that are approximately 11 to 18 years of age. About eighty secondary students were initially monitored for this research, with fifteen of the group forming the focus.

Key Focus Student:

A focus student is a person whose experiences and insights have helped the researcher understand the ideas behind this research. The focus student is an advanced learner who has experienced challenges within their courses and can articulate these experiences. In this action-research there were fifteen Key Focus students: three from Year 8, three from Year 9 and two from Year 10 as well as a number from the senior secondary Mathematics and Physics classes. These students were tracked over a period of three years on the basis that they demonstrated, or appeared to have, the ability to use meta-cognitive reasoning to make academic decisions.

Advanced Learners:

This particular work was not concerned with differentiating a gifted learner from an advanced learner. Whilst there are a multitude of definitions for ‘giftedness’, when placing ‘advanced learners' into any search engine, invariably the results are linked to a subject (or context); advanced learners of English or advanced learners of Mathematics. These types of learners are defined by their characteristics rather than 'hard and fast' parameters. They are also defined by the group that they share the learning with. Therefore, the term tends to be subjective and the defining characteristics are a comparison to the average learner in any group. My observation as a practising teacher seems to indicate that the common belief amongst my colleagues is that an Advanced Learner is synonymous with an autonomous learner, one that does not require much intervention, if at all, and achieves a high level of competency. Some of the characteristics listed by the College in identifying Advanced Learners are:

- Understands new topics easily and quickly.
- Is reluctant to practice skills already mastered, (futile).
- Curious about the topic and motivated to move on.
- Finds the classroom textbooks superficial.
- When absorbed by a topic may be impatient.
- Able to articulate problems and problem solve.
- May choose to work alone rather than collaborate.
- When in a group may be distracted.
- Advanced use of symbol systems.

(Johnsen & VanTassel-Baska, 2022; Santini, 2021)

An Advanced Learner may be advanced due to advanced cognition or advanced effort. Unfortunately, though both show traits of advanced learning at an early stage, as content becomes more complex there may be a disparity in the respective outcomes (Johnsen & VanTassel-Baska, 2022). This is further discussed in the analysis chapter.

Metacognition:

Metacognition is defined as thinking about one’s thinking. It is typically understood as the ability to monitor and scaffold the thinking required to analyse and problem solve. Metacognition is associated with planning of required resources, self-regulating and monitoring progress. It is strongly linked to learning style and study habits, (Martinez, 2006; Noushad, 2008; G. Schraw, 1998; Sternberg, 1998).

In this study it is used to formulate strategic and ultimately provide agency for the students.

Metacognition happens implicitly all the time. When engaged in any task students make instant decisions about how to tackle the task, plan, and in determining demands on time and resources. In most cases students are not aware of these meta-processes; this is not a problem. It is when cognition becomes problematic that explicit meta-cognitive strategies must be deployed. If these processes are unknown, they cannot be effectively engaged and the task remains out of reach. This affects other psychological constructs like motivation and emotions (Efklides, 2011).

Academic Motivation:

Simply put academic motivation is the desire to learn; it is a psychological construct and modern articles associate motivation to beliefs, values, and goals with action. In this work I draw out motivational links associated with ‘expectancy-value’ models (Watt, 2005).

“Expectancy refers to beliefs about how one will do on different tasks or activities and values have to do with incentives or reason for doing the activity” (Eccles & Wigfield, 2002, p. 215). This study couples student goals and meta-cognitive strategies to motivate students. The study aims to develop “continuing Motivation” (Maehr, 2012, p. 10); a term meaning the type of motivation which is free from external incentives, or external pressure to do so.

Mediocrity:

A premise of this work is that advanced learners that experience problems with cognition and have not developed meta-cognitive strategies are likely to revert to the safety of mediocrity rather than risk reputation and self-concept (Nota, Soresi, & Zimmerman, 2004). It is important to present the advanced learners a curriculum that deliver them to the 'Zone of Proximal Development' (Eun, 2019). However, to cope with the thinking required, meta-cognitive strategies must be explicitly exemplified by teachers and trialled by learners.

Strong evidence shows that failure to extend the advanced learners and only providing them with a curriculum meant for the middle of class, (one size fits all mentality), will often lead to the advanced learner developing poor habits (Baird, 2012).

> When standards are higher, students work harder. And as a result of increased effort, they learn more. Low expectation cause low effort. That many students follow a "satisficing" strategy— they work only as hard as they need to— is obvious to anyone who listens to them. In one comprehensive survey of tenth graders, 60 percent agreed with the statement "I don't like to do any more school work than I have to. (Baird, 2012, p. 49).

When a teacher teaches to the middle, average students learn at the target pace while advanced learners are being under challenged and still achieving high grades. The lure of high grades with minimal effort traps the advanced learners in an environment of mediocrity (Baird, 2012).

Cohort:

Within this work a cohort is meant to distinguish between groups that experienced the program. The groups (cohorts) were separated by time. The first cohort started in February of 2017 and were students from Year 9 to Year 12. The second cohort started in July of 2018 and were students from Year 8 through to 10. Each cohort shared the same basic routine, they were tested with the same diagnostic test, those within the same range of diagnostic achievement (95^{th} percentile) were accepted into the program, they were interviewed with the same techniques (although the questions differed depending on responses), questionnaires were the same, and they were scored using the same accepted scoring instrument. What differed was the way that the metacognitive skills were delivered to, and practiced by each cohort. Due to the time delay between cohorts the action-research methodology allowed for analysis of the actions undertaken to instil strategies within each cohort.

There is a limitation that needs to be realised from the onset, that is, that each cohort comprises of different personalities and has its own particular group dynamics. Though this may seem like a possible obstacle to any conclusion drawn, in reality, it is very true to what happens in every classroom. Every classroom is different, students and dynamics; what this study does is analyse how these students react in a crisis point, given that they are now users of metacognitive strategies. Can the strategies turn around the trend of students opting for subjects that deliver fewer academic challenges in their final years of schooling?

CHAPTER 2: THE RESEARCH CONTEXT

ACTION AND RESEARCH IN CONTEXT

This action-research was specific in its focus, targeting a specific clientele. Understanding the context of this research is essential to situate the actions undertaken as a response to reactions observed from the students. Therefore, qualitative research of this nature is context specific (Wiersma, 1969).

The research is underpinned by three major assumptions; firstly, acknowledging that the classroom is a group of learners led by an educator, therefore an organization of scholars; students within the organization are individuals and interpret the actions of teachers differently. Secondly, student potential is seldom realised without the self-actualization of strategies that scaffold and delineate a path to a successful outcome, finally, that teachers, as leaders of the classroom organization are responsible, at least in part, for positively influencing their students' academic motivation (Sternberg, 1998).

The assumptions are evident throughout the research and therefore are overarching influences to the actions applied within the context of the research. There are three contextual considerations important to the meanings that flow from this work

- The stated mission of the research case-study school
- Research and practices in boys' education
- The researcher's involvement and purpose

these three contextual considerations give meaning to actions within the studies; whatever the action research was problem solving, and the subsequent actions, had to align with the mission statement publicly stated by the school. Any action, proposed by the research, had to be aligned with the school's philosophy before it could be enacted within the classroom. It needed to be supported by best classroom practices that enhanced and support boys' learning. Finally, the researcher was a practicing teacher within the employ of the school, bound by its philosophy, and ultimately endowed with the purpose of furthering and improving his charges' learning. His involvement in the study was bound by the Position Information Document that defined his role.

THE NATURE OF THE SCHOOL

The nature of the school is important because it defined the type of activities which could have been used. Metacognition, motivation, self-regulation, a positive self-image, are all attributes that are fundamental to this research, however they can be attained in a variety of ways. Some paths that lead to these outcomes had a better chance of success if they were supported by the greater community of the school. The activities required investments of time, money, and organization, for example, timetabling the components of this research so that they were properly accommodated within the school day only happened because the school's executive body were able to visualize the advantages and benefits to the students. Advantages and benefits are subjective references that were measured against the aims of the school community.

Examining the nature of the school allows us to better understand what actions could best fulfill, both, the goals of this research and the school's greatest purpose.

The College, established in 1878, is less than one kilometer from the center of Adelaide, well within the bounds of the central business district. The school has three separate campuses; a co-educational early learning center, a junior campus, and a secondary campus, housing both the middle and senior secondary students. All three campuses cater for 1100 students, at the time of this writing.

It is a Catholic school in the tradition of Edmund Rice and as such offers a distinctive educational philosophy. Understanding this philosophical stance, the charism of Edmund Rice, is relevant to this research as it explains the distinctive educational focus that gives the College its purpose for existing. Under its publicly stated Position of Information Document any teacher at the College must be faithful to the four key "Touchstones" that underpin all of its relationships and educational philosophy. The four Touchstones are reflected in the Vision and Mission statements of the College strategic plan. This plan also connects the Touchstones with the four core strategic values of the College- Faith, Excellence, Community and Compassion- values which inform continuous improvement in education, decision making, and strategic direction. "These values are at the heart of the college's vision, mission, and strategic plans" (*The College Vision Statement*, 2015).

Further to this, these values supported by the teaching staff, need to be applied to the school's student population, which, is extremely diverse. At the time of writing 58% of students are from a non-English speaking background, 9.3% of students are classified, (by government guidelines), as having special educational needs, 22% of students are on school card and therefore from a low social economic background and a further 15% are on the borderline.

All students at the College are broken up into five mixed ability learning groups at appropriate year levels.

Considering the above context, what are the implications for this particular study?

- Consideration needs to be given to the notion of exclusivity when determining the grouping and selection of students in the program and subsequent investigation. The school has a philosophy of not streaming students and that all educational groups are to be of mixed ability.
- The statistic of 58% of students having a non-English speaking background draws attention to the nature of the testing for, firstly, identification of advanced learners, and secondly, for how to explicitly exemplify and assess metacognition, motivation,

and resilience of the students in this study. There is also an inference that social customs, and therefore prioritization of what is valued, maybe divergent within the group and therefore common acceptance could not be assumed. This includes Advanced Learners either aspiring or otherwise to either University study or a STEM career.

- When setting up this study at The College consideration needed to be given to students outside of the immediate study, in terms of self-perception and motivation. This was particularly evident in hindsight of the project as there were many students wanting to be involved that did not meet the criteria for inclusion. This proved to be a sensitive issue and needed to be carefully navigated.

RESEARCH AND PRACTICES USED BY THE COLLEGE IN FORMING THEIR BOY'S EDUCATION POLICIES.

Whilst the literature review will deal with the specific nature of this research, namely, to explore how a student's knowledge and use of metacognitive strategies effects resilience and motivation when learning becomes problematic, an important area of exploration, due to the nature of the research site, are the practices adopted by the school associated with the education of boys. The College at its secondary campus is an all-boy educational institution. This has many obvious implications for how the action- research needed to be conducted.

The literature on gender based education varies quite markedly with some researchers claiming that gender does not particularly define pedagogy as no gender grouping is homogeneous with respect to learning styles (M. Mills, Martino, & Lingard, 2007a), other researchers claim that the difference is not gender as such but the difference in the rate of maturity, and yet others claim marked difference due to the nature of masculinity, feminism, and the subsequent differences in brain chemistry and activity (M. Mills et al., 2007a).

Such researchers turn to statistics as a source of validation. In non-government schools, (such as the research site), the dropout rate for boys (20.7%) reports to be significantly higher than for girls (9.4%). The same report clearly states that boys have lower academic achievements as well as being overrepresented in behavior management programs, suspensions, and exclusions. The report suggests that boys are less likely to attend tertiary studies, a trend which does not seem to be changing (Bristol, 2015; Education & Training, 2002).

Whilst this research acknowledges that more recent work has moved away from the notion of 'education for boys' and 'education for girls' (M. Mills, Martino, & Lingard, 2007b) as described in the Australian federal Parliamentary Inquiry into Boys' Education, *Boys: Getting it Right*, the document is important to this work as the College has based many of its strategies on the report. The College used the 2002 Parliamentary report to form its policies, (many still in existence), and as such is a signpost to what the College embraces as useful pedagogies for teaching boys. Critics of the inquiry do not imply that the pedagogies themselves are wrong, but cite that whatever is good education for boys is also good education for girls; it is not about gender (Hodgetts, 2010). This research does not deny that proposition.

Of particular relevance are the following (summarised) observations made in the report, (and backed by more recent sources):

- Boys often over-estimate their own abilities, both cognitively, and resource management; often over-estimating what they can do by themselves.
- Success and failure are an important source of motivation for boys. Perceived failure is very difficult to overcome and can influence the self-identity poorly.
- There is often a difference in what the educational aim of the task is and what a boy perceives it to be. Boys tend to have a pragmatic and narrow view of educational requirements.

- Peer group identification and membership are very important to boys. Often the peer group influence is not supportive of higher educational achievement, helping maintain an anti-culture towards being too clever.
- Cultural messages available to boys do not tend to place value on positive approaches to learning.

(Bristol, 2015; Chandler, 2004; Education & Training, 2002; Martin, 2002)

An Australian government parliamentary inquiry report "getting it right" in response to growing concerns with the alienation and disengagement of boys in the classroom made the following recommendations:

- Boys tend to need explicit teaching and tend to prefer active, hands-on methods of instruction
- Structured programs are better off for boys because they need to know what is expected and they like to be shown the steps along the way to achieve success
- Boys respond more to relationships with teachers than the content of the lesson
- Activities help boys establish rapport with teachers and therefore facilitating a greater chance of success
- Boys respond better to teachers who are attuned to their sense of justice and fairness and who are consistent in the application of rules

(Carroll & Beman, 2015; Education & Training, 2002, p. 78)

The "getting it right" report also offers some researched insights as to what might constitute successful pedagogical elements crucial to an environment which supports motivation and student engagement. Elements important to this study are discussed below.

Lessons must be structured. Lillico (2003) argues that boys need to make sense of the lesson and therefore it must have a beginning, action, reflection, and conclusion. The lesson must also have an explicit emphasis on higher order thinking skills.

Within each lesson higher order thinking needs to be recognized and appreciated by the teacher (Carroll & Beman, 2015; Education & Training, 2002), this addresses motivation within the group. Some authors address the same issue by espousing a constructivist approach to the lesson, prompting intrinsic motivation rather than motivation by teacher praise.

Lessons need to be supported by inclusive practices since boys are not a homogeneous group. This suggests that a differentiated approach to the curriculum is vital for classroom engagement and motivation. Differentiated practices provide a means for success to be achievable for every individual in the class (Carroll & Beman, 2015; Education & Training, 2002).

Collaboration is essential in the lessons, both in its formal and informal forms. Boys in particular can be prone to mental role play, therefore expert groups, think-pair-share groups can further a student's self-concept as well as motivate. Lillico (2003) suggests that the type of group needs to differ whereby 35% of the time students are in randomized groups, 30% in friendship groups, and 35% in teachers selected groups.

Finally, there is a need to ensure that the set of lessons make a connection to the students' world. One way of achieving this is by having different presenters throughout a set of lessons. This enables boys to make a variety of associations giving greater context to the topic (Carroll & Beman, 2015; Education & Training, 2002).

In the research "a framework for best practice in boys' education" (Keddie, 2005) these issues, discussed above, are framed under four important headings that describe productive pedagogies; Intellectual quality, Connectedness, Supported classroom environment, and a Recognition of differences. Her work claims that the dimensions of productive pedagogies provide educators with a framework for “enhancing boys’ academic and social outcomes in comprehensive and contextualise sensitive ways” (Keddie, 2005, p. 8)

This brief and simplistic summary of the thinking and literature which surrounds boys’ education at the school, at the time, whilst not the crux of this particular research, is nonetheless extremely relevant. This research specifically addresses boys and therefore needed to be grounded by the thinking and practices at the school. The research, being longitudinal, needed to be supported by the school over a sustained period and therefore the practices within the program needed to be relevant to the times and the clientele.

THE RESEARCHER’S INVOLVEMENT AND PURPOSE

As the researcher I was the coordinator of gifted programs at the College, Wakefield St, Adelaide. This involved managing advanced learners within their subjects and more directly teaching them mathematics.

The coordinator’s role involved following and analyzing the achievements of these students as well as initiating and formulating strategies when these students became disengaged for any reason. Working with staff was another important aspect; all teachers were expected to differentiate, however, differentiating for advanced learners and gifted students can be more complex as often there are wellbeing and affective issues to consider.

The role of coordinator and manager was not divorced from the role of researcher, observing and collecting data for this work. This is a primary reason why this works sits comfortably as qualitative research with elements of ethnography. This research involved observing the students whilst scaffolding them with metacognitive knowledge and strategies when cognition became problematic, which subsequently effected resilience and motivation. It studied the students in the educational environment and determines if the meaning they attached to their achievements changed due to their new learning; in this way it closely related to ethnographic methodology (Gilbert & Stoneman, 2016).

Action research involves teachers identifying a school-based problem to study; collecting, analyzing information, to solve or understand aspects of their practice (Lingard, Albert, & Levinson, 2008). “Of all the research designs, action research is the most applied, practical design” (Creswell, 2014a, p. 608). The actions to enable change to occur are based on informed decisions; decisions that are data driven and therefore based on the research component of the process. It is more accurately often referred to as a “Participatory Action-Research” (Creswell, 2014a, p. 614) as it does not focus on the practice of teaching but rather on the actions of the students. Participatory action research “when applied to education focus’ on improving and empowering individuals in the school” (Creswell, 2014a, p. 615), in this case the students. By nature, this form of research is practical and collaborative (Rauch, 2023).

Whilst acknowledging this particular context, there are some obvious questions that need closer examination, namely, since the researcher was collaborating with the participants, as both teacher and researcher, (which was central to the process), could this have biased and distorted responses? This will be further explored in the methodology section of this work; however, it is a context which shapes the way the research was approached.

In this chapter, three considerations which are relevant to this context of the work are addressed: the mission and defining purpose of the school where the research takes place; an understanding of boys’ learning; and the clarification of the researcher's role within the study. These considerations give meaning to the structure and format of the research. Chapter 3 presents a review of the most current literature. The methodology, data collected, and analysis of the data was based on these current ideas. The literature review also informed the actions that follow from the observations in the action-research.

CHAPTER 3: THE LITERATURE REVIEW

INTRODUCTION

There are three important areas that need exploration and explanation. To summarise: When there are many choices on offer, students need to see the value in committing to science or mathematics. Once a commitment is made then motivation and a sense of 'fit' must be established and maintained. Motivation and the 'sense of fit' ought to be maintained by cognitive scaffolding that a student can readily access rather than be teacher dependant. The following three questions drive the literature review.

1. What actions within a pedagogical framework can increase the 'value' that a student places on a subject?
2. What constructs influence a student's motivation and sense of fit, and therefore persistence in the Mathematics and Science subjects?
3. Can meta-cognitive reasoning better inform a student's decisions and actions providing a learning pathway which includes Science and Mathematics?

Current discussion around the poor uptake of science, technology, engineering, and mathematics (STEM) witnessed within the Australian community is important to this research; it is a principle reason for challenging our most promising students and encouraging their participation in the sciences and mathematics (Mather & Tadros, 2014). There is a vast amount of literature that addresses the issue of the declining student numbers in STEM related subjects, from different perspectives (Bøe & Henriksen, 2013; M. Brown et al., 2008; Murray, 2011). The first theme of the literature review examines how this problem is being tackled on the global stage, considering how competing subjects become relevant to students and pedagogy encourages a sense of fit, empowering students to overcome adversity.

Studies indicate that choosing to enrol in mathematics and science is influenced by a number of factors including attitude towards science; mathematical self-concept; gender issues;

motivation; goal structure; learning environments; planned behaviour; social cognitive perspectives – amongst others (Diezmann & Watters, 2002; Minstrell & Anderson, 2011). When students choose subjects there is an interplay between the individuals, the learning environments and the actions (Erdogan & Stuessy, 2015; Holmegaard, Madsen, & Ulriksen, 2014; Lazarides & Watt, 2015; X. Wang, 2013; Watt, 2005). The subjects that students choose to study and "particularly the grades achieved can have a significant influence on individuals' future prospects, facilitating access to further university education, which, in turn, can have important influences on future career and employment prospects" (Payne(2003) in Taylor, 2015, p. 214). One of the most important factors contributing to subject choices, particularly in students choosing senior mathematics and sciences, is career/employment aspirations (Bell, Malacova, & Shannon, 2005; Davies, Davies, Hutton, Adnett, & Coe, 2009); this adds to the relevance and value of STEM subjects to students.

STEM SCHOOL INITIATIVES

STEM, (Science, Technology, Engineering & Mathematics), subjects have been significantly de-valued by current cohorts of students (Mather & Tadros, 2014). As a strategy to curb the falling numbers of students in science and mathematics subjects the United States have introduced a variety of specialised STEM schools in order to facilitate "A vibrant capacity in Science, Technology, Engineering and Mathematics [which is] pivotal to increasing the nation's productivity" (Marginson, Tytler, Freeman, & Roberts, 2013, p. 10). These schools exist to guide their students towards a STEM career by "offering a unique and comprehensive environment – one that includes an advanced curriculum and opportunities for significant immersion in the work of the field through mentorship, internship, and research apprenticeships" (Olszewski-Kubilius (2010) in Erdogan & Stuessy, 2015, p. 80). Such 'apprenticeships' bring the outside world into the classroom, making the study more realistic as the student becomes an apprentice scientist. These specialised schools address the same constructs that a heterogeneous school aiming to nurture a community that values STEM pathways and careers would need to address (Erdogan & Stuessy, 2015).

The learning and assessment in these schools is based on a successful framework to create meaningful courses for students. The BOLT framework 'Building on Learner Thinking' (Minstrell & Anderson, 2011), hinging very much on an inquiry approach that makes strong links with the community in order to create a meaningful context for the learning. The BOLT framework depicted in Figure 3.1 shows the conceptualisation of instruction and assessment as an ongoing process; boxes are where ideas are generated - in community. Box A, the students, is where *problematic ideas* are identified by teachers and the learners (initial conceptual ideas); Box F, the scientists, broadly represent the *learning goals ideas*, important for how teachers prioritise the learning experience; Box E, the consensus are the products of processes of the learning journey, (*shared understandings by the group*). The circles are the sense making experiences for learners, these come from different sources; observations and measurements, hands on activities and other interactions with the community that promote ideas to generalisations.

Figure removed due to copyright restriction

Figure 3.1: Diagram of the BOLT framework (Minstrell et al., 2011, p.4.)

The framework is based on research which links a student's motivation on *how they see themselves within the subject matter* and the *utility value of the subject* relative to the difficulty of creating contextual meaning. Partnerships, mentoring, and inquiry learning are pillars that sustain the process (Minstrell & Anderson, 2011). … these STEM programs do have a very positive effect in shaping students motivation to pursue mathematics and science careers .

Written for Australian schools, this statement penned by practicing engineers in consultation with the University of NSW and the government,

> "Many STEM initiatives [as described within the BOLT framework] provide valuable platforms for meaningful experimental learning to take place. They engender <u>social interaction</u> and can facilitate the raising of young people's <u>self-esteem</u>" (Prieto et al., 2011, p. 88)

is in total concordance with the philosophies behind the American STEM schools.

