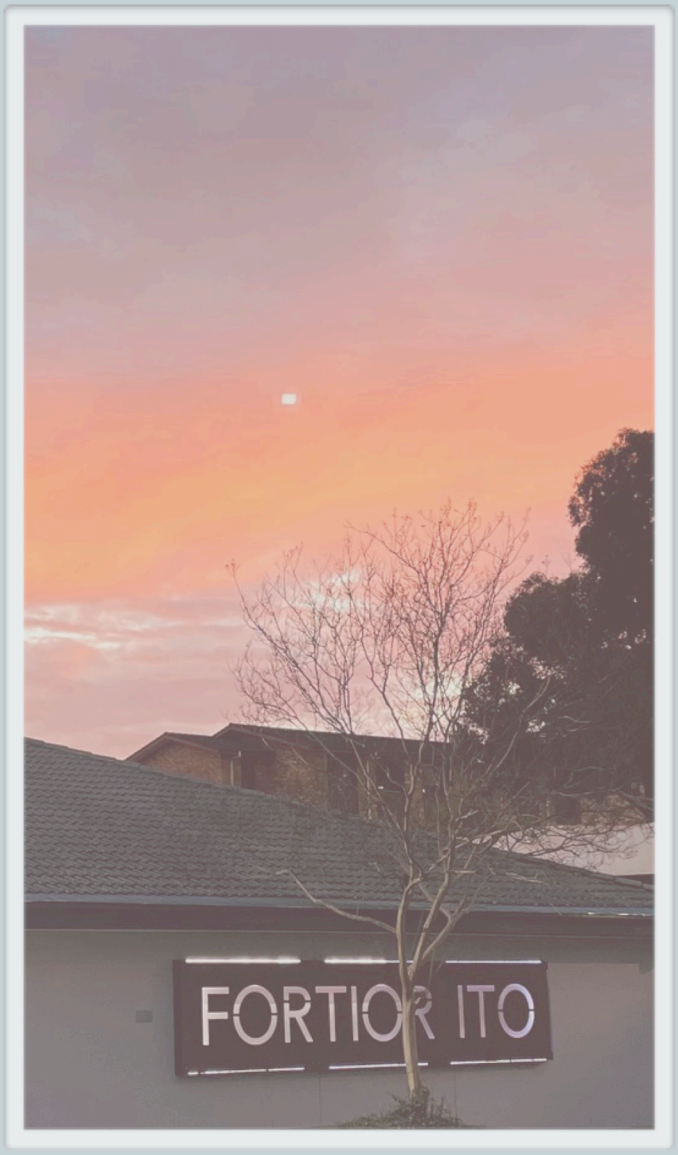
Microanalytical Studies into Self-efficacy and Achievement in a Project-Based Learning Classroom



Adam Hendry

Microanalytical Studies into Self-efficacy and Achievement in a Project-Based Learning Classroom

Microanalytische Studies naar Self-efficacy en Studieprestaties in Project-Gestuurd Onderwijs

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Overige leden:	Prof.dr. M.Ph. Born Prof.dr. A.A.C.M. Smeets Prof.dr. S. Loyens
Copromotor:	Dr. J.I. Rotgans

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Chapter 1

Introduction and Literature Review

Introduction

The focus of this thesis is on how efficacy beliefs develop and how they interact with instruction and academic performance within a secondary school project-based learning environment. In this chapter, the objectives of and background to the thesis will be explored, first, by reviewing the current literature and discussing current findings; second, by outlining some of the shortcomings of the present state of self-efficacy research; and third, by introducing the research questions that formed the starting points of the studies described in this thesis.