The Australian report, as with the article describing best practices in American STEM schools, stresses community as a vehicle to:

- challenge naïve notions of STEM careers;
- create contextual meaning of the learning;
- sustain motivation through social validation

(Erdogan & Stuessy, 2015; Prieto et al., 2011).

The report strongly endorses the importance of the quality of education and the need to better inform teachers and career advisors about the range of opportunities arising from STEM subjects. The report states "Australia has insufficient numbers of highly trained teachers in science, technology, and mathematics" and that current pedagogy does little to stimulate curiosity, problem solving, depth of understanding and continued interest in learning amongst students (Erdogan & Stuessy, 2015, p. 85).

The second theme of the literature review explores constructs that effect persistence in the face of challenges and factors that influence subject choices.

FACTORS INFLUENCING SUBJECT CHOICES

"A large number of studies from the U.S., Australia, and Europe have demonstrated the salience of students' motivational beliefs – in terms of expectations from success and task value – for course choices and career intentions" (Lazarides & Watt, 2015, p. 51). Research investigating why students choose mathematics and science related studies suggests that students who either persist or leave these subjects are influenced by proficiency in the areas of mathematics and science; the high school curriculum; advanced courses; information early in the subject search process; types of opportunities, experiences, and support students receive; and the classroom experience (DEST, 2003; Minstrell & Anderson, 2011; X. Wang, 2013).

In longitudinal (Holmegaard et al., 2014) and empirical studies (Eccles & Wigfield, 2002) researchers are situating these influences within a student's questing for a realistic identity. Watt (2005) examines these influences in terms of the Expectancy-Value theory (Eccles & Wigfield, 1995) and finds that the constructs addressing motivation to choose and remain in STEM subjects must measure a student's:

(i) expectation of being successful in the subject;

(ii) the high ability in the subject;

(iii) the interest in the subject;

(iv) perception of the subject being useful;

(v) the subject as an important to do

(vi) the subject not competing with other major interests (Watt, 2005).

The six items listed are summarised from the Expectancy – Value theory derived from a psychological viewpoint. The same list can also be found embedded in the cognitively based 'Social Cognitive Career Theory' (Lent, Brown, Hackett, & Brown, (2002) in S. D. Brown, Lent, Telander, & Tramayne, 2011). Whether examining motivation from a purely 'thinking' perspective or from a social process viewpoint, the constructs remain the same.

Figure 3.2 visually portrays relevant factors as they form the major elements of the Social Cognitive Career Theory (SCCT). The flowchart refers to a post-secondary setting but is of interest because of the similarity that the chart has to the research completed of secondary students and their subject choices (Lazarides & Watt, 2015). The theory "posits that determination to produce a particular choice is a result of interest and goals" (X. Wang, 2013, p. 1086). The flowchart illustrates that a student's intent galvanises subject choices; however, the intent is itself dependent on continual self-referencing and learning experiences.

Figure removed due to copyright restriction

Figure 3.2: Factors influencing students' STEM choices (X. Wang, 2013)

"This model suggests that academic and work interests are influenced by four interrelated cognitive and behavioural variables – general cognitive ability and specific skill sets, outcome expectations, self-efficacy beliefs, and goal mechanisms" (S. D. Brown et al., 2011, p. 81). Specialised STEM schools guide these influencing factors by employing highly trained teachers who understand how to build self-efficacy (Erdogan & Stuessy, 2015).

PERSONAL INTERPRETATIONS OF THE CONSTRUCTS

Current literature is rich with insights regarding why students initially drawn to the sciences and mathematics do not persist. These students "perceived Science and Mathematics as stable, rigid and fixed, and, hence, too narrow a platform for developing and constructing desirable identities" (Holmegaard et al., 2014, p. 186). Individuals interpret experiences affecting the constructs in different ways. The many facets that make up the student population are increasingly diverse, and the choice of study is shaped differently for different students, this highlights that simply identifying variables and reducing choice of study to a general model is inadequate. Rather focus should be on how the students themselves handle and make their choices meaningful" (Louise et al., 2010). Meta-cognitive and self-regulatory strategies would serve as tools by which students interpret the variables and make their choices meaningful.

The different constructs known to shape student choices of study create a 'sense of fit' for the students (Bergerson, 2009). Theories from the domain of academic motivation (psychological understanding) highlight experiences in mathematics and science being important to the formation of self-perceptions. "Academic self-concepts represent a key predictor of an individual's motivation, emotion, and performance and is often used in way of explaining the role of the self within the school context" (Sax et al., 2015, p. 815). Academic self-confidence is much like self-efficacy within a specific domain in a normative way (comparing oneself with some notion of average); these include both cognitive and affective self-evaluations (Marsh & Martin, 2011a).

Figure 3.3 revisits SCCT overlaying it with the constructs that define the science and maths classroom experiences which predict STEM subject selections. In this form SCCT explains how "personal, contextual, and experiential factors influence an individual's perceived ability to successfully understand the task (self-efficacy) and how that self-efficacy then influences actions towards a particular career path" (Sax et al., 2015, p. 818) and therefore the subjects considered.

Figure removed due to copyright restriction

Figure 3.3: Model of career-related choice behaviour (Sax, Kanny, Riggers-Piehl, Whang, & Paulson, 2015, p. 818)

Figure 3.3 clearly suggests that the learning experience (in the maths and science classes) affect self-efficacy and the student's outcome expectations which subsequently directly influences the student's interests, choices, and value of the subject.

While both perspectives strongly re-enforce the importance of the student's experience within the subject, the self-efficacy, and the achievements, the psychological framework states that these be cannot be divorced from other contextual influences. What we do in the classroom may shape the choices that a student makes but we must also be aware that other strong demographic and personal influences that may also come into play.

The final theme of the literature review explores how students draw meaning and make choices from learning experiences and how metacognition better supports a student's course choices.

OUTCOME EXPECTANCY AND THE VALUE OF A SUBJECT

The SCCT model is beginning to illuminate how these constructs are involved with each other. The Expectancy-Value theory of Eccles (Watt, 2005) encompasses SCCT but then links the various components by suggesting causal sequences and describing relations between beliefs (perhaps implicit but not evident in SCCT) and subsequent behaviours. The Expectancy-Value framework "represents a student's expectancies for success and subjective valuation of maths as major influences" on career and course related decisions (Watt, 2005, p. 107). Important in this theory is the value that a student places on the tasks. Value is described in four distinct ways:

- intrinsic value, the enjoyment gained by being involved in the task;
- utility value, the usefulness of the task for the future (concept of instrumentality);
- attainment value, how important is it to accomplish the task well;
- cost, how much effort and time is required.

In the research conducted to discern patterns of career and subject choices at secondary school level the three Expectancy – Value constructs of self-, task- and values perceptions featured prominently (Watt, 2005).

THE METACOGNITIVE LINK

While cognition is the act of 'thinking' through a problem, research has shown that if we resource, plan, and monitor our thinking then we are far more likely to attain a successful outcome (Cubukcu, 2009). The act of planning, monitoring, reflecting and thinking about our thinking (as opposed to thinking about the actual problem) is known as metacognition (Cubukcu, 2009). All learners are meta-cognitive but only when one is aware of the meta-cognitive activity can one use it to properly enhance cognition (Cubukcu, 2009; Thomas, Anderson, & Nashon, 2008). Self-regulated learning, on the other hand, is a conscious effort to construct goals and then regulate and monitor the thinking involved in problem solving (Cubukcu, 2009). Metacognition is about knowing how we best think; self-regulation is about controlling those processes.

Student experiences, expectations, motivations, and perceived task value have been highlighted as major influences that guide a student's enthusiasm for subjects. These are factors commonly discussed by those who espouse the value of metacognition, often referring to them as "transitory and highly sensitive to person, task, situation and context effects, rendering them highly variable" (Efklides, 2006, p. 11). A meta-analysis of meta-cognitive thinking strategies concluded that "pedagogical promise and possibilities of metacognition suggest 'value-added' strategies or techniques in the sense that students might do something more than attempt to solve problems and engage in learning" (Ellis, Denton, & Bond, 2014, p. 4016). They suggest that 'meta-cognitive' students become involved in their learning, valuing the experience and develop a personal sense of fit with the subject material. A similar study involving 197 students established a link between self-enhancement, motivation and being a confident user of meta-cognitive strategies (Jiang & Kleitman, 2015). Even more conclusive was a longitudinal study which found "positive direct effects of meta-cognitive self-regulation on deep learning strategies …" (Al-Harthy & Was, 2010, p. 1). Research clearly establishes a link between meta-cognitive and self-regulatory practices and motivation for learning, value placed on the effort, and placing the self as a fit within the subject (Cubukcu, 2009). However, meta-cognitive experiences, unless properly understood by students, can be both a negative or positive stimuli (Efklides, 2006); therefore, how the meta-cognitive strategies are developed within the classes is also important.

One final, important, idea to be gleamed from the literature warns us that just because we think we know a solution we should not expect students to passively take up the solution.

> "Gourgey shows that students should not be expected wildly to welcome instruction on metacognitive skills. On the contrary, they may actively resist it, an experience I have had with my own students. When students have become used to and have been rewarded over the years for passive and mindless learning, they will not jump at the chance to take a more thoughtful or mindful approach to what they are doing. Often the teacher's greatest challenge is to interest the students in the first place in metacognitive procedures" (Sternberg, 1998, p. 129)

Students need to value metacognitive reasoning and self-regulatory strategies and not just the STEM subject content. This has important implications for how they are presented to the students.

SUMMARY AND IMPLICATIONS

Taking into consideration the literature reviewed, there are some dominant ideas which appear consistently in the research.

1. In order for the students to prioritise and expend effort on their STEM studies they need to find value in their learning. Value brings about a sense of fit, enabling the students to visualise a future and therefore set plans and goals.
2. An important way of adding value to the studies is by having experts enter the educational environment. This allows the students to interact with professionals, collaborating to solve problems and work on longer term projects. They form subject mentors.
3. Collaboration is an important part of the process; it is a way in which a student can self-reference. This is important for the building of the 'sense of fit' within the STEM

courses. Collaboration is also important in order to produce shared understandings, expand the individual thinking, and test ideas.

4. Success in not always guaranteed and students will need strategies to overcome the difficulties encountered. This is particularly true for high achievers as a low grade can easily influence self-confidence; high stakes to gamble. The challenges could be of their making (for example employment) or external sources (for example pedagogy and demands), irrespectively, students need a set of strategies to rationalise and comfortably work around the challenges. Metacognitive reasoning and self-regulatory strategies have been found to be very successful in such situations, allowing students agency and independence.
5. For students to employ metacognitive reasoning and self-regulatory strategies they must be taught by example, in context, and then practiced independently by the students.

Whilst this research is based around learning these modifications certainly have some implications for teachers.

1. Teachers need to look for opportunities to bring real world examples into the classroom, either by extending the classroom to where the experts are or inviting the experts into the classroom. These opportunities need to be planned and focused so that students can formulate questions and make authentic connections (Erdogan & Stuessy, 2015).
2. Within the units planned time for discussion and sharing sessions are important. Whilst these could be modelled and initiated by teachers they need to be eventually driven by the students (Minstrell & Anderson, 2011).
3. Since student independence is very important for ownership of the learning to be transferred from the teacher to the learners then time needs to be provided for independent learning (and the consequent metacognition skills) to happen. For this the

> teacher needs to be prepared to relinquish some of the structure and organisation. This will not always be successful but such experiences are an important part of the learning. Teachers need to embrace failure and mistakes as part of the learning journey (Lazarides & Watt, 2015).

The literature suggested that the students needed to value the subject, be guided by experts, discuss their experiences and, scaffold their experiences by employing metacognitive thinking. Chapter 4 details how these elements were introduced into the program and why their introduction is analysed using a specific methodology.

CHAPTER 4: RESEARCH PLAN

INTRODUCTION

The literature review concentrated on three themes that underpinned this work (i) an exploration of how successful STEM schools have engaged students, with particular reference to the BOLT (Building on Learner's Thinking) framework (Minstrell & Anderson, 2011); (ii) recent theories and ideas on how students make and pursue subject choices, again with a focus on STEM subjects; (iii) ways of shaping the activities around developing the relevant constructs so that students gain agency and motivation in planning their own futures, focusing on metacognitive strategies.

These topics have led the teacher (as the researcher) to investigate *how* programs might be implemented so as to produce the desired outcome, that is, scaffolding student thinking so that they are able to generate alternate pathways to fulfil their academic goals, when needed. At the beginning of the research the dominant student mindset, when challenged by a subject, was to opt for mediocrity. It was not uncommon for bright students to leave a subject because they could not achieve the 'A' they were accustomed to in middle school; they would chase the 'A' by taking on less challenging subjects. The question of *what* was happening was the starting point of this research, the aim to determine *how* to change the situation.

WORKING TOWARDS A METHODOLOGY

In this work I situated the reality of *what* is happening within the students involved and in keeping with this position, *how* to modify the initial status needed to be garnered from the students in the field (Brewer, 2005; Creswell, 2014a). *How* questions are concerned with bringing about a change through a set of actions (Blaikie, 2007). This suggests a research approach that is qualitative and interpretive, designed around action-research. The purpose of this research was to respond to a relational situation designed to determine how a teacher's actions can contribute to students better fulfilling potential and persevering in their chosen STEM subjects despite the challenges that they might face.

THEORETICAL PERSPECTIVE

The theoretical perspective frames the problem being researched "by expounding our view of the human world and social life within that world" (Crotty, 1988, p. 7). The theoretical perspective is the lens that has been applied to any research; it gives permission for what theories are used to inform the work and from this an appropriate methodology is derived. The theoretical perspective providing the context for the logic employed in this work is psycho-cognitive (Bolade, 2021), relating explicit metacognitive thinking to students' motivation for pursuing and persevering with STEM pathways. Much research underpins this work but fundamental to its reasoning are the ideas of Weiner's attributional theory of motivation (Molden & Dweck, 2000) along with the metacognition research of Sternberg (Sternberg, 1998). This work is not researching the individual, rather it solicits global truths from individual responses. It does this by examining the content of key informants' responses rather than counting and matching ideas, although some of the latter has been presented to show some correlations collaborating the interpretations made. The psycho-cognitive theoretical perspective draws on ideas that effect student thinking and the actions that follow; therefore, it necessitates discussions and questioning of the focus group as well as observing their actions.

The method by which this work explores the research question, informing possible change within school procedures and courses, is based on an abductive research strategy (Blaikie, 2007). The abductive research strategy begins with an existing environment, peopled with the subjects that the research will focus on. The aim is to "discover their constructions of reality, their ways of conceptualising and giving meaning to their social world, their tacit knowledge. [For this to happen] the researcher has to enter their world to discover the motives and reasons that accompany their activities" (Blaikie, 2007, p. 10). This is an important step to initiate any type of change if students are to successfully interact with structures within the new processes.

The study, through a variety of sampling techniques, (detailed in Chapter 5), focused on a range of students, who were interviewed in a semi-structured style. The questions were open-ended, responses have been recorded and transcribed verbatim for analysis. During the interviews unexpected topics arose; these were not discarded as not fitting any profile but explored by ongoing discussion. These topics often unveiled limitations which were addressed in revisions of the action process. From the initial emergent data a concept map was penned (figure 5.1). The knowledge informing change and subsequent actions was constructed from the interpretations of the responses. Being interested in the underlying complexities to be addressed as students live the experience of navigating towards their academic goals, qualitative research is most suitable as it is flexible, content specific, and categorised by themes rather than patterns (Creswell, 2014a).

Interpretivist inquiry allows for connections to be made from a student's action to a student's thinking, known as psychological re-enactment (Schwandt, 1994). The interpretive practice allows for exploration of "educational interaction too often missed by more positivistic inquiries [leading to a greater range of] relationships, cause, effect and even dynamic processes in school settings" (Burns, 1994, p. 94). This is very much aligned with the objectives and purposes of the research.

EPISTEMOLOGY

While the psycho-cognitive perspective provides a set of research parameters that bounds this research, the structure of this work and therefore the processes that produces the ideas are governed by the researcher's epistemological assumptions. What counts as knowledge in this particular work is an important epistemological concept to come to terms with as it determines how the data is discovered. The epistemological assumptions are also determinants of whether the knowledge drawn from the data is reliable and valid (Seale, 2012, p. 567). If these questions remain ambiguous the methods by which we interrogate our theoretical perspective on the issue raised by the school may be confused by levels of complexities introduced by conflicting ideologies (Blaikie, 2007).

The themes that run throughout this research are based on how students respond to achievements, perceived requirements, stress, and self-perception (identity). It is a logical leap that the students' reality can be considered as constructed by the individual's that are the focus of the study. To put into place a system that would positively affect the students' responses the research needs to probe feelings, thought processes and emotions. This data cannot be extracted from an individual by simply observing and quantifying, (framed by an empirical epistemology), but rather from the voices of the students being interviewed. The research borders on producing its knowledge by a process of ethnomethodology, "the study of people's methods of construction of reality in everyday life" (Silverman, 2012, p. 35).

The abductive research strategy and the notion that the research can bring about change are strong indicators that there might be no absolutes; different students, same scenario, does not mean the same solution. This research, from the onset, defers to a plurality of truths and is therefore firmly ensconced within an constructivist epistemology (Blaikie, 2007; Crotty, 1988).

ONTOLOGY

As the researcher's belief is that the reality is situated within the perceptions of the students, then logically the epistemological perspective must be one of knowledge being created by interrogating the students' perceptions. An interpretive or constructivist epistemology emanates from the researcher's conviction that student self-efficacy and motivations, key elements being explored, have a reality subject to interpretations of the individuals who experience the emotive stated engendered from the actions within the Higher Achievers program. This is derived from an idealist ontological perspective. The same ontological ideology may also be labelled as constructivism, interpretivist, or hermeneutic (Blaikie, 2007); they all espouse a view that "social reality is co-constructed by individuals who interact and make meaning of their world in an active way. Researchers can search for truth in people's lived experiences through rigorous interpretations" (Bracken, 2010, p. 2). The researcher has been tasked to alter the currently constructed reality by introducing a set of different thinking tools which may be able to change the emotive responses to such events like test results, comparisons, criticisms and the like, thereby, also affecting the reactions to those events. This implies that as the researcher I also had a role as a participant (teacher) being studied, hence the action-research can be likened to an ethnomethodology, with an added element of change.

METHODOLOGY

This project required a practical solution, rather than theoretical analysis, therefore an action research approach was adopted ; as Creswell (2014) reminds us "Action Research is the most applied, practical design" (Creswell, 2014a, p. 608) enabling the field to be affected, not merely observed and explained.

"Experience with action research, so far, has shown that teachers are able to action research successfully and can achieve remarkable results" (Nasrollahi, 2015, p. 1). Action research is best suited a research question explored and understood through a collaborative process, between researchers and partners. The research endeavours to meet the partner's needs in a collaborative and equitable manner, affecting change in a substantive way (Lingard et al., 2008).

Critics of action-research assert that the data collected, and therefore the actions that ensue from the data, often fail to adequately justify its claims "because of dependence on validities that primarily assess the emancipatory features of the research" (Newton & Burgess, 2008, p. 19). This claim suggests that the research may be based on clinical and sterile data divorced from social and political nuances which the participants are bound to. Other criticisms question the outcomes; "action-research has assumed a reality which can be uncovered and then altered in some way or improved for emancipatory purposes. However this begs the key questions about where our ideas as to 'what counts as improvement' comes from" (T. Brown & Jones, 2001, p. 5)

Such criticisms serve to highlight possible bias's that can creep into research if left unchecked; for this reason, it is important that student voices are clearly heard and regarded as an important component of this work. Student voices are collected through focus group discussions, personal interviews, and questionnaires. Community of inquiry group discussions, often used as a research data collection tool, have the benefit that the students are more relaxed and are prepared to ask questions of each other as well as to review each other's understanding. Such discussions are likely to bring into focus social and political incursions that may influence student decisions and actions.

The quarterly journal *Educational Action Research*, which has reported on hundreds of researches over many years makes the following valid points

- Action research pursues worthwhile practical ends by trying to find solutions for authentic problems by empowering people concerned to acquire relevant knowledge and share it with others.
- Action research is collaborative and participatory
- Action research is responsive and developmental
- Action research connects theory and practice as praxis by balancing action and reflection and generating theoretical knowledge, delivering viable solutions.

(Rauch, 2023)

In its latest publication the journal reports on an action research successfully applied to an investigation on *how* to develop a healthy relationship between students and mathematics. It took the form of a longitudinal study in which researchers repeated the *plan, act, and reflect* spiral over three years before sharing their findings (Samuelsson, 2023). This particular research, albeit on a similar but parallel topic, follows the same process.

This research has adopted the Stringers (2007) model (Creswell, 2014a). This model contains three basic phases common to all action research processes, look, think, and act. Stringers (2007) model was selected because it lends itself to being explained and understood by the wider stakeholders in the school. Figure 4.1 which lays out the basic design of method applied shows how this model was applied.

Stringer's model names its look, think, and act stages using a more applied phraseology.

Look: Building the picture. Think: Interpreting and Analysing. Act: Resolving problems. As can be seen in figure 4.1 the processes in the model should be familiar to teachers, therefore when explaining the research, the language used is also very much part of the teaching vocabulary. This is important since the final outcomes and the processes leading to them need to be understood by the school leaders and the teaching staff.

Steps in Stringer's (2007) Action Research Model		
Building the picture	Interpreting and Analysing	Resolving problems
Purpose: To assist stakeholding groups in building a picture	Purpose: To distil the information gathered, identify elements of people's experiences, and enable the participants to understand the way the issues affects their lives and activities.	Purpose: To plan and implement practical solutions to problems
<u>Process:</u> Gather information Record information Extend understanding Organise meetings Communication	<u>Process:</u> Frameworks Categorising and coding Analysing key experiences Enriching analysis using frameworks Writing reports collaboratively Presentations and performances.	<u>Process:</u> Planning Implementing Reviewing Evaluating
Figure 4.1 (Adapted from Stringer, 2007, pp. 63, 124, 144) (Creswell, 2014a, p. 616)		

The school and its overarching values must also be considered within this research framework. The school gave rise to this particular research, outlining what it deemed a situation that warranted change. This largely determines the response to the question of 'what counts as an improvement'; it is predicated and judged by the curriculum developers, to whom the researcher is accountable. The researcher is not concerned with 'what' constitutes the change but 'how' to affect the change. As previously noted, this 'how' framed research is relational in nature, being explored through an constructivist ontological belief serving an interpretivist epistemology, that uses an abductive research strategy leading to a plurality of truths, and therefore, solutions.

This action research was undertaken in an Independent, all boys' school in Adelaide, South Australia, specifically focused on the staff and students from Years 8 to 12 in the secondary campus. The school had recognised its 'advanced' student population by introducing such programmes as 'Accelerated Mathematics' and 'Advanced Science and Mathematics' and employed a 'Gifted and Talented' coordinator. These programmes, while very popular in the Middle School, had not translated into students enrolling in chemistry, physics and mathematics in their senior secondary years.

Observations, made by teachers, that had triggered this study include: advanced learners achieving high grades in their middle school science and mathematics but failing to meet the rigor for the same senior secondary subjects; high ability students not opting for science and mathematics subjects due to a lack of confidence in their ability; students dropping out of mathematics and science courses when failing to achieve an 'A', without considering alternative actions; students unaware of how to implement new strategies; lack of teacher awareness of alternative learning strategies and teachers lowering academic standards and rigor due to pressure from administration and parent expectations. It is noted that these observations are not solely confined to the boundaries of the school where this study was proposed; numerous studies have found these same ideas expressed throughout many different educational communities (Dinham, 2011; Mather & Tadros, 2014; Rotigel & Fello, 2004). The school sought to address the issue of students seemingly not reaching their potential and had invested in STEM laboratories, opened spaces suitable for an inquiry strategies, professional development for teachers and leaders, flexible timetabling and on-line resources. Despite the innovations, there still existed a need for students at the school to be empowered to make informed choices based on feedback given by teachers.

APPLYING THE METHODS TO THE FOCUS GROUP

The study involved a narrow sample of 10 -15 focus group students who met a pre-determined criteria. The criteria for selection of the focus group, students had …

- to be enrolled in either the middle school Advanced Learners Programme OR stage 1 or 2 physics or maths methods;
- to be identified as an above average student (rating > 90 percentile points on the Raven non-verbal test). PatM, NAPLAN and teacher identification checklists also were used to verify the high ability;
- and having fulfilled the first two criteria (i) requested to "dropout" of subject due to poor performance in assessment and (ii) found the effort of maintaining high achievements too arduous;
- and/or having been identified as being an advanced learner were counselled away from attempting physics, maths, or chemistry due to poor study strategies.

The main variations within the group came from either demographic or family factors; Drawing on the literature review, it was hoped that the new skills introduced to this group of students affected positively the constructs related to persistence and interest, namely, self-perceptions, self-efficacy (Sax et al., 2015), intrinsic value, task value, and self-value (Watt, 2005). Participants were explicitly introduced to ‘self-help’ strategies.

The planned teaching programs, detailed in chapters 6 and 8, within the research allowed for an appropriate interplay between the individual, the learning environment, and the pedagogy; the factors that mediate the constructs the research aimed to influence (Erdogan & Stuessy, 2015; Holmegaard et al., 2014; Lazarides & Watt, 2015). Action-Research inquiry method allowed for the introduction of variants within the interplay.

“Action research [is] an orientation to inquiry rather than a methodology in itself, a way of enquiring into everyday practices to understand and improve them” (McNiff, 2016, p. 47) and therefore, was particularly suited to this project due to the currency of the issue. Three months into the Academic year, in 2017, 30% of senior Physics students left the subject citing the reason that the subject was too difficult or not of their interest anymore. This study explored if there were alternatives to leaving the subject and if these alternatives could have been realised by the students themselves. The action – research steps proposed guided but did not define the project. In this type of research, the actions are applied, data collected and analysed, the results are the basis of reflective thinking and further modified actions (if needed).

The action-research necessitates that changes, informed by the literature, are made to the program and then the observations analysed. The nature of this particular study required two different sets of students (referred to as cohorts) to run through the High Achievers Program. Whilst changes were introduced to the actual program the research methodology remained the same.

The research methodology followed the same basic design, presented in figure 4.2. Data was collected at regular intervals within the program, focusing on the students that displayed difficulties.

The initial group of students (Cohort 1) experienced the program as it had existed for the past decade. From experience most students were expected to excel, however, a small percentage would also be expected to drop out of the program. Their data, reasoning, and actions provided the initial focus of the study.

The second group of students (Cohort 2) were put through the same program. Though the content of the program was essentially the same, the ‘actions’ and pedagogy within the program underwent some changes. The modifications, detailed in chapter 7, were based around how students were allowed to use their time and the interactions that occurred within the sessions, therefore timetabling and format changes. The modifications were based on data collected from Cohort 1 and informed by the literature. The data from the second cohort were collected and analysed using the same format and criteria as with Cohort 1. From this some inferences could be made in response to the research questions.

Figure 4.2 displays the basic research design; embedded next to the design are the elements from Stringers Model. Each cohort of students followed the same research path.

Chapter five will detail the data collection instruments including their origin, purpose, validity and reliability/credibility

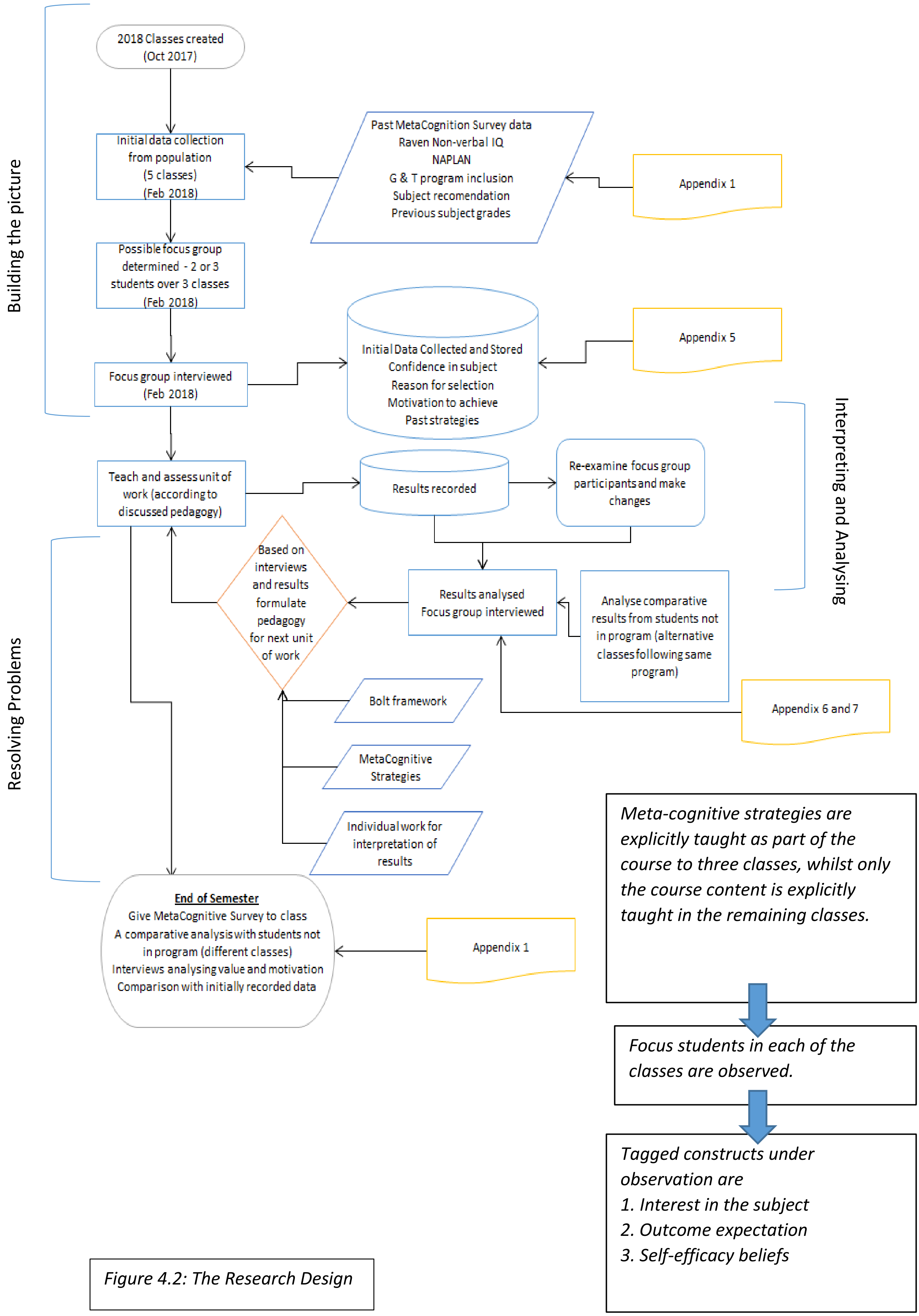

Figure 4.2: The Research Design

ETHICAL CONSIDERATIONS

There were strict ethical considerations guiding the implementation of this study. Since the research encompassed student aspirations and academic success it had to be clear from the start that the student welfare was paramount. The researcher had a moral contract to be the teacher, first and foremost. "What makes the subject of ethics particularly challenging for teacher researchers is the intimate and open-ended nature of action research" (G. E. Mills, 2014, p. 29). Action-research necessarily needs to be in the best interest of those facing the issue being addressed in the study (Creswell, 2014a). The ethical considerations guided what to include and when to probe. At all times utmost care was practiced to protect the privacy and integrity of participants. The following steps were taken:

- Approval for the study was gained by Human Research Ethics committee at Flinders University, and from the Principal where the Action-Research was held.
- Student participation was voluntary. Both student and parents of the students were informed in writing about the topic of the study, the methods used to collect the data, and how the data was going to be reported.
- Participants' identities were concealed, pseudonyms were used where appropriate.
- In the general community of enquiry discussions the topics were of a general nature; any comments that were more personal were quickly averted by the researcher and followed up with a private discussion.
- Access to the data was limited only to the researcher and his supervisor, where necessary. This was clearly explained to students and parents.
- All records of interviews and survey questionnaires were scanned and stored in a locked filing cabinet in the researcher's school office.
- All participants were clearly told by the college's deputy principal that opting out is always an option and would have no bearing on their ongoing education.

CHAPTER 5: THE COLLECTION OF DATA AND ANALYSIS

INTRODUCTION

The purpose of this study was to describe the effects of explicit use of metacognitive and self-regulatory strategies, as reported by advanced learners, when purely cognitive strategies fail. Underpinning this purpose is the assumption that explicit knowledge of metacognitive and use of self-regulatory strategies produces greater student agency and self-determination. The aim of gathering and analysing the data is to track and record the changes and effects on the key informants, the students who are deemed to be at risk. Their stories formed the argument through which a determination was made by the school about resourcing the actions proposed by this research school-wide (committing financial, time and personnel resources). This chapter will detail the data collection instruments including their origin, purpose, validity and reliability/credibility

This research values the experiences of the students; self-identity and social reality is constructed by the students as they interact with prominent individuals, the learning environment, and the actions that link them. In this setting the study uses qualitative methods that extricate ideas from the participants. Such studies often conclude that the endpoint is pluralistic and though the evidence might bias some viewpoint, there are in fact no absolutes (Blaikie, 2007); this research does not look to solve why the issue is occurring but address its consequences at a particular instance.

In line with this philosophy the study has made use of open-ended questionaries, meta-cognitive and self-regulatory checklists, student discussions and interviews, and observations within the classroom. The questionnaires, checklists, discussions and interviews culminated in a triangulation of data helping to provide reliability and trustworthiness. As described all of the questionnaires and interviews were based on known and verified instruments. The responses explored later in this work, whether transcribed from interviews or directly answered by the participant, were analysed according to keys that accompany the instrument.

Interview transcriptions were also checked against a meta-cognitive and self-regulatory rubric designed by the researcher to provide further validity of the interpretations (appendix 8).

TYPE OF DATA COLLECTED

Data collection in this research can be broadly categorised under three headings:

Examining the data already available: NAPLAN results (5 years of data), PAT M and PAT R tests (3 years of data), Raven© tests on file (completed 2017), school reports and teacher reflections that are on file (from Year 5 to Year 12). This data helps to verify that the participating student is of high ability. These are more fully explained in appendix 4.

Interrogation through surveys, interviews, and focus questionnaires the extent of the students' knowledge of meta-cognitive and self-regulatory strategies; ambitions for school and careers; attitudes towards subjects; ideas of success (appendices 5 and 6).

Experiencing the data through the teaching and interacting with the students; including recording field notes when explicitly teaching the meta-cognitive strategies; informal classroom discussions with students before assessments to analyse the strategies they intend to use and post-assessment to determine the strategies used, community of inquiry discussions on stress level, and their interpretation of feedback.

Part of the story lies with the observations made outside of the classroom, this included anecdotal evidence and discussions that the students had at home with their parents. As the teacher, armed with the mindset of the researcher, parent-teacher interviews were opportunities for collaborating data interpreted from the student transcripts. These interviews were also sources of insights for discussions with the student. The parent teacher interviews do not form major sources of information but, nonetheless, provided valuable contribution to the story this research presents.

Three instruments were used to collect the data through interrogation methods. Since this is action-research these instruments were used repetitively whenever a modification was made to the program. Therefore, it is important to understand what these instruments draw out from the students' responses, and, rather than repeat the reasoning at every change, a summary of the instruments and their purpose is presented in this section as an over-arching explanation of actions that follow from the data collection.

INSTRUMENTS USED TO COLLECT THE DATA

The Raven's Progressive Matrices (Raven, 2000) was used as an identifier of students with advanced learning potential by assessing their skills for recognising and logically thinking through patterns.

As with many programmes for gifted students and advanced learners, multiple steps of the identification process are widely used, including parental evidence, student portfolios, and teacher records. However, because there are also many reasons why cognitively advanced students may not achieve their potential at school; cultural, language, underachievement, motivation, to list a few, the Progressive Matrices assessment was used as the base indicator.

Some students that do very well at school are not necessarily gifted or advanced learners. Such hard-working students may suffer under the burden of more complicated tasks presented in a manner that does not step out entire processes. Evidence of the Progressive Matrices' stability and reliability has been established over many years with hundreds of different student samples (Raven, 2000). The Progressive Matrices consists of non-verbal pattern recognition tasks assessing general cognitive ability for ages ranging from 5 to 80. It is a norm-referenced, multiple-choice test, administered solely in pencil-paper format. For many years it has been widely used in both research and identification of cognitively high functioning students, and in this case, advanced learners.

A second instrument used very extensively in this research is the Motivational Strategies Learning Questionnaire, MSLQ (Duncan & McKeachie, 2005), appendix 6. This instrument was developed to verify if students that were meta-cognitively aware were also able to exert influence on their own learning. It was thought that such learners produced better outcomes when faced with cognitive challenges as they were able to be more strategic (Garner & Alexander, 1989; Pressley & Ghatala, 1990).

One explanation is that metacognitive awareness allows individuals to plan, sequence, and monitor their learning in ways that directly improves performance (G. Schraw, 1998)

This instrument separates the various components of metacognitive knowledge and self-regulatory skills and identifies them through related strategies, for example, goal orientation, task value, control of learning beliefs, different learning approaches, time, resource and effort management. From the responses researchers are able to create links between the knowledge of strategies and the changes in attitudes and behaviours.

In this study we are interested in change rather than drawing a line between the knowledge and performance. We use the instrument to examine the change in knowledge and then separately the change in performance once a program has been delivered.

A third instrument, an edited version of the MSLQ, the Metacognitive Awareness Assessment, (G. J. Schraw & Dennison, 1994), appendix 5, was used as a quick gauge measuring student use of self-regulatory strategies. The instrument was used to work out what strategies were missing from the students' repertoire. From these results the strategies were then explicitly introduced and practiced.

DATA COLLECTION THROUGHOUT THE RESEARCH

Students were initially assessed using the Metacognitive Awareness Assessment (G. J. Schraw & Dennison, 1994), presented in appendix 5. They were also surveyed about their motivation for selecting physics and mathematics, appendix 7. Students that found the subject material challenging and whose results lead them to question their capabilities, doubting their initial choice, were candidates for this study. The intervention that followed a topic assessment consisted of a series of self-evaluating questions and a researcher led discussion that directed the student to understand how improvements could be made. The discussion and questions were rigorously based on the Reliability and Validity of Self-efficacy for learning Form, (Baker & O'Neil, 1994) and the Motivation Strategies Learning Questionnaire (Duncan & McKeachie, 2005), found in appendix 6 and 8, respectively. At the start of a new unit of work the class were presented with explicit techniques for either meta-cognitive thinking or regulatory strategies that could be employed during future assessments. Between assessments the formative work also included embedded metacognitive hints, continually prompting the students to practice the newly introduced skills. At the end of the course the students were re-assessed using the Metacognitive Awareness Assessment and also took part in a round-table discussion which focussed on the skills, their performance, and their affect towards the subject.

Figure 5.1 maps out assessment of the students, focussing on those that showed (or reported) performance-anxiety as well as those that might not have achieved as high as expected. Data collected included knowledge and use of strategies and, attitude towards the subject so that 'where to from now?' decisions could be informed.

Apart from data being used to decide future actions it also informed the researcher whether the planned intervention had a positive effect on students with respect to wanting to continue with the subject and a positive and ***realistic*** attitude despite results. This enabled the researcher to make a judgement on how autonomous students were in planning their pathways to improvement (show of resilience) and how interactive they were in negotiating their assessments (student agency). The 'Reliability and validity of Self-efficacy for Learning Form' (Zimmerman & Kitsantas, 2007) was used to assess attitude and agency.

ANALYSIS AND INTERPRETATION

Analysis was continuous and therefore occurred from the articulation of the research problem through to the final discussions of implications for theory and practice. In the spirit of a constructionist framework, thought had to be given to the analytic interplay between the researcher and the participants. As the researcher was analytical towards the responses gathered, the participants were also analytical in the way they interpreted the questions, their selection in what they chose to reveal, and how they framed their portrayals of their own experiences. This was one main reason for sourcing the data in a variety of ways. Different sources and different presentations of the data, (Chapter 9), allowed the researcher to triangulate the interpretations.

In this research it was important to make the distinction between analysis and interpretation. Although difficult to make a clear distinction if the research (as this does) requires both analytic alongside of the interpretive work. The two can be differentiated by the conceptual meanings they hold. Interpretation is about assigning meaning or attaching significance to data (in the process of theory construction) whereas analysis is mostly about a process of fragmenting the data and identifying patterns formed (Seth, 2022). Both exist in this study and the two processes are at a continuous interplay. The implication for this research is that there needs to be clear parameters that are applied to governing the purpose for any question asked, the method that the data is grouped and structured for analysis, and the actions that come from analysis. If there is confusion between the interpretations and the analysis the result could be a confusion of ideas and an over-lengthy cyclic process of drawing out relevant conclusions (Blaikie, 2007)

GENERAL ANALYTIC STRATEGY

To conclude this chapter outlining the data collection strategies, figure 5.1 shows the process which flows from the two theoretical propositions discussed in Chapter 1. The propositions shaped the nature of the research and defined the purpose. Figure 5.1 shows how the data is collected from two separate groups of students. The data were analysed by tabulating differences and also interpreted from assigning meaning to the students' different reasoning. The data collection methodology was in keeping with a constructivist epistemology, seeking the lived experiences and the students' interpretation of those experiences. Strategies were introduced within the action research to alter how the same lived experiences are interpreted by the different students. It would be unusual for all the students to have a common reaction or even a common understanding of the experiences in the learning program, however, the action research interprets the different reactions through a metacognitive lens, endeavouring to establish a link. It is hoped that through the implementation of the new strategies students do not choose to avoid challenges for fear of failing but employ the meta-strategies to give themselves the best opportunity of success.

In keeping with the previous discussion on analysis and interpretation, whilst this research is qualitative in nature, primarily because of its use of the Action-Research process, some discourse analysis has been employed. In general, discourse analysis is a technique used in qualitative research studies (Sayago, 2015).

" … Discourse Analysis is an analytical technique that works as a toolbox where we find concepts elaborated by different theoretical currents" (Sayago, 2015, p. 273). In this research the tool is used to collaborate the qualitative interpretations. Chapter 9 validates the data collected and interpreted in Chapters 6 and 8 by fragmenting it and exploring patterns. The analytical treatment of the exploring the discourse does not tell the story of this research, the story is revealed by the student voices, the analysis merely adds authenticity to these discussions by finding collaborating patterns.

Chapter six analyses the data collected from the initial cohort of students that went through the program. It is their voices that will enable further modifications to be made to the interventions before applied to a second cohort of students.

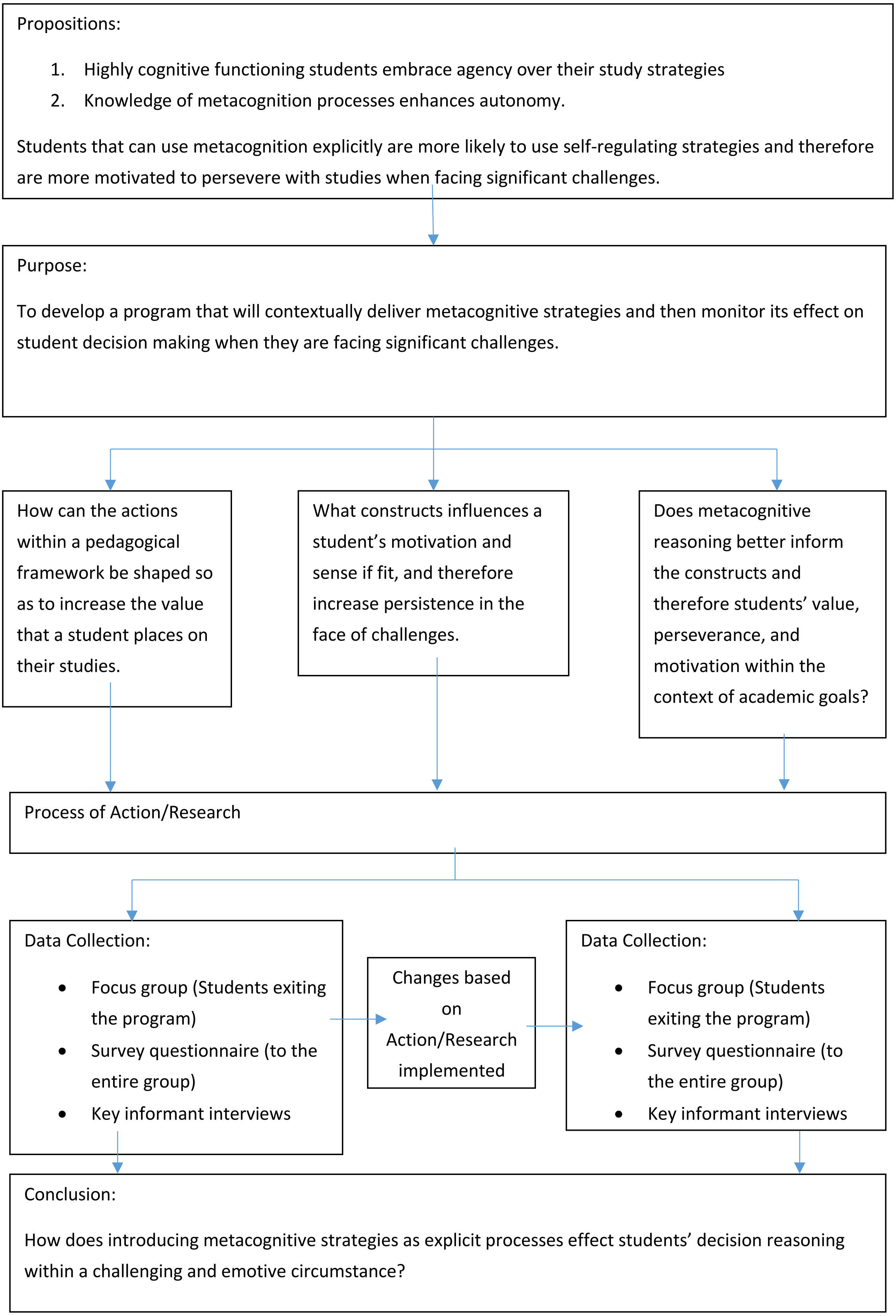
Propositions:
1. Highly cognitive functioning students embrace agency over their study strategies
2. Knowledge of metacognition processes enhances autonomy.
Students that can use metacognition explicitly are more likely to use self-regulating strategies and therefore are more motivated to persevere with studies when facing significant challenges.
Purpose:
To develop a program that will contextually deliver metacognitive strategies and then monitor its effect on student decision making when they are facing significant challenges.
How can the actions within a pedagogical framework be shaped so as to increase the value that a student places on their studies.
What constructs influences a student's motivation and sense if fit, and therefore increase persistence in the face of challenges.
Does metacognitive reasoning better inform the constructs and therefore students' value, perseverance, and motivation within the context of academic goals?
Process of Action/Research
Data Collection:
• Focus group (Students exiting the program)
• Survey questionnaire (to the entire group)
• Key informant interviews
Changes based on Action/Research implemented
Data Collection:
• Focus group (Students exiting the program)
• Survey questionnaire (to the entire group)
• Key informant interviews
Conclusion:
How does introducing metacognitive strategies as explicit processes effect students' decision reasoning within a challenging and emotive circumstance?