Impetus for the Studies in this Thesis

The role of efficacy beliefs in learning has been of significant importance to educational researchers for some time. Chief amongst them is *self-efficacy*. Simply put, self-efficacy involves a self-judgement as to how successful one will be in completing a particular task with the skills one presently possesses. For more than forty years, self-efficacy has shown itself to be an important motivational construct to learning and one that possesses significant predictive powers in relation to performance particularly in the academic domain. It has also revealed itself to be a powerful mediating influence on other constructs. At the same time, new instructional approaches to learning (beyond 'conventional' didactic approaches), particularly constructivist approaches such as problem- and project-based learning, have proliferated in recent decades. Whilst once largely limited to tertiary education, such approaches are now expanding significantly into primary and secondary schools. It may be argued that this expansion has accelerated in the age of the internet and personal devices where information is no longer the preserve of the teacher alone, which, in turn, has begun to shine a light on the effectiveness of these instructional approaches as well as the impact of instruction itself on psychological constructs such

as self-efficacy. Lastly, the ubiquity of personal devices has meant that the development of these (and other) constructs can now be studied in a natural classroom or learning environment with respondents' judgements, beliefs, feelings, or attitudes captured instantaneously through the use of a microanalytical measurement approach (as was used in the studies in this thesis). The following review of the literature highlights the current state of play in relation to self-efficacy and constructivist approaches to learning in order to provide a more detailed background to this thesis.

The Definition of Self-efficacy

Self-efficacy has been studied in a range of psychological disciplines in areas ranging from sports performance, business management, dietary practices, work-related training, computing and, of course, in learning. It is within an academic context that self-efficacy has, perhaps, received most attention. Self-efficacy is defined by Albert Bandura (1986) as: "An individual's assessment of their capabilities to organise and execute courses of action needed to perform certain tasks and is concerned not with the skills one has but with judgments of what one can do with whatever skills one possesses" (p. 391). Self-efficacy thus involves a self-judgement as to how successful one will be in completing a particular task. Grounded within social cognitive theory, which is based on an agentic perspective where one can "exert intentional influence over one's functioning and the course of events by one's actions" (Bandura, 2012, p. 11), it has been posited by Bandura (1977, 1986, 1997) that there are four main sources that create, develop, enhance or diminish feelings of self-efficacy. These sources are (1) *previous performance accomplishments* or *mastery experiences*: the belief in one's competence and ability based on the interpretation and evaluation of past performances; (2) *vicarious experience*: to gauge one's own ability by observing and relating it to the performances of others; (3)

verbal and social persuasion; being encouraged or convinced by others regarding one's level of ability; and (4) *emotional and physiological states*: one's mood or state of mind (e.g., anxiety) can impact feelings of self-efficacy. Usher and Pajares (2008), following a review of self-efficacy studies up to that point confirmed Bandura's hypothesis of performance accomplishments or mastery experiences as the most powerful source of self-efficacy beliefs across domains. The other three sources, whilst likely contributors to self-efficacy, are not as clearly demonstrated in empirical studies (and certainly not to the extent of the influence of mastery experiences) but this may also be a consequence of the measures used (Usher & Pajares, 2008). Other sources of self-efficacy have been conjectured by social cognitive theorists with the most prominent candidate being the *invitational approach*, that is, the messages that one gives and receives helps to frame the world or provide a lens through which to view it (Usher & Pajares, 2008). With this in mind, it is perhaps easy to see how self-efficacy beliefs relate to learning given how these sources of information are often implicitly or explicitly incorporated into the learning process itself and how they fluctuate as a consequence of the vicissitudes of learning particularly across multiple knowledge domains.

The Extent to Which Self-efficacy is Situationally Determined

Bandura and other self-efficacy researchers (Bandura, 1977, 1986, 1997, 2012; Duncan & McKeachie, 2005; Gist & Mitchell, 1992; Mathieu, Martineau, & Tannenbaum, 1993; Wolf, 1997; Zimmerman, 2000) have asserted therefore that self-efficacy is dynamic and is the product of the interplay of three factors: (a) personal, (b) behavioural, and (c) environmental; with self-efficacy itself being considered a constituent of (intra) personal factors but influenced by all due to 'triadic codetermination' (Bandura, 2012). The construct of self-efficacy is therefore believed