Figure 5.1

CHAPTER 6: ANALYSIS OF DATA: COHORT 1.

INTRODUCTION

The methodology adopted was Action-Research, “In this spirit, educators can test their own theories and explanations about learning, examine the effects of their practices on students, and explore the impact of approaches on parents, colleagues, and administrators within their schools” (Creswell, 2014a, p. 612). Therefore, the data analysis in this research has been solely based on the reactions of the study participants, with the intent of creating a very particular learning environment. The desired outcome was meta-cognitive, self-regulated learners; the learning environment was where the desired outcome was fostered; the questionnaires, survey, and interviews, together with the data analysis allowed the researcher to monitor the effectiveness of the program at any point.

LOOK – BUILDING THE PICTURE – STRINGER’S MODEL

PART 1: Building the picture from questionnaires and interviews.

In this part of the research the initial data was analysed to determine what may have been happening within the current processes, what was working and what may have been missing.

In building our picture of what might be happening we remind ourselves that an

> Action research seeks to give voice to people who have previously been silent research subjects. Action research aims to support teachers in dealing with the difficulties of student *learning* in a reflective way. Action research as any systematic inquiry conducted by teachers, administrators, and counsellors with a vested interest in the teaching and learning process, for the purpose of gathering data about how their particular school operate, how they teach, and how their students learn. (Nasrollahi, 2015, p. 18668)

When analysing the cohort 1 data the research was not focussed on causality, as there are many reasons for students leaving the subject (Bøe & Henriksen, 2013; M. Brown et al., 2008; Murray, 2011). The results were analysed to explore the strategic pathways that can lead to students who can draw on meta-cognitive routines and therefore exercise control over their learning, maintaining motivation or determination 'in the face of adversity' (Pintrich, 2004; Pintrich & Groot, 1990; Zou et al., 2009).

The school's High Achiever's programme has a history which needs to be understood. The program was purely based on accelerating students through the Year 8 to Year 12 Mathematics course, with the aim of having the advanced learners complete the Stage 2 (Year 12) Maths Methods course during their Year 11 studies. The program had been running since the late 90's with limited success. One of the more notable outcomes was that of the approximate 35 students that would start the course in Year 8 less than 10 would still be in the course at Year 11. Of greater concern for the school was that students that dropped out of the course along the way often 'dropped' out of all the higher mathematics and science courses; therefore, they did not re-assimilate into the normal classes. These students were all highly recommended by their respective subject teachers and they also were able to achieve between the 90^{th} and 99^{th} percentile in the Raven Progressive Matrix assessment, therefore by all accounts had advanced cognitive development and yet they were lost to the higher mathematics and sciences.

The current program had been running since 2000 and it fitted the school's thinking of how Advanced Learner's Programmes ought to deliver but it did not have the intended outcomes.

ANALYSING COHORT 1 – STUDENTS IN THE EXISTING PROGRAM

This study begun with the participants in the program being assessed using the Meta-cognitive Awareness Inventory (G. J. Schraw & Dennison, 1994) to determine the groups' awareness of metacognition and self-regulation. Tables 6.1 and 6.2 shows a breakdown of the responses given by Year 10 students who had been accelerated in Mathematics from year 8. They were all advanced learners and had achieved highly in their accelerated Year 8 and 9 courses. Their Raven Progressive Matrix assessment placed them in the 90th percentile or above (for their age group) with regards to cognitive abilities. They were preparing to start their Year 11 Maths Methods studies. It is during this year level that teachers are reporting students seemingly unprepared and the greatest number of drop-outs.

COHORT 1: INITIAL METACOGNITIVE DATASET

Tables 6.1 and 6.2 show what percentage of the whole group were aware of the different types of knowledge and at what proficiency they had in skill usage. For example, every student in the group knew a variety of planning strategies, but only 12% of the group used them consistently. 41% of the students recognised that they did use some strategy to plan their task, but it was not a deliberate action (rather more haphazard), whereas 47% used the metacognitive strategies but not as a planned or practiced routine.

Responses from initial Meta-cognitive Awareness Inventory assessment				
Knowledge	Did not show any understanding of this type of knowledge	Showed use of strategies but could not identify the knowledge	Understood the types of knowledge but inconsistent with use	Showed understanding of this knowledge and could use it
Declarative	0	0.47	0.36	0.17
Procedural	0.35	0.29	0.12	0.24
Conditional	0	0.64	0.24	0.12

Table 6.1 – Cohort 1: Initial breakdown of metacognitive knowledge assessed

Skills	No evidence of use	Sporadic use, inconsistent	Familiar but unplanned use	Explicitly practiced
Planning	0	0.41	0.47	0.12
Comprehension	0	0.47	0.41	0.12
Information Management	0	0.23	0.59	0.18
Debugging	0.05	0.36	0.35	0.24
Evaluation	0	0.24	0.58	0.18

Table 6.2– Cohort 1: Initial breakdown of self-regulatory skills reported

The data in these tables showed a breakdown of the extent of knowledge and the subsequent skill use as these advanced learners entered their first year of Senior Secondary Mathematics, whilst at year 10. This group of students had always known success in their Junior Secondary Mathematics classes therefore it is not particularly surprising that most of the group either were implicitly using successful strategies or at least were aware of the strategies.

The fact that 35% of students were not aware of the procedural steps for applying mathematical algorithms is not a surprise, as in mathematical assessments students are allowed to use a prompt sheet when undertaking assessments. The prompt sheets are commonly filled with examples on how to accomplish procedures, usually step by step. An analogy of this would be asking someone to find a square root and supplying a calculator, the procedure (how) of finding the solution would be accomplished by the calculator and seldom would someone know how to find a square root without the calculator. Students are seldom required to memorise procedures, graphic calculators displaced and replaced procedural knowledge. Students do however know *when* to use the various algorithms (conditional knowledge). Interestingly a lack of procedural knowledge has been a point of stress of many students if the task was not based on algorithms but a folio or investigative piece, this becomes apparent later.

META-COGNITIVE SKILLS OF COHORT 1

Of the group of 21 students assessed (table 6.1), five students dropped out of the course. While 25% of Cohort 1 students dropping out of the course is a significant number, on average it reflected what has happened in the past, before the study. It was these cohort 1 students that were of particular interest to this study; this is the problem that the school had cited in the past and has been trying to remedy.

The study compared the skill acquisition of the five students that left the program with that of the top five students that remained in the program. Of the five top students, two of these students went on to achieve merits in their Year 12 Maths Methods course, with Australian Tertiary Admission Ranks (ATAR) in the high 90's, whilst another three achieved straight A's in their Year 12 Physics and Mathematics subjects. Whilst their stories will not be told in this study, of interest is their responses in the initial Metacognitive Awareness inventory; their knowledge and use of skills compared with the same for the five students who dropped out of the course during the year. The tables 6.3 and 6.4 are by way of comparison between the five *top* students, (1-5), to emerge from the older HAP program with the five students, (6 – 10), who found the experience overwhelming.

After scoring the 52 questions in the Metacognitive Awareness Inventory any students that showed a very strong explicit knowledge or strong usage of the strategies were recorded as a 5. Students that showed no knowledge or usage of a strategy was recorded as a 0. In general, the recorded figure aligned with the following 5: Consistent, 4: More often than not,
3: Developing, 2: Attempted usage, 1: Weak and inconsistent, 0: no knowledge or usage.

Student	Declarative	Procedural	Conditional	Planning	Comprehension	Info Management	Debug	Evaluation
1	5	5	5	5	5	5	5	5
2	5	4	5	5	3	5	5	5
3	5	5	5	4	4	4	5	5
4	5	5	5	2	2	4	4	4
5	5	4	5	2	1	4	4	4

Table 6.3: Group 1 - Students who excelled in the STEM subjects

Student	Declarative	Procedural	Conditional	Planning	Comprehension	Info Management	Debug	Evaluation
6	4	4	4	3	3	4	5	2
7	4	4	3	2	2	4	4	2
8	4	2	4	1	1	4	4	0
9	4	3	4	1	1	3	4	2
10	3	0	3	1	1	2	4	0

Table 6.4: Group 2 - Students who left the program and abandoned the STEM subjects

From the start the students that did drop out clearly were not able to explicitly call on the range of metacognitive strategies available to the students that excelled. Cognitively students 6 – 10 (table 6.4) were not significantly different to the students 1 – 5 (table 6.3), they had all achieved top grades for their middle secondary subjects and were all above the 90^{th} percentile in their cognitive abilities. The difference between middle secondary and senior secondary is the complexity of the content, there is far more analytical and critical thinking involved, and some different pedagogical styles; an idiom often heard is that middle school teachers teach students whilst senior school teachers teach subjects! These differences between middle and secondary education alongside the deficit found within a student's own skill set has led to disappointing outcomes for the students in Group 2 (table 6.4). It is these students that the study seeks to influence. One can assume that the educational differences between senior and middle school education will probably not change significantly in the near future therefore it is the student's skill set that needs to be expanded.

Interestingly, from their own reporting to the Metacognitive Awareness Inventory (MAI) students in both groups affirmed their motivation and desire to do well, their commitment to task, and control over their own learning, however when the students responded to their use of strategies there was a divide between the desire to achieve and succeed and how to explicitly do so! As an example whilst some students responded that they used debugging skills to recheck their work, they were unable to explicitly cite how or when this was done, "it just happens" was a typical response.

In the above tables a score of a 4 or 5 is indicative that the student is able to identify the skill and its usefulness, as an example a score of 4 under the heading of Conditional Knowledge indicates that the student, from his responses, has knowledge about when and in what conditions certain knowledge is useful. From the initial questionnaire, as recorded in tables 6.3 and 6.4, and in discussions with the group it was clear that the Year 10 advanced learners were familiar with meta-cognitive and self-regulatory strategies, most recognised them as processes that they had occasionally called on in their middle years. Tables 6.3 and 6.4 are a good representation of the whole cohort from the fact that about 50% of the students recognised the processes but also dismissed them as irrelevant as they had not needed the strategies in the past. Interestingly, many of the students recognised the strategies but could not explicitly explain how the strategy was used and under what conditions. As an example when given the statement: “When I study for this class I practice saying the material to myself over and over”, (G. J. Schraw & Dennison, 1994) many recognised this as a strategy that could be used but the majority associated this action as a way of rote learning rather than name it as a strategy for encoding or elaborating. This has subtle consequences, when the strategies are only used implicitly, they cannot be called on when needed the most, that is, when cognition fails and there is an element of stress involved such as in an assessment situation (Bruning, Schraw, Norby, & Ronning, 2004a). In senior secondary classes the stress can be more pronounced as assessment provides more difficult and complex challenges; there is also more at stake.

COHORT 1: EXITING STUDENT DATA IN FOCUS

At the end of each term or unit, as per the map of the study, figure 4.1, the students are again questioned on how they think they are faring and in doing so report their own use of strategies. The end of unit questionnaire (appendix 6) examines what importance the students attach to the unit (is it worth expending effort?), how independent the student felt in what was studied, (a balance between teacher scaffolding and solo achievement), how the student was allowed to ‘learn’ (agency), and finally the stress felt during the assessment of the work; these are all important traits that affect how a student values the subject (Watt, 2005). The second part of the questionnaire was all about the use of strategies.

Although five students left the course only 4 of the responses are reported as the 5th student left the course during the semester and did not complete a questionnaire, however his exit interview was quite telling. Table 6.5 represents student responses from the ‘Motivated Strategies for Learning’ (Duncan & McKeachie, 2005) questionnaire, found in Appendix 6. The questionnaire separates attitudes towards and use of strategies. For the purpose of this analysis a student’s responses was reported as a percentage, for example in table 6.5 Student

6 completed tasks successfully 50% of the time if the motivation was intrinsic but 100% of the time if there was extrinsic motivation. The same student recognised that he used rehearsal strategies 25% of the time and reported using effective organisational strategies 25% of the time. Students 6 to 9 left the STEM subjects, so, for the purpose of our analysis the scores of the continuing students were averaged and presented (Success 1).

Student self-reported attitude to motivational aspects of the learning.					
Motivation	Student 6	Student 7	Student 8	Student 9	Success 1
Intrinsic	0.5	0.25	0.5	0.5	0.5
Extrinsic	1	0.5	1	0.5	0.75
Task Value	0.7	0.8	0.5	0.8	0.5
Control of learning	0.5	0.75	1	0.75	0.75
Test Anxiety	0.4	0.4	0.4	1	0.4

Table 6.5: Breakdown of responses to Metacognitive Awareness Inventory

Student use of strategies					
Learning Strategies	Student 6	Student 7	Student 8	Student 9	Success 1
Rehearsal	0.25	0.25	0.25	0.75	0.75
Organisation	0.25	0.25	0.5	1	0.25
Self-Regulation	0.4	0.08	0.4	0.5	0.8
Time and Study	0.5	0.5	0.5	0.6	0.9
Effort	0.75	0.5	0.75	0.75	0.75
Resources	0.5	0.5	0.5	0.5	0.5

Table 6.6: Responses analysed in terms of the strategies

The data produced by this questionnaire, completed by the students that were struggling with the course content, suggested that they had the attitude necessary for persistence despite difficulties (Table 6.5). The responses indicated that the students saw value in the tasks that they were asked to complete; they self-reported that they were motivated within themselves to do well (intrinsic) and were challenged and supported by external factors (extrinsic) as well; they believed that they had some agency over their studies. These self-reported traits are all important aspects of motivation (Lent, Brown, Hackett, & Brown, 2002). There was, however, a discrepancy when the students self-reported on their use of learning strategies. Most of these students had poor use of rehearsal and elaboration strategies. These are memory encoding processes, the method by which students commit new information to long term memory and have a significant bearing on how the information is remembered (retrieved). “How we encode to-be-remembered information makes a huge difference in how well we remember it. One very important dimension of encoding is rehearsal” (Bruning et al., 2004a, p. 66). Rehearsal influences memorability and is the initial process of learning. There are several strategies for efficient learning “when long term memory is desired some form of elaborative rehearsal should be employed. Many encoding strategies employ elaborative rehearsal” (Bruning et al., 2004a, p. 67). Elaborative rehearsal is learning new material by associating it with material already known; the new information is not learnt in isolation but within a context. The four students who struggled with the content of the course had problems explicitly calling on any effective elaborative rehearsal strategies, therefore the quality of their recall would have been compromised (Hattie, Biggs, & Purdie, 1996). In summary, these students self-reported that they were satisfied with their efforts, motivation, and preparation, however, when asked to identify what strategies they used it became apparent that they had not properly understood either the correct procedures for applying the knowledge and/or the correct conditions of when the knowledge had to be applied. The students knew the ‘what’ of the knowledge but not the ‘how’ or ‘when’ and therefore struggled to find success. “… metacognition and performance was fully mediated by self-efficacy. This suggests that students with effective metacognitive strategies also have strong belief in their capabilities to successfully perform a task” (Coutinho, 2008).

Based on the gaps highlighted by this questionnaire, taking control of learning and applying self-regulated strategies when most required would have proven difficult for these students. Students that are able to assume control are less likely to experience stress, anxiety, and depression when goals or grades have not been met (Bruning et al., 1990). This discrepancy was further confirmed when the students were interviewed about the reasons for not meeting their goals. In these discussions the students attributed their apparent failure to external sources, such as, too many simultaneously competing assessments, outside sporting commitments, or the content was delivered too fast; these are factors ‘outside’ of the student’s control, for example from student 2 transcript, “I have other commitments as well, working part time (at a fast food outlet) and I play soccer. Training twice a week and playing on weekends makes it difficult to find the time to do all the work that is sometimes set …”. The low use of self-regulatory strategies means that when goals are not met attribution is often assigned to external influences. Self-regulated learning refers to all aspects of one’s learning; planning through to self-evaluation. Irrespective of one’s own belief about control, not being able to call upon strategies would seriously limit the options available to a learner when difficulties are encountered (Mayer, 1998). Mayer suggests that three components are necessary if cognitively demanding tasks are to be successfully completed; skill, Meta skill, and will. The students in our study had the cognition (skill) and the motivation (will) but lacked the Meta skill.

These concerns were highlighted in the students’ responses and manifested themselves, eventually, as students leaving the subject and the Higher Achievers Program, the acceleration program developed for the school’s advanced learners. The need for introspection was obviously needed. Looking back at the program might seem like wanting to find causality, (why did this happen?), but this is not the case. Causes could differ markedly for every student; by looking back at the program we were comparing it to what is presented in the literature. This, together with listening to students’ stories and experiences within the program, enabled informed modifications to be actioned. By following such a process, we were not starting blindly from the beginning every time but adapting past processes in order to better arm the students with strategies, regardless of whatever the initial causes might have been.

COHORT 1: STUDENT TRANSCRIPTS

Listening to student voices is an important component of Action-Research. In order to fully understand the exiting student's reasoning for leaving the program, a brief anatomy of the program is presented here.

The program was delivered through mathematics; it accelerated content presenting Year 11 topics to the Advanced Year 10 group. A range of topics were presented that were a mixture of the Year 10 and Year 11 course. The course was set up as a normal class following a standard timetable; at this school the time allotment was five, forty five minute lessons per week. The students were to complete the Year 11 course by the year's end so the course was the Year 11 course integrated with a revision of the important components of the Year 10. The students sat the same assessments as the Year 11 students. Interspersed amongst the maths lessons were also sessions on metacognition. This was known by the school as the Higher Achievers Programme (HAP).

The meta-cognitive sessions included:

1. Introductory lessons that introduced the distinction between metacognition and cognition. This is an important distinction that needed to be understood if self-regulation was to be achieved (G. Schraw, 1998). Within these lessons both cognition and metacognition were modelled for the students.
2. Lessons were structured so that students could practice and reflect on the skills, using a community of inquiry approach, which were modelled. Problem solving competitions and engineering challenges were provided; successes and failures were analysed within the time allowed. A community of inquiry is an important aspect of reflecting and giving importance to the skills (Kuhn, Schauble, & Garcia-Mila, 1992).

3. Students were given a ‘regulatory’ checklist to follow. When students did not achieve as they expected this checklist was used as an interview springboard to determine what they thought could help in the future.

Students were never forced to remain in the course and could have left whenever they wished, although, there was an exit interview. The final discussion was of a general nature, primarily to make certain of the well-being of the student but also to determine if the program could have better catered for the special needs of specific students. Quitting the program meant returning to a mainstream class and all the unspoken innuendoes that accompanied the decision. The following are transcripts of three such interviews.

Transcript 1:

> “When I do the test I think that all my answers are correct. I usually finish the test with time to spare so I check answers. When I get my test back I get very disappointed at my grades. When we go through the test in class I understand my mistakes. I’m not sure what else I’m supposed to do, especially when I think I’m right during the test.”

The first excerpt is reported from one of the students that dropped the course citing that he was losing confidence in his ability to do the mathematics; there may have been some parental suggestions leading to this insight. He also stated that the subject was not one that was needed for his university course therefore he possibly was not going to pursue it any further, concentrating on the more relevant courses.

This was a common thread that came through when talking and discussing reasons for leaving the course with many of the exiting students in the past. A fear of not attaining the required ATAR was also connected to the same reasoning. One of the students who gave the ATAR as the main concern and therefore the reason for leaving the course was averaging high level ‘B’ standards whereas throughout his entire middle secondary classes he had achieved straight ‘A’ standards. His claim, supported by his parents, was that the time spent on the course did not match the grades he was achieving and this could have a bearing on his final school result. He, too, did not pursue the subject in his final year.

This very much agrees with the literature which states that “…academic and work interests are influenced by four interrelated cognitive and behavioural variables – general cognitive ability and specific skill sets, outcome expectations, self-efficacy beliefs, and goal mechanisms” (S. D. Brown et al., 2011, p. 81)

These are very real concerns for the students. It also might indicate that the teaching of metacognitive strategies alongside of a senior secondary SACE course could be a distraction rather than provide the intended scaffolding. Transcript 1 shows that the student had not specifically connected the metacognitive strategies to the difficulties that were being experienced, the stakes that were being affected were the outcome expectations, self-efficacy, and goals (S. D. Brown et al., 2011), the consequence was the student dropping out of the STEM subjects.

The second transcript reveals more insight from the student. There are two main issues that are most relevant to this study, the lack of knowledge demonstrated by the student, specifically on how to organise and plan, as well as the distancing of the individual from the justifications given for dropping the course.

Transcript 2:

> … I’ve always felt good about my tests … not sure I stressed … I just generally focus on the test. Maybe I could have done better but I did look at all the review tests in the (text) book. My cheat sheet (prompt sheet) was prepared but I did not use it during the test. I’ve prepared my cheat sheet as I’ve always had and it’s worked so I don’t know why I’ve been getting lower marks this year …

> … if I redo all the tests again I think I would do better. … there were questions that I had never seen before, I don't think we were taught examples of those questions. This year I have stressed over my grades in maths more than in the past and it has affected the grades in my other subjects so I think if I return to mainstream I would do better in my other subjects as well …

> … I have other commitments as well, working part time (at a fast food outlet) and I play soccer. Training twice a week and playing on weekends makes it difficult to find the time to do all the work that is sometimes set … I don't want to give up sport and work and I can do both and normal maths.

These transcripts are abbreviated, as the discussion takes about 30 minutes. The main ideas are always reported using the students' wording and phrasing. This second transcript has a lot to unpack.

Of particular concern that the ideas within this second transcript raise, is where the student apportions the reasons for leaving the program. To briefly list them:

- The examples were not specifically taught or demonstrated during the course.
- The demands of the other subjects together with the added stress of the program is affecting overall grades.
- The demands of soccer games and training make it difficult to give time to the program requirements.
- Holding down part-time casual employment is also creating a time stress.

It is also worth noting what is not mentioned in the transcripts. Students do discuss cheat sheets, but they do not discuss any metacognitive strategies which allows them to refer to them effectively, even though these strategies were incorporated into the course.

All of these, as in the previous transcript, are valid concerns and very real to the student, (and his parents). This transcript is no doubt representative of many other students' concerns who have left the program since it started in 2000. The reasons listed here are ones where the students have little control over (unless activities are terminated, which is not an option).

In a review by Peterson (1990) it was found that students' who attributed failure causality to uncontrollable circumstances (e.g. attributing failure to ability, teachers, and resources) often have "underlying issues including less help seeking, vaguer goals, poorer use of strategies, and lower performance expectations" (Bruning et al., 1990, p. 123). The same review suggested that students that do not apply help-seeking strategies after a poor achievement do not seek help because in doing so provides an explicitly low-ability cue to one's peers. Herein lies a subtle link to a theme that also was raised in the first transcript, beliefs about intelligence.

The third exit interview was a discussion based around a new future …

Transcript 3:

> … tests were ok but after talking to my parents I've decided to follow a different career path. I don't need Maths Methods and Physics for what I want to study so I am changing my subjects.
>
> … what led up to this was that I found I wasn't really interested and therefore did not spend the time to learn for the tests … I sort of knew I was going to change. I also talked to other teachers about coming into their subject late and they said it was fine. I am going into business and economics subjects rather than maths and science. Other teachers said this should be ok and there are plenty of opportunities … if I was interested I'm sure I'd do better …

Again, as per the other interviews, a very valid and justified reason. In this study's review of the literature, it was cited that career orientation is very dependent on self-referencing. Studies completed in developing the Social Cognitive Career Theory (SCCT) showed how personal, contextual and experiential factors adapt the self-referencing process to formulate a viable future. Self-referencing is an important component of self-efficacy, a primary influence of actions undertaken by individuals towards a particular career path (Sax et al., 2015). There may be many reasons for the student's change in career path, however, it would be highly probable that the experiences provided by the HAP program along with the student's lower achievements (B-standard) contributed to that decision.

In the three transcripts as well as the responses to the MAI the students thought they were applying themselves as they had always done but were not seeing the results of their efforts.

The semester ended with an examination. This was followed by a final questionnaire where the students self-reported on their use and acquisition of skills. The data presented in the tables 6.7 and 6.8 compares data from students continuing with the HAP program with those that chose to opt out at the end of the semester. This final set of data, when combined with the interpretations made from the transcripts and the responses from the initial questionnaire can be used to inform the changes to be made before delivering the program to the second cohort of students.

Student	Rehearsal Strategies	Organisation Strategies	Self-Regulatory	Time and progress monitoring	Self assessment of effort	Resource and assistance Management
Dux Student	4	3	4	4	4	4
Merit Student	4	5	5	5	5	5
Student 3	3	4	3	5	4	5
Student 4	4	4	3	5	5	4

Table 6.7

Student	Rehearsal Strategies	Organisation Strategies	Self-Regulatory	Time and progress monitoring	Self assessment of effort	Resource and assistance Management
Student 5	2	2	3	3	4	2
Student 6	2	2	1	3	4	2
Student 7	2	3	2	4	4	2
Student 8	3	5	1	3	4	2

Table 6.8

The two tables show some significant differences and also supports the literature, that is, although metacognition is not necessarily aligned with cognition, (all of these students showed advanced cognition), students that are able to scaffold by being metacognitive are far more likely to attain a successful outcome (Cubukcu, 2009).

The four students that continued and the four students that left the program (and the subject) had very similar cognitive abilities and were very motivated high achievers in middle secondary, yet the experience of the HAP program led to different outcomes. This, together with the literature, informed the research of important changes that needed to be made to the initial HAP program. The analysis of the final questionnaire, broken down and displayed in tables 6.7 and 6.8, along with the interpretations of the reasoning within the transcripts, forms much of the discussion in the next chapter, and informs the research of modifications to be addressed before a second cohort of students is entered into the program.

CHAPTER 7: PROGRAM MODIFICATIONS

INTRODUCTION

Following the data analysis from the cohort one experiences, course modifications were developed.

It became evident from the transcripts and the actions of some of the students that they interpreted any lowering of the achievement score as personal failure. They opted out rather than sacrifice reputation, self-esteem, or (in their opinion) a career pathway. The students were unwilling to risk ongoing failure. Somehow the program had to 'lower' the stakes so that the students would be comfortable with fluctuating achievements. Lowering of the perceived stakes, (and another issue discussed later), involved a change in the mindset of the students.

As evident from the transcripts, this was the first time that some of these students struggled with mathematical concepts, (the program was delivered through the Maths course). Many of the middle school concepts, for example, the fundamentals of ordinality and cardinality develop in students without instruction, however, the more abstract concepts such as algebra, graphing, needed to be explicitly taught and practiced. The extent of mathematical progression is impacted by the cognitive ability of the student. The beliefs that students held about the development of their cognitive abilities significantly affect their learning and performance (Dweck & Leggett, 1988).

"Metacognitive skills do not exist in a vacuum. All too often, students possess knowledge and strategies that are appropriate to the task, but do not use them" (G. Schraw, 1998, p. 137). One of the main reasons suggested for this is that students do not engage and persist in the tasks if they <u>believe</u> that intellectual ability, or the lack of it, makes a difference. As alluded to in the introduction to this work, the reason often given by students for not attaining an expected standard is a missing cognitive tool, e.g. "Maths is just not my thing", however *this* *is not the case here* since these students had been tested and had shown advanced cognition. “Ruling out cognition leaves two other possibilities – metacognitive and motivational factors may be involved” (Mayer, 1998, p. 61). Therefore, the school’s revised HAP program needed to embrace metacognition and motivation, however these were not enough. “Researchers are beginning to understand that much of our behaviour is shaped by our unconscious beliefs about key aspects of learning, such as the nature of intelligence and knowledge” (Bruning et al., 2004a, p. 137). Within the Higher Achievers program time needed to be provided to introduce the idea that intelligence and reasoning is not limited by nature, it is not static but an evolving quality (Dweck & Leggett, 1988). This brought a new focus to the course, that is, intellectual development is controllable since it is incrementally developed. Effort is rewarded by intellectual development; the effort is in the process not the answer and therefore the process of problem solving is possibly more important than the product or the final solution. Mistakes and failures need not be an endpoint but rather part of the formation of intelligence, information gathering, and as such needed to be embraced and not shunned. Every mistake is the result of an effort to come to some solution.

The notion of incremental intellectual growth was an important idea to establish at the beginning of the program. Failure to do so made the stakes too high as each failure erodes at a student’s academic self-worth and confidence. When the stakes are too high many students will not risk the self-worth; this is one of the major influence determining whether students persist with their courses (S. D. Brown et al., 2011).

Actions that were implemented in the second phase of the study, primarily to a second Cohort of identified students at Year 7, 8 and 9 were:

MODIFICATION 1: SCHOOL IMPOSED CHANGE

The action research existed within the scope of the education that the school provided. When the study perceived a problem, research was initiated, however, the actions (modifications) that were proposed were all negotiated with the school authorities. The researcher had the role of Coordinator of Gifted Programs at the school and developed modifications with the appropriate curriculum and subject coordinators.

The newly appointed Head of Mathematics at the school was not in favour, (unless out of necessity), in the acceleration of students through coursework. The idea of Year 11 students completing Stage 2 subjects was not one that had shown huge benefits at the school in the past. It was suggested that the students be enriched but not accelerated. This affected the content which was to be delivered. It also meant that the students now completed the same assessments as the mainstream mathematics students. Some parents did not see the value in an advanced program that did not involve acceleration. This modification was not one which was recommended through the action-research but was nevertheless implemented.

MODIFICATION 2: MINDSET

In response to the last set of observations and the exit interviews, a unit of work on incremental mind growth was introduced. In their interviews, students often mentioned that they did not apply the required effort because they were considering a change in ‘career’ direction or had lost interest. When students encounter what they perceive as failure they respond with either helplessness or a robust mastery orientated approach to resolve issues. A sudden change in interest coupled with disappointing achievements could be a helplessness response (Dweck, 1999). Such responses are possibly a symptom of the student’s lack of knowledge of strategies or a personal belief that intelligence is an immutable quantity or both. A ‘career’ change may be a response to a student’s self-belief that any person has limited potential depending on the intelligence that nature has bestowed on the individual. Notions such as “my son will never be good at maths … we (his parents) have always struggled with it” or “I can’t draw to save myself … I’m just not an artsy person” and so on, are not uncommon. These type of statements subtly justify the idea that intelligence in any specific domain may be limited by nature and no amount of nurturing will change it (Dweck, 1999). These beliefs also determine the effort which is expended on tasks. “children who believe that a trait like intelligence is malleable (an incremental mindset about intelligence) tend to focus on learning, believe in the efficacy of effort, attribute their setbacks and successes to their effort and strategies, and show resilience in the face of difficulty; that is, they have an incremental motivational framework” (Gunderson et al., 2018, p. 397). The suggestion is made that “the ideal task within a learning goal would be one that maximized the growth of ability and the pride and pleasure of mastery, quite apart from how one's abilities are showing up at any given moment” (Dweck & Leggett, 1988, p. 261). This speaks to the type of activities that ought to be included to action this change. It also clearly states the importance of when and what was assessed. To encourage an incremental mindset, it is the processes rather than the product which should form the basis of the assessment (Gunderson et al., 2018). Studies have been conducted encompassing the spectrum of student levels, from elementary to tertiary level, with very consistent results, that is, value the process more that the product (Dweck & Yeager, 2019). This change links up the idea discussed in the literature review pertaining to the importance of the classroom experience in persisting with any subject (DEST, 2003; Minstrell & Anderson, 2011; X. Wang, 2013). The change also associates the important construct of self-esteem, group validation, and, the processes in the educational experience, highlighted by the BOLT framework (Minstrell & Anderson, 2011), to which this research is bound.

MODIFICATION 3: INDEPENDENT PRACTICE

Although the transcripts reported here are from exit interviews, community of inquiry discussions with continuing students supported some of the same concerns. Community of inquiries are a fundamental part of the BOLT framework and served as a source of actualising reforms to the program. The community of inquiry exists

> To create an environment that supports the focused synergy of minds through communication and commitment to a common interest and purpose. This is an environment where participants come together to explore an idea or resolve a dilemma, feel free to express their ideas, provide mutual support and constructive feedback. Such an environment describes a community of learners whose purpose is to critically inquire into areas of common interest (Garrison, 2015, p. 8).

The second transcript, (Transcript 2, page 72), suggested that meta-cognitive strategies had not been well understood or that the cohort were not implementing them effectively, this was strongly supported by the community of inquiry discussion that followed. The change that needed to be made was one where students could practice the strategies in a non-high stakes situation and then be able to discuss their effectiveness. This change needed the co-operation of the school as it impacted on the students' timetable. It also required negotiation with the students' teachers as it involved student extraction from regular timetabled lessons. Given that metacognition is initially best taught in context (G. Schraw, 1998) and at this school Mathematics is the vehicle by which the strategies were introduced, then the way in which Mathematics was taught to the high achievers in the program had to undergo a significant change.

The idea of this change was to allow students to practice the strategies independently once they were introduced, that is, not under the guidance of their teacher. After each unit of work the group came together and discussed the effectiveness of the strategies, as a community of inquiry. Self-concept is a major influence for student identity within a subject, it has a descriptive (“**I am** happy solving problems”) and an evaluative (“**I will do well** when presented with mathematical challenges”) components, constructed through personal (individual) experiences with content (Marsh & Martin, 2011b). The change to the program allowed for personal, individual experiences with the strategies, followed by a group dialogue and opportunities to share experiences, and finally a chance to re-adapt the strategies from the shared experiences. Merely modelling the strategy and expecting students to use it effectively and persist with it, was an oversight in the original program delivered to Cohort 1. The mechanics of this change were as follows:

	MonA	TueA	WedA	ThuA	FriA
BS (8:30 - 8:48)					
PC (8:48 - 9:00)	PC.S1: JRO W103	PC.S1: HBU W103	PC.S1: JRO W103	PC.S1: JRO W103	PC.S1: JRO W103
1 (9:00 - 10:00)	7HAP.A: JSA BH103-D 7ENG.B: RMC R103	UNSTRUCTURED LESSON	PC.S1: JRO W103	7HUM.B: RMC R103	7ENG.B: RMC R103
Br1 (10:00 - 10:05)					
2 (10:05 - 11:05)	7PHE.B: PTI R103	7CHI.B: WBE OB205-C	7SCI.B: GRO R103	7HAP.A: JSA 7PHE.B: PTI R103	CHI.B: WBE OB205-C
R1 (11:05 - 11:25)					
R2 (11:25 - 11:45)					
3 (11:45 - 12:45)	7REL.B: OJO R103	7DRM.A: AME H006-D	7REL.B: OJO R103	UNSTRUCTURED LESSON	7HUM.B: RMC R103
Br2 (12:45 - 12:50)					
4 (12:50 - 13:50)	7SCI.B: GRO R103	7SCI.B: GRO R103	7DIG.2: RMC W105	7ENG.B: RMC R103	UNSTRUCTURED LESSON
L (13:50 - 14:10)					
5 (14:10 - 15:10)	UNSTRUCTURED LESSON	7ENG.B: RMC R103	7HUM.B: RMC R103	7DRM.A: AME H006-D	7DIG.2: RMC W105
AS (15:10 - 15:30)					

Figure 7.1: A typical HAP student timetable.

Figure 7.1 shows a typical timetable of a student who was in the Higher Achievers Program. The student (in this example) was taught the maths concepts on Monday lesson 1 (where he was withdrawn from his normal English class) and again on Thursday lesson 2 (withdrawn from a Physical Education theory class) – the lessons are shown here with a black perimeter. Normally students had four lessons of Mathematics per week (shown in red), however, the advanced learners only had two face-to-face lessons per week. During those two lessons they covered what mainstream students covered in four; they were also given on-line or independent work to complete. The usual four timetabled Maths lessons (seen as red rectangles in figure 6.2) now became unstructured lessons, during which they were under the supervision of their mainstream maths teacher but were not directly taught by them. They were able to seek assistance from their mainstream maths teacher. In their unstructured lessons the students could complete any work they wished – they had independent maths work to complete and also needed to ‘catch up’ on the work covered by the classes they missed whilst at the HAP sessions (in this case English and Physical Education Theory). Students needed to prioritise, plan, communicate with either teachers or peers to find out the work required, and generally organise their time effectively. They were also working independently on multiple levels: they chose the work they did in the unstructured lessons, and they were not working under the guidance of their normal maths teacher. Students also needed to stay focused on their plans and not be distracted by their immediate environment. This change to the program allowed the students to implement and then practice their strategies explicitly; their experiences, successes and failures, formed the basis of the discussions within the community of inquiry.

MODIFICATION 4: REAL LIFE LINK

The fourth and final change was the introduction of experts into the program. These were day sessions that were not necessarily centred on mathematics, in fact they were focused on work being completed in science, humanities and languages, one day per semester for each of the subjects. The theme of the day was chosen by the students, normally based on current work. Classroom teachers were invited to participate, they either ran sessions or facilitated in the running of sessions; experts in the field were sourced and invited to attend. This change was in line with the BOLT framework (Minstrell & Anderson, 2011); experts and opinions could be sourced from textbooks, the internet, peered reviewed journals and articles, however wherever possible experts were contacted and asked to come into the classroom in person. This was done so that students could determine how the subject fits into their future plans. Longitudinal aims were explored to helped students explore possible pathways for associated subjects. The days were also motivational. Often the experts in the field would speak of the failures before the one successful outcome, highlighting what was learnt in the process of coming to a solution. Our review of the literature found that a student's experience, expectations, motivations, and perceived task value drives the level of enthusiasm for the subject (Efklides, 2006). Having professional visitors address and dialogue with the group affects these traits that drive enthusiasm.

Having 'experts' come to the group and join them in problem-solving exercises provided a completely different range of insights, "experts right from the beginning of task processing identify the critical task features and information, whereas novices refer to superficial task characteristics irrelevant to the procedures needed to deal with the task" (Efklides, 2006, p. 5). Having students as part of a problem-solving team partnered with 'an expert' exemplified meta-cognitive strategies at a different level. Students, when being de-briefed about the day's experiences were asked, in a discussion, about the problem-solving strategies they had witnessed. As one of the young students explained, when problem solving a terraforming scenario based on Mars, "I had no idea that in space you could drown in your own sweat or that dressing yourself in space is different from dressing yourself on Earth!!"

A further reason for introducing this change, based on literature, "by linking science (and other subjects) to the surrounding world, the students also link the subject to themselves, and understanding the world through a particular subject becomes a way of making the subject meaningful to themselves" (Holmegaard et al., 2014, p. 197). This has a motivational link that affects future subject choices (Efklides, 2006). When the subject becomes important, as a way of understanding the world, the strategies to overcome challenges within it become more implicit. Professionals from the community working with students to solve problems enabled purpose to be discovered. Questions like: "why would I choose to do astronomy? It might be interesting but how could I possibly use it afterwards?" (Astronomy is one of the Physics courses offered at senior secondary level), were very quickly answered when the students visited Lot Fourteen, the Australian Space Agency, and interacted with the scientists.

SUMMARY

As we developed the program modifications, examining the discussions, results, ideas and voices of the group of students from Year 10 to Year 12, particularly those that were not successful in completing the course we found:

- Students had knowledge of strategies but did not apply them under stress
- Students blamed lower than expected results on external factors rather than concentrating on factors that could be controlled by them
- Reasons for leaving the courses (and subjects) tended to reflect a belief that intelligence was defined by nature and was limited.
- Students did not see the purpose for the course and therefore did visualise a future in it.
- Students were only interested in the endpoint (the possible ATAR that could be gained) and did not value the processes, therefore strategies were ineffective.
- Students that left the High Achievers Program interpreted it as a failure and often would drop the subject rather than go back into its mainstream equivalence.

The four major modifications that were made as a result of the above observations were:

1. The new course was an enrichment course not an accelerated course as this was the new approach the college wished to follow.
2. Explicit practical and theoretical sessions were introduced so that the work on mindsets, that is, Incremental Vs Fix, (Dweck, 1999) could be demonstrated and acted on.
3. Student timetables were changed so that they had unstructured lessons. They were also withdrawn from different subjects to participate in the HAP program. This allowed the targeted students to use many of their strategies independently and then discuss them at the ‘community of inquiry” round table sessions.

4. Days were set aside to drive meta-cognitive strategies through school subjects other than mathematics. Although research has shown it is difficult for students to transfer strategies across domains (Sternberg, 1998), it has also been found that the more practiced the students are at using these strategies the easier that they will eventually use them in a multi-discipline approach. These days have the added benefits of bringing other teachers on board.

Even with these modifications we were able to follow the mapped path (Appendix A) as the *structure* of the intervention accommodated for change, as would be expected from a research-action approach. The delivery of the content and its timing within the semester varied significantly as face-to-face lessons were now reduced to two and students had a lot more supervised “freedom”.

For this research the following list formalises the skills and processes that the above discussion focuses on; the work on mindsets (Dweck, 1999) was an over-arching practical philosophy which was necessary should the final product not have achieved the highest grade. Students are not born with these skills, they need to be learnt.

To conclude this summary the changes made to the programme need to maintain and address the following criteria:

- Develop a rich declarative knowledge schema that the student can access
- Students having well organised schema, this speaks to the interconnectivity of ideas
- Allowing for time so that students can develop automaticity with strategies therefore focusing on problem representation rather than research.
- Develop an awareness of structural similarities between problems
- Implementing strategies to work forward from given information to solve unknowns
- Within the developed student schemas also develop procedural knowledge associated with the problem representations.

- Automatizing many sequence of steps within problem strategies
- Working within time constraints without deep thought of strategical steps
- An ability to predict time resources needed to achieve the outcomes as well as what the outcomes will 'look like'
- Monitoring progress and efficiency of processes
- An ability to gauge the accuracy of the outcomes and show high accuracy in reaching appropriate solutions to task outcomes within the subject

(Sternberg, 1998)

These modifications were applied to the delivery of the subject content. The metacognitive strategies were embedded in the learning and the processes of understanding the content. The introduction, modelling, and use of the strategies was not changed as the program morphed from the one delivered to the initial cohort. Whatever strategy was introduced (time management, prioritising tasks, resource collection, and so on) was modelled and presented to both cohorts; the modifications were made to the scaffolding structures that allowed the students to experiment, discuss, personalise, and understand those same meta-cognitive strategies.

CHAPTER 8: ANALYSIS OF DATA: COHORT 2

Cohort 1 and Cohort 2 began the Higher Achievers Program in similar fashion. Students new to the school were asked to participate in the Raven's Progressive Matrices assessment. This, combined with teacher reports and advice from home, enabled us to form the next group of advanced learners.

As with the previous cohort, students were initially using the Raven's Progressive Matrices. All students in the program either scored within the 90th or 95th percentile; there were more students in the 95th percentile in cohort 2, however, whilst there may be potential impact in raw assessment scores within the program, previous research has shown high achievement/ability does not equate to a higher level of metacognitive skills - these must be learnt (Sternberg, 1998).

FINDINGS AFTER MODIFICATIONS

Students invited into the programme achieved in the 95th percentile when assessed with regards to cognitive potential, although not all were high achievers in all of their subjects. However, all were well above average mathematics students as this program was delivered through the subject of mathematics. Cognitive and meta-cognitive skills are not divorced of content, what is referred to by some researchers as developing expertise (Sternberg, 1998; Weinstein & Mayer, 1983).

One immediate consequence of the changes was in the increased uptake of the Higher Achievers Programme. In the past it was not uncommon for students of high ability to decline the invitation to be part of the program

> Students should not be expected to wildly welcome instruction on metacognitive skills. On the contrary, they may actively resist it. When students have become used to and have been rewarded over the years for passive and rather mindless

learning, they will not jump at the chance to take a more thoughtful or mindful approach to what they are doing. Often the teachers greatest challenge is to interest the students in the first place in metacognitive processes (Sternberg, 1998, p. 129).

The introduction of unstructured lessons for students in Years 8 to 10 was a drawcard for students whose school days were strictly regulated and governed by bells and periods. Allowing the students to have the freedom to choose what work they wished to prioritise during a supervised but unstructured time period had mixed consequences. The students perceived it as a huge incentive to be in the programme, conversely, it required significant explanation to parents who perceived it as a decrease in formal teaching. From a researcher's and teacher's point of view, it was neither a decrease in instruction time nor a 'free lesson' but rather the time when the students actually practiced the metacognitive skills introduced throughout the course.