to vary across domains and situational conditions rather than manifest uniformly across tasks and contexts in the likeness of a general trait (Bandura, 2012) which, in turn, has led researchers (besides Bandura) to stress the importance of operationalising and measuring self-efficacy in relation to defined tasks within specific domains (Pajares & Graham, 1999; Usher & Pajares 2008). This supposed situationality (and volatility) of the construct is acknowledged by researchers who believe that the self-reporting of efficacy is often context-dependent and affected by the situational circumstances at the time of reporting (Bandura 2012; Duncan & McKeachie, 2005; Gist & Mitchell, 1992; Mathieu, Martineau, & Tannenbaum, 1993; Zimmerman, 2000) due to the "multidetermination and contingent nature of everyday life" (Bandura 2012, p. 10). It has been shown that even the inducement of a happy mood is capable of altering participants' feelings of efficaciousness (Kavanagh & Bower, 1985). Essentially, these efficacy beliefs not only influence the particular courses of action a person chooses to pursue but the amount of effort that they expend, their levels of perseverance in adverse circumstances and resilience, as well as their ability to cope with the demands associated with that specific course of action (Chemers, Hu, & Garcia, 2001).

On the other hand, other self-efficacy researchers have conceptualised a more generalised or dispositional quality to self-efficacy that refers to "global confidence in one's coping ability across a wide range of demanding or novel situations" (Scholz, Doña, Sud & Schwarzer, 2002, p. 243). Therefore, one's ability to execute certain actions in a variety of circumstances appears to be an accumulation of efficacious experiences which were, at once, related to task performance, but now, perhaps due to reciprocal determinism, is extrapolated across domains and developed into a more 'trait-like' confidence; it is theorised that the opposite is also true, that negative

experiences lead to a lack of confidence, in general, across multiple domains. This more generalised aspect of self-efficacy was conceived as early as 1982, when Sherer and Maddux (1982) constructed and attempted to validate a 'general' self-efficacy scale. Subsequent researchers, like Schwarzer and Jerusalem (1995), have done so successfully with their scale been widely used and adapted. And whilst both general and specific self-efficacy measures are often still tied to a particular task or domain (even if measured two years apart in the case of Zhao, Siebert and Hills, 2005), as indicated by Williams and Williams (2010), some global measures of self-efficacy are not related to a specific task at all but instead attempt to measure efficacy beliefs respondents 'in general' (cf. Multon, Lent & Brown, 1991; and Choi, 2005). Chapter 5 of this thesis aims to contribute to this discussion.

The Causal Relationship Between Self-efficacy and Achievement

Another reason for the enduring interest in self-efficacy has been its predictive utility in relation to achievement in both *specific* tasks undertaken by participants in studies as well as *overall performance* in different subject domains that has been the focus. Bandura (2012) reasserted the importance of self-efficacy to academic performance by stating that it plays an influential role at the operative level because the "malleability of ability is strikingly illustrated in research demonstrating that individuals of higher self-efficacy outperform their counterparts of lower perceived efficacy at each level of ability" (p. 24). Honicke and Broadbent (2016) in their meta-analysis of 59 self-efficacy studies published between 2003 and 2015 (those eligible under their terms of reference), found much support for the importance of academic self-efficacy as a determinant of subsequent academic performance. They assert that "academic self-efficacy has consistently been shown to positively correlate with academic performance, with meta-analytic studies reporting moderate effect sizes"

(Honicke & Broadbent, 2016, p. 64). Interestingly, also in their meta-analysis, Honicke and Broadbent (2016) caution that whilst existing research provides significant support for the relationship between academic self-efficacy and academic performance (most cogently at university level), the limited number of longitudinal studies they identified means that further research is needed into "how these variables relate over time is necessary in order to establish causality" (Honicke & Broadbent, 2016, p. 63).

This leads to another debate arising in the literature centred on the directionality of the influence between self-efficacy and achievement. For example, is self-efficacy a consequence of achievement or does achievement result from self-efficacy? Alternatively, is the relationship reciprocal? Most studies assume a one-directional relationship between self-efficacy and achievement (Pajares, 1996). For instance, Zuffiano (2013) measured self-efficacy beliefs among eighth-grade students at the beginning of the school year and was able to demonstrate its influence on achievement at the end of the school year, beyond effects of previous academic achievement, gender, socio-economic status, intelligence, personality traits, and self-esteem. On the other hand, Diseth (2011), in a study among psychology students, found that self-efficacy was mainly determined by previous academic achievement. The relationship between self-efficacy and academic performance is certainly complex with many variables moderating the relationship as well as the directionality of influence remaining uncertain. As shown in their study, Talsma, Schüz and Norris (2019) found that self-efficacy bias predicted academic performance on similar subsequent tasks, with under-efficacious students performing better than accurate or over-efficacious students with the authors suggesting that "self-efficacy is not a self-fulfilling prophecy; instead, over-efficacious students may experience negative

impacts on academic self-regulation and performance" (p. 182). Chapter 6 presents data relevant to this issue.