META-COGNITIVE SKILLS OF COHORT 2

As with the previous group the program began with assessing students' knowledge and use of Metacognitive processes using the Metacognitive Awareness Inventory (G. J. Schraw & Dennison, 1994). Tables 8.1 and 8.2 records the breakdown of the responses given by the students who had accepted the program:

Responses from initial Meta-cognitive Awareness Inventory assessment				
Knowledge	Did not show any understanding of this type of knowledge	Showed use of strategies but could not identify the knowledge	Understood the types of knowledge but inconsistent with use	Showed understanding of this knowledge and could use it
Declarative	0	0.47	0.36	0.17
Procedural	0.35	0.29	0.12	0.24
Conditional	0	0.64	0.24	0.12

Table 8.1 – Cohort 2: Initial breakdown of metacognitive knowledge assessed

Skills	No evidence of use	Sporadic use, inconsistent	Familiar but unplanned use	Explicitly practiced
Planning	0	0.41	0.47	0.12
Comprehension	0	0.47	0.41	0.12
Information Management	0	0.23	0.59	0.18
Debugging	0.05	0.36	0.35	0.24
Evaluation	0	0.24	0.58	0.18

Table 8.2– Cohort 2: Initial breakdown of self-regulatory skills reported

There was little to no significant difference in how these students self-reported the knowledge and skills related to metacognition and self-regulation in comparison to the first intake of students into the program. Slight differences might have been due to a higher percentage of students in the 95th percentile whereas in cohort 1 there were more students in the 90th percentile, this is not something that could be controlled, it was totally random depending on the school's student intake at the time.

As with cohort 1, a significant percentage of students were not aware of procedural steps for applying algorithms. A number of students had declarative knowledge but were unable to develop strategies to problem solve scenarios that were beyond the textbook examples. From a cognitive perspective they had the schema but it was not sufficiently organised in a manner that it could be linked to problems, this concerns elaboration of the schema (Anderson, 2010; Bruning, Schraw, Norby, & Ronning, 2004b; Sternberg, 1998). Such students could not make a mental representation of the task and therefore could not devise any strategy to solve it, despite having knowledge of the raw concepts. This was also common within previous groups of students participating in the program.

In this second intake there were approximately fifty-six Year 8 to Year 10 students that joined the program, with no abstainers. For the sake of consistency, the study concentrated on the Year 10 class, the same year level analysed in the previous cohort. The newer cohort numbered 16 of which three left the program during the year. Percentage wise this dropout rate seemed to match the previous cohort:

Cohort 1 (before the changes): 5 / 21 students left the course (24%)

Cohort 2 (after the changes): 3 / 16 students left the course (19%)

Therefore, from the numbers above, the modifications did not result in a higher rate of retention. However, analysis of student responses and actions revealed other differences in student outcomes following the implementation of the modified course.

Whilst these high achievers were in the 'gifted' spectrum and had well-developed mathematics skills, merely providing an advanced course comprising of more complicated mathematics, without appropriate scaffolding, either re-enforced poor habits acquired in previous mainstream classes or tempted the students to look for easier options. The students required specific instruction and support to effectively learn more complex concepts and to manage their own learning.

Very briefly an anatomy of the altered sessions (the actions) is presented here so that future analysis can be made with reference to this outline. Not all sessions are the same; what is presented is a skeleton.

At the very beginning of the term students were presented with a course outline, along with topics that to be covered every week for the semester. Resources and expected work were outlined in the document. Assessment dates were pencilled into the calendar as well as major school events and student free days. Students were also encouraged to record any family events and special days that were known to occur during the period of time; they were asked to discuss and plan this with their parents. This included celebrations, sporting commitments, training, and so on. These personal calendars were referred to frequently during the Higher Achievers Program. In addition to developing interest, adolescents need self-control to remain engaged. Self-control is a part of self-regulation that needs to be fostered and supported by the classroom environment (M. Wang, Binning, Del Toro, Qin, & Zepeda, 2021).

Within each session the following occurred (to varying degrees)

- A review of the concepts from previous sessions (Declarative Knowledge)
- Introduction to new concepts – in holistic terms rather than piece-meal. If teaching algebraic concepts students began with the problem rather than a step by step build-up of the concept. The approach was – this is the problem – how can we solve it – what skills do we already have - what new skill do we need? (Procedural Knowledge)
- A variety of scenarios where this type of problem might be presented were explored. Different representations of the same problem, what to look for, and how to gleam the necessary data from the representation are crucial to schema organisation. (Conditional Knowledge)
- The expected work to be completed over the next seven days was outlined – students were to complete the work during their own time (the unstructured supervised lessons can be used, but this is the students' choice).
- A clear statement of expectations including where to get help and other resources was explained
- Either a community of inquiry sharing problems from the new concept or a discussion of past work, strategies used, difficulties encountered was part of the routine; this was not limited to the mathematics and could include work from other subjects, for example, completing an English assignment that was commenced when the student was withdrawn from the English class and so on. (Discussion of a variety of strategies and resources normally ensued).
- Looking at the work that had been set from maths and other classes, including assessment pieces and assessment dates, and making sure that prioritising strategies, motivation and monitoring strategies (checklists and so on) were in place. Communication was an important part of any strategy.

The type of activities and the structure of the lesson were modelled on the "Building On Learners Thinking" (BOLT) framework, explored in the literature review (Minstrell & Anderson, 2011). There were two one-hour sessions every single week.

Student work was carefully but not overtly monitored by the 'Gifted and Talented' counsellor. This included dialogue with teachers of all subjects not just in mathematics so that a holistic perspective was established, to support the students in the programme.

COHORT 2: STUDENTS THAT LEFT THE PROGRAM AND WHY.

As with the previous cohort a comparative analysis has been presented between the 'most comfortable' candidates in the program and those that asked to leave the programme. It is a comparison of the meta-cognitive knowledge and the use of strategies between the two groups.

Tables 8.3 and 8.4 compares the self-reported knowledge of cognition and self-regulatory skills of students that continued with the Higher Achievers Program with those that asked to leave the program; the comparison was not meant to be aligned with achievements, (grades attained), but they did. Achievement wise there were no unsuccessful candidates.

Their responses have been 'graded' as: 5: Consistent, 4: More often than not, 3: Developing, 2: Attempted usage, 1: Weak and inconsistent, 0: no knowledge or usage.

Student	Declarative	Procedural	Conditional	Planning	Comprehension	Info Management	Debug	Evaluation
1	5	5	5	5	5	5	5	5
2	5	4	5	5	3	5	5	5
3	5	5	5	4	4	4	5	5
4	5	5	5	2	2	4	4	4

Table 8.3: Group 1 - Students who excelled in the subjects and continued with the program.

Student	Declarative	Procedural	Conditional	Planning	Comprehension	Info Management	Debug	Evaluation
5	4	4	4	3	3	4	5	2
6	4	4	3	2	2	4	4	2
7	4	2	4	1	1	4	4	0

Table 8.4: Group 2 - Students who left the Higher Achievers Program

When cohort 1 was asked to self-report on the same knowledge and skills there was a clear distinction between those that had remained in the programme and those that had asked to leave the programme. The data gathered from cohort 2 did not show a clear differentiation between those that remained in the program and those that opted out. In cohort 2 the data differences were in the areas of comprehension and evaluation strategies; the transcripts from the same students (reported below) explain these differences as a withdrawal of effort as they pursued new interests. The results show that there was certainly a difference in proficiency, however, students in both groups reported knowledge and use. Part of this, I believe, is a result of the unstructured time that was afforded to cohort 2 allowing them to use the self-regulatory skills that were introduced during the program. These students were more aware of the three types of knowledge required to understand concepts holistically, therefore making the concepts useful tools for the students.

Throughout this discussion it is important to remember that the skills introduced to these students only come into play when cognition becomes problematic (Noushad, 2008). In general, these students had excellent cognitive abilities and had little difficulty thinking their way through most tasks. Cognition is about problem solving; however, metacognition is about the process of problem solving and it is used when the task scenarios are not immediately recognised. Within this second cohort of students those that left the programme did not do so because they were overwhelmed by the content as was witnessed with cohort 1.

At the time of the students withdrawing from the programme their achievement were B+, B-, and C+, with A+ being the highest possible achievement, C- the lowest pass. The majority of students in the mainstream program ranged from a B- to a C for the same topic, however mainstream assessments were composed of straight forward algorithms whereas the assessment for the students in HAP included significantly more worded problems as well as questions which involved higher cognition, or in some cases, the use of metacognition.

COHORT 2: STUDENT TRANSCRIPTS

The exit transcripts from cohort 1 when compared to those of cohort 2 were also notably different. One major difference was the absence of misplaced attributions (“I studied the work but the teacher made the test too difficult”), often reported in the transcripts from first cohort of students to account for lower than expected achievements.

Exit Interview Transcript from Key Focus Student 5 – Cohort 2

The conversation revolved around the key informant leaving even though he was achieving ‘B’ standard …

> Key Focus Student 5: “I don’t mind the (HAP) programme but I have decided to take on a vocational course (Electronics) to see if I like it. It will take me away from school 1 day a week and I’d prefer not to miss other lessons (by being withdrawn from lessons to attend HAP).”
>
> Researcher: “Wouldn’t the skills in HAP help you manage your courses?”
>
> Key Focus Student 5: “I think that I’m ok at self-management right now. We have covered most of the normal Maths (mainstream Yr. 10) course anyway so if I return to mainstream, it will be one subject I won’t need to worry about, so I can concentrate on the other subjects as well as the new VET (Vocational Education Training) course.”
>
> “… if I get behind in some work I can always talk to teachers and see if I can work out some way of making up the stuff that I’m behind in. Maybe I can do a little catching up during the term break…”
>
> Researcher: “Does the fact that you have always been an ‘A’ maths student and now you are averaging a ‘B’ bias your decision towards leaving the programme and returning to mainstream maths?”

Key Focus Student 5: "Not really. I was actually getting quite bored in normal maths; getting the 'A' was good but in the end it wasn't hard to do. In lessons we just did things that I knew from before and we repeated lots of things. I really like HAP because it was always new and I did learn things. My going back to normal maths is just because it will take pressure off finishing my other subjects while I do the VET course for the term."

This key focus student's transcript was very different to the transcripts from the first group of students interviewed. Those transcripts were all about returning to mainstream mathematics because of failing confidence, concerns about the ATAR, and losing interest in the subject. The one point that did correlate with what students in the first cohort reported was that dropping the programme should result in better performances in the other subjects. In general, as a teacher, I did not find this to be the case. A quick analysis of the whole range of subject achievements before and after dropping the programme in most cases did not result in significant improvements; nonetheless it is a perception that did seem to persist for some reason.

Exit Interview Transcript from Key Focus Student 6 – Cohort 2

Researcher: "You have asked to return to mainstream mathematics, why?"

Key Focus Student 6: "I have had so many days off due to illness. I thought I could catch up and gave it a try but found myself worrying. I found it too hard as the new work kept coming and right now I am struggling with the amount of work."

Researcher: "With the new programme you have four unstructured lessons per week when you can prioritise your work. We also go through a different set of study techniques and planning, does this not help?"

Key Focus Student 6: “Sort of, but when I’m withdrawn from classes to do the HAP programme I miss out the new work that the class is doing and I have to catch up that work as well as what I’ve already missed out. I am finding that I’m panicking about the new work I’m missing and I end up worrying and doing very little. I want to continue with Maths next year and I like the maths we do in HAP but it’s hard to concentrate on the extension work when I need to deal with another four subjects that I’m behind in.”

“… I have made a timetable and a check list. I have talked to my teachers (and parents) and found out what is important for me to cover, so I’m pretty confident that I’ll be able to catch up if I follow the plan. I just would find it hard to do the HAP at the same time.”

Researcher: “Understood … If you had the gift of foresight, would you have joined the programme knowing this current outcome, or would you have played it safe and remained in mainstream?”

Key Focus Student 6: “I would have still joined the program. Right now I am well ahead of the mainstream maths class (course) – so I’m behind in HAP but not in mainstream so it’s worked out well, bonus! As I have spoken with my other teachers I’m pretty well ok with what I need to do to catch up and I’ve listed all the things I have to do and when I need them done by.”

Researcher: “So where to from here?”

Key Focus Student 6: “Well… I want to catch up on what I have missed out, which is my first focus. I know I will need to get good enough grades to be able to continue with the Maths (Methods) and Physics at Year 11. I don’t need to get A’s just good enough to be accepted in those subjects next year. I want to do these subjects because I find them interesting (Science and Maths) and I think that is what I want to do when I leave school."

Again, this exit transcript is quite different from the ones that were recorded from the first cohort students that left.

These two 2nd cohort exit transcripts have much in common. Both students had set long term goals that were career orientated, rather than based on an ATAR score. Student 1 wanted to sample electronics and was aware that doing so and missing additional lessons to complete extension mathematics would hinder his goals; he prioritised his studies and tweaked his timetable accordingly so as to produce a favourable outcome. The second student who had been absent for a significant amount of time, was undeterred by the low semester grades and applied a self-regulated approach to his studies in order to reach an optimal position. He had planned out the time available to make sure he gave himself the best chance of continuing with his chosen subjects in Year 11.

Both of these students showed:

- Significant forward planning
- An ability to monitor current progress without relying on teachers telling them
- Independent work and therefore exerted control over their work
- Both students knew what they knew (metacognition)
- They both had realistic expectations and knew their limitations
- They showed the motivation to succeed

These are advanced metacognitive skills.

Restating some of the assumptions made at the beginning of this research:

i) That given the opportunity students will embrace a greater autonomy in their learning, (Ames, 1992).

ii) All students that employ meta-cognitive strategies explicitly exercise more control over their own learning than students who do so passively, (that is, students unaware of meta-cognitive strategies), (Mevarech & Fridkin, 2006)

iii) That the degree of motivational influence that can be attributed to knowingly deploying meta-cognitive strategies can be measured within an organised structure like a classroom, (Mevarech & Fridkin, 2006)

Certainly, the first two of these assumptions is embedded within the responses of the first two exit students from the second cohort, whereas the same could not be said of the transcripts recorded from the first cohort. The third assumption, whilst not measured, is witnessed by the desire of these students to continue with their courses. They had exited from the program because of their motivation to continue with the maths and sciences. Further proof of this comes to us from the gift of hindsight, as this research preceded the writing of the research report by a couple of years, all these students returned to the Physics and Mathematics at Year 11, the following year. This could not be said of the first cohort analysed.

A further point to be made about these two transcripts is they clearly show metacognitive strategies being deliberately used rather than their passive execution. These students thought about the way they learnt; they know their limitations. Metacognition happens all the time, passively. Students are not aware of the meta-processes which is fine, until cognition becomes a problem (Efklides, 2011). These two students were problem solving, used metacognition, and were able to explicitly explain their processes. These students went on to join mixed ability groups in Mathematics at Stage 1 (Year 11).

SUMMARY OF COHORT 2 DATA

Observations made were accumulated from talking to their new teachers and the students themselves:

1: All students opted to continue with mainstream courses that would allow entry to STEM sciences (Physics, Chemistry, Specialist Mathematics, and Mathematical Methods). These students (unlike the students from cohort 1), changed from the High Achievers program but did not ‘drop out’ of the more challenging subjects. As cited in their transcripts, they had a variety of reasons but they self-reported *confidence* in continuing with the challenging subjects; they showed *resilience* in spite of difficulties and they made changes based on attributions which was within their control, (prioritising new interests and outside commitments).

2: Student 5 followed his interests in music, gaining high levels in achievements in his chosen fields, working independently on music projects (writing). He continues with the higher level of mathematics and physics, although he has prioritised his music. He has planned and successfully implemented actions to form an extra-curricular band all the while time managing work commitments and continued success in his educational goal to become an engineer.

3: Student 6 has continued with Stage 1 Physics and the higher level of mathematics. He has developed an interest in electronics to the extent that he had enrolled in an external electronics course, 1 day per week. Therefore, he now manages all his scholastic subjects (including making up for missed school lessons whilst he attends the electronics course). He continues to achieve commendable results in all of his courses.

Both students 5 and 6 showed significant knowledge of metacognitive strategies and utilised them effectively to meet their desired goals. They did not give up when faced with challenges; they also showed high level of self-regulatory skills and independent thinking. They had a high degree of 'supported' agency in determining their own learning paths.

4: Over time, however, not all the students that changed from the Higher Achievers' Program managed to maintain results that allowed them to continue with the higher STEM subjects beyond Stage 1. This is significant as all the students in the program had the capacity to achieve the required outcomes. Student 7, (table 8.4), though initially continuing with mainstream STEM subjects, eventually did give up on the subjects giving the same type of attributions that was typically witnessed when interviewing the students in cohort 1. Although initial diagnostic assessments placed him as a possible high achiever (cognitively), when he left the program the exit survey showed significant gaps in his ability to plan and execute successful strategies that could deliver successful outcomes. This presented as time-stress during longitudinal assessments and gaps in shorter timed written assessments. The program, it seems, was not effective in inculcating the strategies alongside of Student 7 existing mindset.

It is a limitation of the program that it does not provide for *all* high ability students, an issue that will be discussed later. The program, as it exists at the time of writing, requires a certain amount of self-discipline and resolve from its participants. Structured learning and highly scaffolded lessons may still be essential for *some* highly cognitive functioning individuals. Student 7 was an excellent 'gamer' and time-management seemed to be an insurmountable obstacle.

CHAPTER 9: VALIDATING THE INTERPRETATIONS

INTRODUCTION

The study has concentrated on comparisons made between different cohorts of students that have left the Higher Achiever program. Using this as a starting point the study analysed what effect explicitly teaching metacognitive strategies may have had on the exiting students. The intent was to reduce the number of students leaving the course; though this was not achieved, what the intervention did accomplish was to retain the students in STEM subjects. The study also explored better ways of delivering the metacognitive skills to the students (by making changes to the pedagogies applied to the different cohorts). This was achieved by employing an action- research approach, making changes to the pedagogy, observing, questioning, and then further refining in a controlled, detailed, and planned cyclic manner. A method well established within research (Creswell, 2014b).

In the final part of this analysis the same data, presented in Chapters 6 and 8, is used in a different manner to explore trends so that a comparison could be made to assess growth within the two cohorts.

The Metacognitive Assessment Inventory (G. J. Schraw & Dennison, 1994), consisting of a 52-item self-report questionnaire was used for this analysis. The instrument, constructed to measure metacognitive awareness, comprised of items that could be coded according to metacognitive skills or metacognitive knowledge. After some consideration the researcher decided upon a sorting that associated the skills with the type of knowledge it was commonly linked with. Skills were grouped by either knowledge that defined the content of a unit of study, Declarative; knowledge that informed the student on how the data is usefully applied, Procedural; or knowledge that informed the student of when its application was appropriate, Conditional, (G. Schraw, 1998). This format was chosen because this sorting of the MAI (appendix 5) best informed the study to the adaptations that had to be made within the action-research methodology. These categories also made immediate sense to the students involved in the research (and program) as they contextualised the skills rather than treat them as isolated actions to be mimicked. Once the data was collected Microsoft Excel was used to analyse the data from which a statistical summary for each cohort was produced. The summary included the mean response, the mode and the standard deviation.

The data interpreted in the previous chapter has also been analysed by fragmenting it and exploring patterns. The analytical treatment ought to support previous findings, that is, the data from cohort 2 ought to show more growth when compared to the data extracted from cohort 1.

Whilst this format informed the pathway of the research, it was also useful in gauging whether the adaptations to the program resulted in the intended outcomes. By comparing the results of this data across the cohorts a more over-arching picture could be extrapolated. It must be noted, however, at this stage any observations and any statement made from these observations only suggest that these actions worked (or otherwise) for this particular cohort, at this particular time. Any conclusive statements can only be made by further research encompassing a more general group, and a greater sample.

THE ORGANISATION OF THE DATA COLLECTED

Three figures were extrapolated from the data; the *mode* shows the most frequently self-reported response; the *mean* gives the researcher a sense of the trend, if the mode is 2 [sometimes happens] but the mean is 2.9 then the skill is used infrequently, however, the trend tells that more students are inclined to engage the skill, with perhaps some outliers skewing the data in the opposite direction; the final figure extrapolated from the data, the *standard deviation,* speaks to the amount of spread within the data. The closer the standard deviation is to zero, the more concentrated the group is about the mean. A higher standard deviation possibly shows that the group might not see the skill as relevant at this point in time, or, that students using the strategy are doing so as a random or implicit choice rather than being explicitly aware of the strategy as a useful approach.

FROM THE SPECIFIC TO THE GLOBAL

In the previous analysis students that left the programme were specifically targeted, examining their reasoning, 'the blame' if it existed, and if they continued within the STEM subjects, despite leaving the program. In chapters 6 and 8 the data suggested the changes contributed to the program creating a positive shift in the students thinking and uptake of self-regulatory strategies. The data presented in this section tends towards a more global perspective rather than the individual student. Did the *cohorts* benefit from the program? And what type of cognitive shift was evident within the *cohort*?

DECLARATIVE STRATEGIES	Mode	Mean	Standard Deviation
I understand my intellectual strengths and weaknesses.	3	3.048	0.805
I know what kind of information is most important to learn.	3	3.095	0.7
I am good at organising information.	2	2.905	0.889
I know what the teacher expects me to learn.	4	3.095	0.889
I am good at remembering information.	4	3.095	0.831
I have control over how well I learn.	3	3	0.775
I am a good judge of how well I understand something	3	2.762	0.944
I learn more when I am interested in the topic.	4	3.667	0.658

Table 9.1: Cohort 1 Declarative Strategies – A final snapshot.

This data comes from the final survey after each of the cohorts had been through the program. As previously established the data gathered from each cohort at the start of program showed very little difference. The students in the study were all high achievers from the onset, therefore one would expect the group to have developed ‘learning’ skills. Table 9.1 analyses the skills related to learning content. The mode for the majority of the strategies indicated that the students were familiar with the strategies. In most cases the mean was higher than the mode indicating that the likelihood was that the strategy was used by the majority of the cohort and there may have been an outlier that skewed the results to the negative. The standard deviation showed that these results did not move significantly from the mean and therefore could be applied confidently to the whole group. The Declarative questions assessed if the students could name the strategies and is a superficial level of knowledge.

Cohort 1 analysis:

PROCEDURAL STRATEGIES	Mode	Mean	Standard Deviation
I try to use strategies that have worked in the past.	4	3.476	0.602
I have a specific purpose for each strategy I use.	3	2.714	0.717
I am aware of what strategies I use when I study.	3	3.238	0.7
I find myself using helpful learning strategies automatically.	3	2.762	0.944

Table 9.2: Cohort 1 Procedural Strategies – A final snapshot.

Table 9.2 displays results from the metacognitive reasoning survey and is focused on the question, does the student know how to apply the strategies in table 9.1? The uptake of procedural strategies is moderate, however, the mean, being lower than the mode, suggests that procedural knowledge of the strategies was not as strong as the knowledge of the actual strategies. For example, relating to the strategy "*I find myself using helpful learning strategies automatically."* Most student in the group indicated that it is a strategy they used occasionally (3), however the mean response suggests that it was "rarely used", indicating that there were a significant number of students that seldom, if at all, used the strategy. This is further validated by a standard deviation of approximately 1, so the 'field' is certainly not tightly grouped.