The Role of Instruction in the Development of Self-efficacy

An area within self-efficacy research that has been underdeveloped is its relationship with instruction. The relationship between the development of self-efficacy and learning has long been assumed, perhaps, a consequence of the findings of early experimental studies where self-efficacy was shown to be susceptible to change following instructional interventions (Bandura & Schunk, 1981, Schunk, 1982, Zimmerman, 2000). Whilst it is easy to assume that self-efficacy *must* develop as a result of the ongoing instructional processes within a learning environment, research into the *mechanisms* of instruction that contribute to self-efficacy's development is limited. An important focus of the studies presented in this thesis is therefore on how instruction influences self-efficacy. Chapters 3 and 4 provide information in this respect.

Constructivist Pedagogies Under Study in this Thesis

Research into self-efficacy was undertaken within an Australian secondary school that deploys project-based learning as its main mode of curriculum delivery in Years 7 through 10 (ages 12 to 16). The review below outlines the definitions and distinctions of constructivist 'active-learning' pedagogies and those factors that may impact upon the study of learning within a project-based learning environment in this thesis. For a more detailed insight into the nature, structure and evolution of project-based learning and other constructivist pedagogies in the school where these studies were undertaken, please see Chapter 2.

Constructivist pedagogies have been variously described, most recently, as student-centred or 'active-learning' approaches to learning. Under that umbrella

(now) sits problem- and project-based learning as well as ‘inquiry’ or ‘discovery’ learning (see English & Kitsantas, 2013; Savery, 2006; Wijnen et al., 2017). The studies discussed in this thesis were undertaken within a ‘project-based learning’ environment. The use of projects, as a means to make schooling more engaging and authentic, first became popular in the early part of the twentieth century particularly within the United States (Barron et al., 1998). Proponents, like John Dewey, attempted to contextualise the learning and leveraging student interest through ‘teaching by projects’ (Dewey, 1897; Hotchkiss, 1924; Kilpatrick 1918; McMurry, 1920) but this approach was deployed only sporadically after that time. Perhaps, then, this lack of a clear definition (and proliferation in variants) is a consequence of both project-based learning’s longevity and marginal deployment (in comparison to teacher-centred instruction) until growing interest increased its use in the latter part of the twentieth century. That being said, a general consensus about what constitutes project-based learning has been reached in that time. Described best by Thomas (2000), there are five essential criteria that need to be present in project-based learning. They are: (1) projects are central to the process and the main mode of instruction; they are the curriculum (2) projects require a ‘driving question’ that ties together the key underlying conceptual knowledge and activities that drive student learning (3) the project’s goals and central activities require students to investigate, transform and construct knowledge and not simply undertake exercises or tasks within their current skill set or knowledge (4) projects are led by students to a significant degree with more choice and autonomy and less supervision than teacher-centred approaches, and (5) projects should be as authentic and real-world as possible where solutions have the potential to be implemented.

Project-based learning is, like its younger but perhaps better known sibling, problem-based learning, an instructional approach that is learner-centred and 'active' (as opposed to the 'passive' teacher-centred modes of instruction). However, there are some subtle differences that distinguish the two approaches and it is important to make these dissimilarities known to better understand how studies into learning in these environments are differentially impacted. According to Savery (2006), problem-based learning inspires learners to undertake research, integrate theory and practice, activate prior knowledge and skills as well as applying newly-acquired knowledge and skills to develop a feasible solution to a defined problem; one which is often ill-structured, interdisciplinary and of reasonably short duration. problem-based learning also requires a tutor to facilitate the learning process and conduct a debriefing at the conclusion of the learning experience. Schmidt, van der Molen, te Winkel and Wijnen (2009) point out that most authors generally agree that problem-based learning has six defining characteristics: (1) the use of problems as the starting point for learning (2) small-group collaboration, and (3) flexible guidance of a tutor. Because problems steer the learning in such curriculum (4) numbers of lectures are limited. The latter is in line with the idea that (5) learning is to be student-initiated and that (6) ample time for self-study should be available.