Finally, table 9.3 provides information about students' knowledge of when to use strategies. As can be seen even though (as expected) these high achieving students use the conditional strategies, the use is random, with an even weaker spread of take up than the strategies relating to procedural and declarative use.

CONDITIONAL STRATEGIES			
I learn best when I know something about the topic.	4	3.381	0.669
I use different learning strategies depending on the situation.	3	2.91	0.814
I can motivate myself to learn when I need to.	4	3.143	0.964
I use my intellectual strengths to compensate for my weaknesses.	3	2.952	0.921
I know when each strategy I use will be most effective	3	2.667	1.017

Table 9.3: Cohort 1 Conditional Strategies – A final snapshot.

Table 9.3 showed the same trend as table 9.2, although, as explained previously, procedural knowledge has been affected by the use of tools in most subjects, we would expect procedural knowledge to be eroded, however, conditional knowledge and strategies are important because they are about the 'when' to call on the strategies. There were members of cohort 1 that were unsure when to use the strategies, for example “I know when each strategy I use will be most effective” had a mean response of “maybe” with a spread as low as “never”.

This analysis, as applied to cohort 1, supports the notion that these students are high achievers, the majority who use metacognitive reasoning and can self-regulate their efforts, (the modes). The numbers also show that there is not a uniformity to the acquisition of skills and there also exists a spread of proficiency within the group. The data cannot tell us anything more than there exists a tail.

Cohort 2 analysis:

DECLARATIVE STRATEGIES	Mode	Mean	Standard Deviation
I understand my intellectual strengths and weaknesses.	3	3.444	0.527
I know what kind of information is most important to learn.	3	3.333	0.707
I am good at organising information.	4	3.222	0.833
I know what the teacher expects me to learn.	4	3.222	0.833
I am good at remembering information.	4	3.444	0.726
I have control over how well I learn.	4	3.111	0.928
I am a good judge of how well I understand something	3	3	0.707
I learn more when I am interested in the topic.	4	3.889	0.333

Table 9.4: Cohort 2 Declarative Strategies – A final snapshot.

At the end of their program Cohort 2 (Table 9.4) showed a high familiarity with the declarative skill set. The means were also high and the standard deviation narrower, indicating high uptake across the whole group. Considering that both Cohorts began the programs with similar statistics, cohort 2 showed a greater positive shift than cohort 1.

PROCEDURAL STRATEGIES	Mode	Mean	Standard Deviation
I try to use strategies that have worked in the past.	3	3.444	0.527
I have a specific purpose for each strategy I use.	4	3.333	0.866
I am aware of what strategies I use when I study.	4	3.333	0.866
I find myself using helpful learning strategies automatically.	4	3.111	0.928

Table 9.5: Cohort 2 Declarative Strategies – A final snapshot.

The 'how to apply' the strategies were better understood by cohort 2 (table 9.5), the mean showing a significant difference. This correlated with the interpretation of the data for cohort 2 (*Chapter 9*). The actions implemented in the program from cohort 1 to cohort 2 which accounted for this difference, according to the literature, was the supervised free lessons allowed to the latter group (DeNeen, 2013).

CONDITIONAL STRATEGIES	Mode	Mean	Standard Deviation
I learn best when I know something about the topic.	4	3.667	0.5
I use different learning strategies depending on the situation.	4	3.222	0.833
I can motivate myself to learn when I need to.	3	3.111	0.782
I use my intellectual strengths to compensate for my weaknesses.	3	3.333	0.707
I know when each strategy I use will be most effective	3	3.333	0.5

Table 9.6: Cohort 2 Conditional Strategies – A final snapshot.

Table 9.6 examined if the cohort understood when to use the strategies explicitly. Both cohort 1 and cohort 2 are high achieving students therefore one would expect that they could successfully apply these strategies most of the time. As seen in the other tables the main difference is the mean. The higher mean indicates that the cohort is more aware of actually using the strategy when necessary. The tighter standard deviation indicates that more of the cohort applies the strategy appropriately, more of the time.

The data presented seems to show that cohort 2 gained more from the program than cohort 1. That is not to say that cohort 1 did not benefit from the experience, however, the numbers indicate that a greater percentage of cohort 2 showed a more consistent use and were more likely to actively engage in metacognitive reasoning to plan and step through the learning tasks.

TRIANGULATION OF THE DATA

The data set presented here needs to be read with the transcripts and the analysis previously presented in this study.

The data in this chapter was gathered from the same surveys and questionnaires previously cited. Both cohorts had similar statistics at the beginning of each respective program. Cohort 1 underwent the program as it had always been delivered and data at the end of the program showed that most students had benefited in a positive way, however, there were enough students that did not benefit to cause concern. Some students did not take up the strategies and the statistics showed that they also held possible misconceptions (conditional knowledge). Changes were made to the program and then delivered to cohort 2. This cohort showed greater uptake (higher mean) as well as a greater consistency of use (tighter standard deviation).

This agreed with the findings discussed in the previous chapters. These chapters analysed the students who left the program. The students that left the program from cohort 1 were also lost to the STEM subject, they did not re-join the mainstream class. The data from cohort 1 as presented in Chapter 6 indicated that the students that left the program were still not proficient in using evaluation, comprehension, and planning strategies effectively to complete long term tasks and assessments (table 6.4). When examining the data from the students that left the program from cohort 2, they also struggled using planning, and evaluation strategies (table 8.4), which is possibly why they left the program, but they recognised that the struggle did not mean failure. It is the transcripts that tell the true story.

The transcripts supported the data gathered from the questionnaire; students were honest in discussing their strength and weaknesses. Cohort 1 students that left the program linked the low achievements with failure. They tended to place the reason for failures on events beyond their control, therefore nothing they could remedy. The goal was the achievement attained. In comparison Cohort 2 students that left the program linked achievements with effort. They owned the reasons for leaving and they were all clearly centred around actions that they could control, time management, prioritising work, planning, and so on. They controlled their pathway, made a choice, and continued with the STEM subjects within mainstream. The goal was the learning.

There was a tendency for cohort 1 exit students to link their problems with external factors, whereas cohort two identified internal factors as contributing to their situation.

CHAPTER 10: REVIEW AND CONCLUSIONS

PURPOSE OF RESEARCH

The purpose of this study is to describe the effects of explicit use of metacognitive and self-regulatory strategies, as reported by advanced learners, when purely cognitive strategies fail. Underpinning this purpose is the assumption that explicit knowledge of metacognitive and self-regulatory strategies produces greater student agency and self-determination, which would then manifest as perseverance to overcome significant obstacles that might thwart their ambitions in their chosen subjects (Cubukcu, 2009).

A further assumption is that given the opportunity, advanced learners would choose to have agency over the way they learn; metacognitive knowledge affords students increased ownership of their chosen pathways to fulfilling their goals; therefore students that can explicitly use metacognitive strategies in the face of adversity are better prepared and motivated to deal and persevere when cognition becomes problematic or the learning becomes stressful.

RESEARCH DESIGN

The methodology used in this study was an action research. The research was borne of an actual problem that existed at a secondary college, that being, that a number of its students identified as high achievers seemed not to fulfil their potentials and were happy to coast along at a mediocre level in senior high. These students were ‘high flyers’ in middle school education and diagnostic assessments indicated high cognitive abilities, however many resorted to chasing high grades by ‘dropping’ the STEM subjects in senior secondary. The study was longitudinal, including students at the beginning of their journey, Year 8, through to those in their final 12th year of study.

Data collection methods used in the action research included cognitive assessments of all students at the school, consistent monitoring of subject achievement scores, bi-annual survey questionnaires related to metacognitive use, and, exeat interviews with focus students.

This study, being based on an actual problem that existed at the college, necessitated a longitudinal approach and consequentially spanned over a number of years and groups of students. Snapshots were gathered before and after. Modifications that occurred were always referenced and justified in the light of current research, as presented in the review of the literature.

Focus interviews were conducted with students across multiple year levels. The interviews were conducted with the students who, for a variety of reasons, had decided to exit the program. From these interviews an understanding was reached as to the level of explicit metacognitive practices understood by these students and how those same practices played any part, if at all, in their decisions to leave the program, and future pathways.

Changes in the program were made to promote the explicit use of metacognitive strategies by the students. The changes were not made to deter students from leaving the program but to structure students' thinking and decision making so that their actions were scaffolded by meta-thinking rather than purely emotive or impulsive reactions bought about by the stress of poor achievements.

The collected data was analysed using a general analytical strategy (Yin, 1994) . The three research premises paved a way to address the problem presented by the school; the premises underpinned the solutions whereas the problem itself gave purpose to the study, shaped the research methodology, and identified elements of data that were relevant. The three premises of the research are that students with high cognitive functioning embrace autonomy over their academic development, (Ames, 1992), the explicit use of metacognitive reasoning gives a student greater agency and control over academic pathways, (Mevarech & Fridkin, 2006);

students with high cognitive ability are more motivated to persevere through challenging academic situations if they are able to use metacognitive strategies to guide their cognitions and exert a degree of agency over their future pathways. In short, knowing how to use metacognitive strategies enable students to visualise a way forward when cognition cannot.

The action-research approach allows a method of successive approximations (Neuman, 1997) whereby initial processes are refined, data collected and analysed, through a cyclic process, moves towards an outcome acceptable by the school. The successive approximations are modified by shaping the constructs highlighted by the research. Each time the actions around the constructs were modified, (as in different processes to develop the construct within the students), the concept around the research question was refined to better reflect the evidence. This occurred until the evidence better aligned with the theory, that is, the actions aligned with the wanted outcomes, (Neuman, 1997, p. 428)

RESEARCH QUESTIONS ANSWERED

The research has three questions which are connected to each other. Within a pedagogical framework *how* can the value that a student holds for a subject be increased? This first questions speaks to the actual constructs. *How* can we best shape the actions that develop the constructs responsible for a student's motivation and sense of fit within the subject? This questions speaks to pedagogy. *How* does the student's use of metacognitive reasoning better inform these constructs and therefore, value, persistence, and motivation within the context of a challenging environment? These *how* questions are best answered by observing actions and the relationship that a student has with the subject material.

The study explored and endeavoured to understand a 'lived experience' at the College in order to best support students as they navigated through their social calendars, complex STEM subjects, their parent's expectations as well as their own self-perceptions as high achieving students.

The questionnaires and interviews conducted with the key informants directed the actions that were applied to this study. Any modifications were recorded and the key informants questioned in order to assess if the changes had the desired metacognitive results and the associated increase in the skills. The three dimensions of this study are now addressed:

Increasing the value that students place on their STEM subjects.

The first of the research questions focused on actions that when included in a pedagogical framework would increase the value that is held by students for the subject. The change made to the program was founded on literature that stated that one of the key actions which influences value positively is the notion of 'apprenticeships', bringing the outside world into the classroom, (Olszewski & Kubilius (2000) in Erdogan & Stuessy, 2015). This study uses the strategy and then, through class discussions, allows the students to analyse their role in the experience, creating possible futures. The Social Cognitive Career Theory posits that value is a product of a student's intent (X. Wang, 2013). Intent is dependent on the continual self-referencing which accompanies the learning experience, which will, hopefully, contain apprenticeships.

When this strategy was included in the program, along with the process of the community of inquiry, self-referencing increased. The use of declarative strategies like "I understand my intellectual strength and weaknesses" and "I know what type of information is most important to learn" along with conditional strategies involving motivation were more dominant in student conversations. Statistically they also were used more consistently.

Students that placed a value in completing the High Achievers courses, despite challenges, displayed high level of intrinsic motivation and agency. A major driver of the value adding process was the introduction of experts to the learning environment, a change implemented in the second running of the program. The introduction of the experts was accompanied by explicit self-referencing strategies, therefore the experts were not there as simply 'show and tell' but rather as a link to a possible future. This had significant impact on the students, allowing them to have a vision of possible career paths. The statistical evidence within this work of the effect of the continual self-referencing showed an increase in persistence and value over the ten week period. Therefore, the experts were important, equally as important was the follow up student discussions on to best use the experts' ideas and advice.

Having experts without the follow-up may serve to inform students generally but it seems that it does not inform them personally. This last observation hints that if students are not explicitly shown how to self-reference and then given the opportunity to do so, it remains an underutilised skill. The research indicated that, in this particular setting, (school and students), it was important to explicitly teach the strategies and then make time for the students to undergo the process of guided self-referencing. When this was done the statistical data showed that self-referencing became an active strategy. Two processes were especially important to establish the self-referencing process, explicitly forcing the students to become reflective by having them complete a questionnaire two to three times per semester, and more subtly as the provision of unstructured time when they prioritised their work and then were asked to reflect on how they had used their given freedom, (perhaps an indication of what they valued the most).

All students that undertook the revised version of the program, whether they persisted or opted out early, demonstrated evidence of self-referencing and had placed value on continuing with the STEM subjects. This was clearly demonstrated from responses recorded in their exit interviews. Students that exited, from the *initial* program cited poor achievements as a main reason for leaving the science and maths courses. Their transcripts showed little reflection surrounding the type of knowledge and skills that might be required for their future selves, it was all about grades and the ATAR. Students that exited the *revised* program were clear that they had thought about their career paths and priorities. Some of these students stated that after experiencing the experts and thinking about their own interests they could <u>not</u>

find a fit; clearly this is high order self-referencing that contributed to their change of thinking and ultimately on how to best achieve their goals.

Whilst the question that was researched was ‘how can the value placed on a subject be increased?’ the evidence from this research indicated that the actions undertaken could work in two ways. Students can place value in the subject and therefore be motivated to persist, on the other hand, value can also be transferred to other disciplines and, as witnessed in this study, students leave the courses – for the *right* reasons.

Enabling students to link career aspirations to the STEM subjects and their efforts to achieve.

The second question posed by this research investigated how to best shape actions, within the program, that developed a student’s sense of fit, motivating persistence in the face of challenges. The changes within the program were guided by literature stating that motivation is greatly influenced by achievement (Taylor, 2015) and a sense of fit is associated with career aspirations (Bell et al., 2005; Davies et al., 2009). Motivation is closely related to how a student predicts their success together with the utility value which is held for the subject (Minstrell & Anderson, 2011). The constructs that the program seeks to shape are: expectation of success, ability in the subject, usefulness of the subject, and, the effort required (Watt, 2005). Analysis of the first cohort showed little growth in these constructs.

In the first cohort of students, those that left the program did not pursue STEM subjects. Every one of them chose completely different pathways. The transcripts indicated that they were prioritising a high ATAR. Perhaps this is one fault of the education system, often it is focussed on the requirements of university admissions and therefore the greatest aggregate of grades. Not all students need to do STEM, but these students had shown aptitude and interest previously.

The second cohort of students also had individuals that left the program, however, in contrast to cohort 1, most of these students remained in the STEM subjects and were still focussed on careers based around the subjects.

The content of the Higher Achievers program was the same for both cohorts, that is, the same metacognitive reasoning was discussed, the same self-regulatory strategies were modelled, and, the same mathematical/science concepts were used to contextualise these skills. The difference was in the structure of the program, brought about by the four main modifications that were made (*chapter 7).*

An important change was to challenge the way the students' perceived success. The emphasis in the revised program was on process and procedure rather than product. This required a different approach to the way in which work was assessed. If the process was to become more important than the product, the assessment needed to reflect this bias. This change was delivered by exploring the idea of the incremental development of intelligence and mindsets, (Molden & Dweck, 2000). The notion that the product will improve with experience and experience often involves learning through mistakes and fine-tuning processes. If the process improves, so will the product.

To summarise, the actions that helped to increase motivation and a sense of fit stemmed from a change in mindset, focussing on effort being rewarded by a growth in ability. Low achievement was associated with inexperience and errors in processes rather than low ability or low intelligence. Assessment needed to reflect this idea and the feedback directed accordingly.

Finally, the community of inquiry was vital as a process of self-referencing. The community of inquiry was conducted in both versions of the program, the difference being that topics of discussions in the latter program were based on personal experiences with experts. This included the discussions of the processes, introduced by the experts. These discussions helped to solidify the correct mindset needed to motivate greater effort and investment by the students. The incremental mindset had the added advantage of dispelling the myth that one was not intelligent because of low achievement and the self-doubt that accompanied it. Students were expected to err, as that was the way to proficiency.

Equipping students with the tools to manage and navigate through their studies.

The final question posed was, how does a student's use of metacognitive reasoning better inform these constructs and therefore increase value, persistence, and motivation within the context of a challenging environment? The first and possibly most important observations that this research uncovered in response to this research question, is that metacognitive reasoning and self-regulatory strategies need practice. As with any new content students will have miss-conceptions, errant expectations, and will make mistakes. Learning to use metacognitive thinking is no different to learning to use scientific reasoning or mathematical logic. Explicit metacognition is not natural when most cognition is implicit. As with any new material it needs elaboration if it is to become a seamless part of our thinking, one that can be exercised explicitly, recalled when needed. This takes individual practice and therefore requires time within the program.

In the first version of the Higher Achievement program metacognition and self-regulated strategies were discussed and modelled. The students were expected to use the strategies; however, the practice was missing, and use was not a natural part of the learning sequence. To accommodate for the practice the second version of the program incorporated sessions of structured individual free time. This was a time when students could plan, prioritise, discuss, complete, and evaluate learning tasks. They practiced the strategies that were previously discussed and modelled. For this to occur the school had to accommodate a restructuring of the timetable for the students in the program.

Although the unstructured free lessons allowed students control over their work it was none-the-less guided. Students journaled their use of strategies, briefly, which were then discussed, both, in their community of inquiry and with the researcher.

It is only when the metacognitive thinking and self-regulatory strategies were practiced in this way and then properly applied that they gradually became tools that did affect value, and persistence. The metacognition, properly used, afforded the student powerful insight on how to control and effect their own achievements. Evident from the transcripts, if something was amiss the student had a diagnostic set of tools to implement changes within their control.

An important theme throughout this research is that motivation and a sense of fit ought to be maintained by metacognitive scaffolding that a student can readily access rather than be teacher dependant. When students choose subjects there is an interplay between the individuals (students and teachers), the learning environment, and the actions (pedagogy) (Erdogan & Stuessy, 2015; Holmegaard et al., 2014; Lazarides & Watt, 2015; X. Wang, 2013; Watt, 2005). Metacognition allows the students agency within the interplay, making success more achievable, especially when there are hurdles to navigate.

CONCLUSIONS

This research was borne of an actual situation that existed in at a secondary college, namely, that a number of students that were identified as advanced learners and had enjoyed success in mathematics and science in their middle years did not continue with the subjects in their senior years. The numbers were high enough to be noted and cause concern at the college. Simultaneously the same type of phenomenon was trending globally, (Lazarides & Watt, 2015; Mather & Tadros, 2014). The study adopted an Action-Research methodology.

At the school, academically inclined students were already being differentiated by an existing accelerated program in mathematics. Informed by current ideas the existing program was tweaked by several modifications including, the introduction of metacognitive strategies, collaboration in the form of communities of inquiry and a focus on learning rather than teaching. The program was then administered to an initial cohort of students.

Surveys and questionnaires indicated a positive reaction from most students, however, students that left the course still did not continue with their STEM studies. This was an issue. Reviewing recent literature, three more modifications were made to the program, a second cohort of students were offered the revised program, data was collected and analysed. The changes did not necessarily stop students leaving the program, however, the students that left persisted with the STEM subjects. The second cohort of students did not see the courses or their content as the problem, but rather their actions within the courses as warranting modification. This was acknowledged by the college as a change in the desired direction. Therefore, what can be concluded from the experience?

The research is notably limited by being specifically applied to one school and then a particular subset of students, therefore any conclusions reached cannot be of a general nature, although there may be some implications for further research, as discussed later in this work. Nonetheless, some conclusions can be made from the study's observations.

The three modifications that were applied to the program before it was administered to the second cohort of students were (i) a unit of work focusing on changing Mindsets (Dweck & Yeager, 2019), (ii) timetabling of students lessons allowing them free, supervised times providing opportunities for individual and independent strategy implementation and (iii) the introduction of experts into the learning environment.

The observations gathered from the second cohort in the study supported the literature. Students that did not meet their self-imposed, normally high standards attributed 'blame' on controllable traits and then proceeded to alter strategies; they were not discouraged (Dweck & Leggett, 1988; Gunderson et al., 2018). The introduction of experts to the field created excitement amongst the students and notably extended their thinking. The interactions with the experts focused on main ideas rather than the ideas peripheral to the subject concepts (Efklides, 2006). These changes tangibly created pragmatic meaning and the sense of fit.

An important idea which was found to be very sparsely discussed in the literature, yet a crux to this study, was that metacognitive thinking and self-regulatory skills needed to be explicitly taught and ‘learnt’ by the students. These concepts needed to be given their own space and time in the curriculum; students needed to practice them before they could be successfully used. So often students are expected to make use of the strategies once they are discussed, but this work found that independent student practice was necessary before students could adopt and assimilate them into their learning routines. It was only when students had practiced the skills that they became useful.

Finally an obvious conclusion, in total agreement with the literature, students will be motivated to persist with STEM subjects (and careers) if they see the courses as valuable and attainable (Watt, 2005) and themselves as having some control within the course structure. In this particular program the value was promoted by the experts, the attainability was scaffolded by the students’ mindsets, and the agency was developed through metacognitive reasoning.

STRENGTHS, WEAKNESSES AND IMPLICATIONS OF THE FRAMEWORK

The research presents a framework for understanding and discussing the relationship between student learning and goals rather than teaching and goals. In this research the discussion was couched within the context of STEM subjects. Students at the school, and globally, were abandoning their goals to pursue STEM studies and careers on the basis that the subjects were uninteresting and often the teaching was inadequate. The teaching and subject content are structures that are beyond the control of students. The study, therefore, aimed to give control to the learner by shifting the focus within the education process from the teaching to the learning.

Immediately one of the weaknesses is the study's inference that learning is the key activity in the education process. If this is not true and teaching is necessary and fundamental to the process, then the framework is invalid since the study contends that strengthening student learning can overcome teacher deficiencies. Some of the student comments, as reported in chapter 6, do imply that if the teaching was of a better quality, then the outcome need not have resulted in them leaving the subjects. Therefore for at least some students, no matter the degree of student agency, the teacher's actions could not be disregarded.

A further weakness of the study is that it pivots around approximately fifty students, of which, twelve form the focus group. What is happening to the other two hundred students? Despite providing positive outcomes for most students in the study, it is clear that the framework cannot be generalised for use with all students. Moreover, the same framework might prove detrimental for some students or under different circumstances.

Clearly the framework is not presented as an answer to the global trend, but as a solution to a particular event occurring at a specific school. Nonetheless it adds to the conversation on possible strategies which can be used to strengthen student commitment to STEM studies; it explores links between motivation, persistence, agency, and strategic learning. The research may provide a starting point for further research into the question asked by Wertheimer (1880 – 1947) over a century ago; why is it that some people, when they are faced with problems, get clever ideas, make inventions, and discoveries, whilst many others cannot get past their own inadequacies? (Wertheimer, 2020).

IMPLICATIONS OF THE RESEARCH

This study has implications for other researchers interested in exploring the relationship between teaching, learning and the students. It may be that future research will address a more heterogeneous group of students inclusive of a wider range of academic abilities or genders. The topics of student self-regulation is prevalent in today's media with the advent of home-schooling and on-line learning, therefore, further research on teaching students how to learn effectively and independently could be useful. In many cases it is assumed that that learners know how to learn, however, as this research has shown, such an assumption should not be made.

Since this research is situated in only one Catholic college, other researchers may seek to expand the study to include schools from a range of ideologies and cultures: Independent, Catholic, the State system, International colleges, or, change the lens to incorporate primary and lower secondary education.

The study has implication for universities, as they are responsible for teacher education. Topical amongst current discussions is the notion that teachers are required to teach outside their area of expertise (Zaid, Gunn, Fedtke, & Ibahrine, 2021), this, and the classroom becoming more inclusive with many students requiring individual learning plans and special accommodations, complicates the profession. It is logical that students that can generate metacognitive ideas to scaffold their learning and then self-regulate their actions will have an enormous advantage. Metacognition, this study has shown, needs to be learnt and practiced. The action-research component also provided classroom activities and structures that could enhance the self-regulated learning. Tertiary units on metacognition, self-regulation, and the associated pedagogies ought to form integral components of pre-service teacher formation, not just units offered to post-graduates.

If there are possible implication for teacher formation, then there also exists implications for the teaching profession. As well as the presumed benefits that this research will offer Gifted Education Coordinators facing similar situations with their talented charges, it is anticipated that the study will also have implications for all teachers. Firstly, the research reinforces that students do benefit from having control of their own learning. Secondly, the study promotes activities that lead students to value self-regulated strategies, a step to lifelong learning. The study also suggests that students require independent, unstructured, supervised time to practice and assimilated the learning skills; they should not be expected to know and be regular users of metacognition and its associated strategies from the onset. These skills are best taught in context therefore time ought to be given to their formation in every subject.

Given that the College students led and facilitated this study, there are obvious implications for the school and the learning management team. This research offers the staff of the College a framework for understanding how to engage its most able students so that they remain engaged learners, motivated to follow their visions and interests. The study is focused on STEM subjects but can easily be applied to any content. The implication for management surrounds the adaptation of structures to support student agency and student voice. A further implication for management is staff development, focusing on mindsets and learning alongside of pedagogy; obvious areas include the development of suitable timetable structures and directing assessment towards processes rather than products exclusively.

Finally, this research supports students' learning by giving them a voice. Through the actions of the staff the students can grow into learners that are independent and strategic. The findings of this research support the idea that students construct their own meaning and identity through the interplay that occurs between the learning environment, the individuals, and the actions within the classroom. Successfully navigating through all the variables can be difficult if the student has no sense of control, no matter how gifted; metacognition and self-regulation provide the navigation tools so that the final outcome leads to a destination of choice and not one of circumstances.

APPENDICES

APPENDIX 1: EDMUND RICE AUSTRALIA APPROVAL

Christian Brothers College
A Birth-12 Catholic College for boys in the Edmund Rice Tradition
Faith **Excellence** Community **Compassion**

Senior Campus
214 Wakefield Street, Adelaide SA 5000
P 08 8400 4200 F 08 8400 4299

Junior Campus
324 Wakefield Street, Adelaide SA 5000
P 08 8400 4222 F 08 8400 4220

CBC Community Children's Centre
178 East Terrace, Adelaide SA 5000
P 08 8223 5469 F 08 8223 7803

GPO Box 2707 Adelaide SA 5001
enquiries@cbc.sa.edu.au
www.cbc.sa.edu.au

24th March 2018

To whom it may concern,

As the EREA executive member associated with Christian Brothers College I approve and support a study to be conducted at the College following ethical approval from Flinders University.

I understand the study may include:

- Lesson observations
- Meeting observations
- Interviews with teachers and students

The study will be conducted by Mr John Santini.

Yours sincerely

Shaun Kenny

Shaun Kenny
Edmund Rice Education Australia

APPENDIX 2: CHRISTIAN BROTHERS COLLEGE APPROVAL

Christian Brothers College

A Birth-12 Catholic College for boys in the Edmund Rice Tradition

Faith **Excellence** Community **Compassion**

Senior Campus
214 Wakefield Street, Adelaide SA 5000
F 08 8400 4200 F 08 8400 4299

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P 08 8223 5469 F 08 8223 7803

GPO Box 2707 Adelaide SA 5001
enquiries@cbc.sa.edu.au
www.cbc.sa.edu.au

24th March 2018

To whom it may concern,

As Principal of Christian Brothers College I approve and support a study to be conducted at the College following ethical approval from Flinders University.

I understand the study may include:

- Lesson observations
- Meeting observations
- Interviews with teachers and students

The study will be conducted by Mr John Santini.

Should your require any further information please do not hesitate to contact me at the College on 8400 4210 or via email principal@cbc.sa.edu.au.

Your sincerely

Noel Mifsud
Principal

APPENDIX 3: PARENT AND STUDENT PERMISSION

Flinders UNIVERSITY

School of Education
GPO Box 2100
Adelaide SA 5001
Tel: 08 84004291
Fax: 08 84004299
JSantini@cbc.sa.edu.au
CRICOS Provider No. 00114A

Dear Parents and Student,

As part of the either the Gifted and Talented program or the Advance Senior Physics class each student is introduced to a variety of learning strategies that could be useful in a variety of situations. These strategies are particularly useful in situations when the concepts, pace of learning, type of assessment or deployment of efforts become increasing challenging and more time demanding.

If the program and/or course becomes onerous and assessments are indicative of problems then a discussion between your son and his teacher would occur where these learning strategies are discussed. During such discussions new strategies might be introduced or old ones might need to be modified; strategies could involve skills such as time management, planning, test and assessment completion, summary techniques, resource availability and so on. The resultant actions determined by these discussions are recorded and monitored; they will always be available on your son's portfolio on the school's portal.

This communique is to seek permission to use the data generated by discussions, surveys, questionnaires which would normally occur in the programs/courses to be used as a basis of a research to determine if the introduction and use of these strategies are of any significant value to your son's education. When the data is used in the study it will be de-linked by use of pseudonyms so that your son cannot be identified by any aspect of the report. No identifying information will be published in the research however please be aware that even with the best of intentions and the most stringent of processes, 100% infallibility of recognition cannot be assured, however small the risk.

The involvement in the study will not add to the student's commitment to the course. However, if for any reason a student (or parent) feels not incline to share the data any further then opting out will not be a problem. The inclusion of the data in the study will help in our understanding of how to best motivate and maintain interest in these programs and courses.

The data is generated primarily to support students as they navigate through the advance courses; this will always be our primary goal. The data WILL NOT be used for any research purpose unless both, the parent and the student, agree to it being included in the research; both parties need to agree. Not participating in the study will not affect the learning experience or the assessment grades in any way.

If you approve for the data to be used in the research can you kindly complete the attached consent form and return or email it back to the Director of Studies.

Parent Consent: I __________________ give consent for my son's academic and progress data to be used for research purposes in determining the value of selected learning strategies when implemented within advance senior courses.

Please sign and date: ____

Student Assent: I __________________ give consent for my academic and progress data to be used for research purposes in determining the value of selected learning strategies when implemented within advance senior courses.

Please sign and date: ____

With thanks for your consideration of this request,

Warm regards,

John Santini

Physics and Mathematics Senior Teacher

Gifted and Talented Coordinator

Principal researcher

APPENDIX 4: GLOSSARY OF STUDENT ASSESSMENTS

NAPLAN: The National Assessment Program – Literacy and Numeracy (**NAPLAN**) is a national assessment for all students in Years 3, 5, 7, and 9 which is completed yearly. All students in these year levels are assessed in reading, writing, spelling, grammar and punctuation and numeracy. It is a normative assessment, publically reported, which is often (incorrectly) paralleled with the quality of education at school level.

PAT M and PAT R tests: Progressive Achievement Tests in Mathematics and Reading which are designed to provide objective, norm-referenced information to teachers about their students' skills and understandings in a range of objectives set by the Australian Curriculum, Assessment and Reporting Authority (**ACARA**). These tests are written by the Australian Council of Educational Research, a not-for-profit independent Australian company.

Raven© tests: **Raven's Progressive Matrices** (often referred to simply as **Raven's Matrices**) or **RPM** is a nonverbal group test typically used in educational settings. It is usually a 60-item test used in measuring abstract reasoning and regarded as a non-verbal estimate of fluid intelligence.

APPENDIX 5: METACOGNITIVE AWARENESS ASSESSMENT

	NEVER				ALWAYS
	1	2	3	4	5
1. I ask myself periodically if I am meeting my goals.					
2. I consider several alternatives to a problem before I answer.					
3. I try to use strategies that have worked in the past.					
4. I pace myself while learning in order to have enough time.					
5. I understand my intellectual strengths and weaknesses.					
6. I think about what I really need to learn before I begin a task					
7. I know how well I did once I finish a test.					
8. I set specific goals before I begin a task.					
9. I slow down when I encounter important information.					
10. I know what kind of information is most important to learn.					
11. I ask myself if I have considered all options when solving a problem.					
12. I am good at organizing information.					
13. I consciously focus my attention on important information.					
14. I have a specific purpose for each strategy I use.					
15. I learn best when I know something about the topic.					
16. I know what the teacher expects me to learn.					
17. I am good at remembering information.					
18. I use different learning strategies depending on the situation.					
19. I ask myself if there was an easier way to do things after I finish a task.					
20. I have control over how well I learn.					
21. I periodically review to help me understand important relationships.					
22. I ask myself questions about the material before I begin.					
23. I think of several ways to solve a problem and choose the best one.					
24. I summarize what I've learned after I finish.					
25. I ask others for help when I don't understand something.					
26. I can motivate myself to learn when I need to					
27. I am aware of what strategies I use when I study.					

28. I find myself analyzing the usefulness of strategies while I study.				
29. I use my intellectual strengths to compensate for my weaknesses.				
30. I focus on the meaning and significance of new information.				
31. I create my own examples to make information more meaningful.				
32. I am a good judge of how well I understand something.				
33. I find myself using helpful learning strategies automatically.				
34. I find myself pausing regularly to check my comprehension.				
35. I know when each strategy I use will be most effective.				
36. I can motivate myself to learn when I need to				
37. I am aware of what strategies I use when I study.				
38. I find myself analyzing the usefulness of strategies while I study.				
39. I ask myself how well I accomplish my goals once I'm finished.				
40. I draw pictures or diagrams to help me understand while learning.				
41. I ask myself if I have considered all options after I solve a problem.				
42. I try to translate new information into my own words.				
43. I change strategies when I fail to understand.				
44. I use the organizational structure of the text to help me learn.				
45. I read instructions carefully before I begin a task.				
46. I ask myself if what I'm reading is related to what I already know.				
47. I reevaluate my assumptions when I get confused.				
48. I organize my time to best accomplish my goals.				
49. I learn more when I am interested in the topic.				
50. I try to break studying down into smaller steps.				
51. I focus on overall meaning rather than specifics.				
52. I ask myself questions about how well I am doing while I am learning something new.				
53. I ask myself if I learned as much as I could have once I finish a task.				
54. I stop and go back over new information that is not clear.				
55. I stop and reread when I get confused.				

APPENDIX 6: MOTIVATION STRATEGIES LEARNING QUESTIONNAIRE AND SCORING

Part A: Motivation					
No.	Item	1	2	3	4
1	In a class like this, I prefer course material that really challenges me so I can learn new things.				
2	If I study in appropriate ways, then I will be able to learn the material in this course.				
3	When I take a test I think about how poorly I am doing compared with other students.				
4	I think I will be able to use what I learn in this course in other courses.				
5	I believe I will receive an excellent grade in this class.				
6	I'm certain I can understand the most difficult material presented in the readings for this course.				
7	Getting a good grade in this class is the most satisfying thing for me right now.				
8	When I take a test I think about items on other parts of the test I can't answer.				
9	It is my own fault if I don't learn the material in this course.				
10	It is important for me to learn the course material in this class.				
11	The most important thing for me right now is improving my overall grade point average, so my main concern in this class is getting a good grade.				
12	I'm confident I can learn the basic concepts taught in this course.				
13	If I can, I want to get better grades in this class than most of the other students.				
14	When I take tests I think of the consequences of failing.				
15	I'm confident I can understand the most complex material presented by the instructor in this course.				
16	In a class like this, I prefer course material that arouses my curiosity, even if it is difficult to learn.				
17	I am very interested in the content area of this course.				
18	If I try hard enough, then I will understand the course material.				
19	I have an uneasy, upset feeling when I take an exam.				
20	I'm confident I can do an excellent job on the assignments and tests in this course.				
21	I expect to do well in this class.				
22	The most satisfying thing for me in this course is trying to understand the content as thoroughly as possible.				
23	I think the course material in this class is useful for me to learn.				
24	When I have the opportunity in this class, I choose course assignments that I can learn from even if they don't guarantee a good grade.				
25	If I don't understand the course material, it is because I didn't try hard enough.				
26	I like the subject matter of this course.				
27	Understanding the subject matter of this course is				

	very important to me.				
28	I feel my heart beating fast when I take an exam.				
29	I'm certain I can master the skills being taught in this class.				
30	I want to do well in this class because it is important to show my ability to my family, friends, employer, or others.				
31	Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class.				
32	When I study the readings for this course, I outline the material to help me organize my thoughts.				
33	During class time I often miss important points because I'm thinking of other things. (REVERSED)				
34	When studying for this course, I often try to explain the material to a classmate or friend.				
35	I usually study in a place where I can concentrate on my course work.				
36	When reading for this course, I make up questions to help focus my reading.				
37	I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do. (REVERSED)				
38	I often find myself questioning things I hear or read in this course to decide if I find them convincing.				
39	When I study for this class, I practice saying the material to myself over and over.				
40	Even if I have trouble learning the material in this class, I try to do the work on my own, without help from anyone. (REVERSED)				
41	When I become confused about something I'm reading for this class, I go back and try to figure it out.				
42	When I study for this course, I go through the readings and my class notes and try to find the most important ideas.				
43	I make good use of my study time for this course.				
44	If course readings are difficult to understand, I change the way I read the material.				
45	I try to work with other students from this class to complete the course assignments.				
46	When studying for this course, I read my class notes and the course readings over and over again.				
47	When a theory, interpretation, or conclusion is presented in class or in the readings, I try to decide if there is good supporting evidence.				
48	I work hard to do well in this class even if I don't like what we are doing.				
49	I make simple charts, diagrams, or tables to help me organize course material.				
50	When studying for this course, I often set aside time to discuss course material with a group of students from the class.				
51	I treat the course material as a starting point and try to develop my own ideas about it.				
52	I find it hard to stick to a study schedule. (REVERSED)				
53	When I study for this class, I pull together information from different sources, such as lectures, readings, and discussions.				
54	Before I study new course material thoroughly, I of-				

	ten skim it to see how it is organized.				
55	I ask myself questions to make sure I understand the material I have been studying in this class.				
56	I try to change the way I study in order to fit the course requirements and the instructor's teaching style.				
57	I often find that I have been reading for this class but don't know what it was all about. (REVERSED)				
58	I ask the instructor to clarify concepts I don't understand well.				
59	I memorize key words to remind me of important concepts in this class.				
60	When course work is difficult, I either give up or only study the easy parts. (REVERSED)				
61	I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying for this course.				
62	I try to relate ideas in this subject to those in other courses whenever possible.				
63	When I study for this course, I go over my class notes and make an outline of important concepts.				
64	When reading for this class, I try to relate the material to what I already know.				
65	I have a regular place set aside for studying.				
66	I try to play around with ideas of my own related to what I am learning in this course.				
67	When I study for this course, I write brief summaries of the main ideas from the readings and my class notes.				
68	When I can't understand the material in this course, I ask another student in this class for help.				
69	I try to understand the material in this class by making connections between the readings and the concepts from the lectures.				
70	I make sure that I keep up with the weekly readings and assignments for this course.				
71	Whenever I read or hear an assertion or conclusion in this class, I think about possible alternatives.				
72	I make lists of important items for this course and memorize the lists.				
73	I attend this class regularly.				
74	Even when course materials are dull and uninteresting, I manage to keep working until I finish.				
75	I try to identify students in this class whom I can ask for help if necessary.				
76	When studying for this course I try to determine which concepts I don't understand well.				
77	I often find that I don't spend very much time on this course because of other activities. (REVERSED)				
78	When I study for this class, I set goals for myself in order to direct my activities in each study period.				
79	If I get confused taking notes in class, I make sure I sort it out afterwards.				
80	I rarely find time to review my notes or readings before an exam. (REVERSED)				
81	I try to apply ideas from course readings in other class activities such as lecture and discussion.				

Figure removed due to copyright restriction

(Duncan & McKeachie, 2005)

APPENDIX 7: QUESTIONNAIRE ON ENTRY TO PROGRAM

GENERAL QUESTIONNAIRE AND AN ENTRY POINT FOR A DISCUSSION AS TO WHY STUDENTS HAVE CHOSEN THE PHYSICS OR MATHEMATICS.

1. *Physics and/or Maths Methods are (sometimes) considered to be difficult subjects, often best avoided, why have you opted to take these courses?*

2. *During course counselling did any of the teachers recommend / not recommend you take the subjects?*

3. *Have you ever found the Maths or Sciences difficult in the past? If so how did you overcome the difficulties?*

4. *Have you chosen the Mathematics/Physics/Chemistry course because you feel they are important to what you would like to study beyond Year 12?*

5. *Do you ever find yourself pushed for time; too much to do and not enough time to complete the work, if so, how do you prioritise your work?*

6. *Do you enjoy Physics and Mathematics or are you just doing them as a means to an end?*

7. *How do you learn for these subjects; do you have a routine?*

8. *At what point would you consider dropping these subjects?*

APPENDIX 8: RELIABILITY AND VALIDITY OF SELF-EFFICACY FOR LEARNING FORM (BAKER & O'NEIL, 1994)

1. When you miss a class, can you find another student who can explain the lecture notes as clearly as your teacher did?
2. When your teacher's lesson is very complex, can you write an effective summary of your original notes before the next class?
3. When a lesson is especially boring, can you motivate yourself to keep good notes?
4. When you had trouble understanding a lesson, can you clarify the confusion before the next class meeting by comparing notes with a classmate?
5. When you have trouble studying your class notes because they are incomplete or confusing, can you revise and rewrite them clearly after every lesson?
6. When you are taking a course covering a huge amount of material, can you condense your notes down to just the essential facts?
7. When you are trying to understand a new topic, can you associate new concepts with old ones sufficiently well to remember them?
8. When another student asks you to study together for a course in which you are experiencing difficulty, can you be an effective study partner?
9. When problems with friends and peers conflict with schoolwork, can you keep up with your assignments?
10. When you feel moody or restless during studying, can you focus your attention well enough to finish your assigned work?
11. When you find yourself getting increasingly behind in a new topic, can you increase your study time sufficiently to catch up?
12. When you discover that your homework assignments for the semester are much longer than expected, can you change your other priorities to have enough time for studying?
13. When you have trouble recalling an abstract concept, can you think of a good example that will help you remember it on the test?
14. When you have to take a test in a school subject you dislike, can you find a way to motivate yourself to earn a good grade?
15. When you are feeling depressed about a forthcoming test, can you find a way to motivate yourself to do well?
16. When your last test results were poor, can you figure out potential questions before the next test that will improve your score greatly?
17. When you are struggling to remember technical details of a concept for a test, can you find a way to associate them together that will ensure recall?

18. When you think you did poorly on a test you just finished, can you go back to your notes and locate all the information you had forgotten?

19. When you find that you had to “cram” at the last minute for a test, can you begin your test preparation much earlier so you won’t need to cram the next time?

APPENDIX 9: RUBRIC CHECKLIST FOR INTERPRETING METACOGNITION & COURSE VALUE FROM INTERVIEWS AND DISCUSSIONS, (VALIDITY).

	Subject Motivation & Sense of fit	Metacognition and Self-Regulatory Strategies
A	Designs a **logical, coherent,** and **detailed** map to achieve best possible results. Has **widely** researched and communicates **accurate data** explaining the usefulness of the course. See the course as highly relevant. **Critically** and **logically** demonstrates the effort required to complete the course.	Demonstrates **deep and broad** knowledge and understanding of a **range** of metacognition and self-regulatory strategies. Develops and applies self-regulatory strategies **highly effectively** in new **and** familiar contexts. **Critically** employs appropriate metacognition and self-regulation differentially understanding its impact in **depth**.
B	Designs a **well-considered** and **clear** map to achieve good results **Obtained appropriate** data, and can communicate **mostly accurately** how this course might be relevant to future plans. Sees the course as important to complete successfully **Logically** steps through the effort exerted to meet the requirements of the course.	Demonstrates **some depth and breadth** of knowledge and understanding of a **range** of metacognition and self-regulation Develops and applies self-regulation **mostly** effectively in new **and** familiar contexts. **Logically** employs appropriate metacognition and self-regulation differentially understanding its impact with some depth.
C	Designs a **considered** and **generally clear** plan to achieve a good standard pass. Using **generally appropriate** resources, communicates with **some errors** but **generally accurately** how this course might be relevant. Sees the course relevant as assumed knowledge for future courses. Reasons why **some** effort has been required to complete course components	Demonstrates knowledge and understanding of a **general range** of meta-cognitive and self-regulatory concepts. Develops and applies self-regulation **generally** effectively in new **or** familiar contexts. Employs some appropriate **aspects** of meta-cognitive and self-regulatory behaviour with some differentiation.
D	Prepares **the outline** for success in the course. Has an **inconsistent** knowledge and can with **occasional** accuracy explain some probable relevance of the course to the future. Makes an attempt to pass the course for grade purposes alone. **Attempts** to make an effort or **suggest** why effort ought to be made to complete course.	Demonstrates **some basic** knowledge and **partial** understanding of meta-cognitive and self-regulatory concepts. Develops and applies **some** self-regulation in **familiar** contexts. **Partially** employs appropriate meta-cognitive and self-regulatory strategies and **recognises** impacts of strategies.
E	**Identifies a simple** procedure that might result is a passing grade. **Has completed some** research and has **limited** knowledge of how this course might be useful in the future. Does not see the relevance of the course and intends to drop it whenever possible. **Acknowledges** that effort is necessary but finds it very hard to implement.	Demonstrates **limited** recognition and **awareness** of meta-cognitive and self-regulatory concepts. **Attempts** to develop and apply self-regulation in **familiar** contexts. **Attempts** to employs **an appropriate aspect** of metacognitive and self-regulatory behaviour.
K E Y	**Black – Intrinsic Value (Motivation)** **Blue – Utility Value** **Green – Attainment Value** **Brown – Cost and effort.**	Black – Declarative Blue – Procedural Brown - Conditional

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