Indeed, project-based learning shares almost all the characteristics described above (Thomas, 2000) and would be considered by most authors as well as a valid instructional strategy that promotes active learning and engages the learner in higher-order thinking and is therefore similar to problem-based learning in that the learning activities are organized around achieving a shared goal, in this instance, not a problem but a project (Savery, 2006). According to Savery (2006), within project-based learning, learners are usually provided with specifications for a desired end product

(e.g., a website) and the learning process is frequently oriented towards following correct processes and procedures. This is not to say that learners in a project-based learning environment are only concerned with processes and will not grapple with any problems, instead, while working on a project, learners are "likely to encounter several 'problems' that generate 'teachable moments"' (Savery, 2006, p 16). In a project-based learning environment, teachers also act more like facilitators (rather than tutors as in a problem-based learning setting) and help to guide students by scaffolding the learning within the context of the project and by offering workshops and feedback to help students achieve a better final or 'summative' product.

However, according to Savery (2006) whilst projects are excellent learner-centred instructional strategies they "tend to diminish the learner's role in setting the goals and outcomes for the 'problem'" (p. 16). Savery continues, pointing out that when the expected outcomes are clearly defined then "there is less need or incentive for the learner to set his/her own parameters. In the real world it is recognized that the ability to both define the problem and develop a solution (or range of possible solutions) is important" (Savery, 2006, p. 16). Another observable difference between project-based learning and problem-based learning are the varying lengths of the time learners have to come up with a solution/resolution to a problem and project respectively. Projects often last considerably longer than 'problems' and can be on a grander scale something that can result in project-based learning being more student driven, perhaps in order to sustain the learning and produce a significant (in scale) final product weeks or months down the track. This is most evident when project-based learning is used in a university or tertiary setting where the choice to utilise either project-based learning or problem based learning (or a combination of the two, see Kolmos, 1996) comes as a consequence of social setting or the changing

requirements of a particular profession; for example, the preferred use of problem-based learning in medical education and the exponential growth in the use of project-based learning in engineering in recent times.

An interesting by-product of the interactive nature of project-based learning, emphasizing student collaboration, is that self-efficacy can also be studied as a collective attribute of groups of students rather than a characteristic of individuals. Chapter 7 delves into this issue.

Research Questions and the Structure of this Thesis

Following a review of current literature, several gaps were identified that required further research. These included the following broad themes (a) the difference between general and situational self-efficacy, (b) the development of self-efficacy over time and the impact of instruction on this development, (c) the nature of the relationship between self-efficacy and academic achievement and (d) the development of efficacy beliefs of students when working in groups. To address these themes, the following research questions were studied as part of the work leading to this thesis:

1. To what extent does self-efficacy develop over time?
2. Is this development (if any) the result of the influence of instruction?

    Chapter 3 describes a study in which students in a 5-week project-based course on chemistry were microanalytically measured several times. The resulting data were analysed using latent-growth curve (LGC) analysis combined with time series analysis to find out the extent to which changes in self-efficacy are caused by the instruction.

3. Do ‘critical learning events’ cause self-efficacy to increase?

Chapter 4 displays the results of a study in which self-efficacy was measured before and after a number of critical learning events during a five-week project-based course on biology. The assumption was that change in self-efficacy over time was to be the result of the confrontation and successful completion of these events. It was assumed that changes in 'situational' self-efficacy were predictive of overall change in 'general' self-efficacy.

4. How different are general and situational self-efficacy?

5. Is academic achievement better predicted by situational than by general self-efficacy?

In Chapter 5 the issue of generality of self-efficacy is discussed (cf. Sherer and Maddux, 1982, Scholz, Doña, Sud & Schwarzer, 2002) and structural equations modelling data are presented that were supposed to shed a light on this issue.

6. How are self-efficacy and academic achievement causally related?

In the study presented in Chapter 6 a four-wave, cross-lagged panel analysis is presented to test three hypotheses regarding this relationship: (1) self-efficacy is a causal determinant of subsequent achievement, (2) achievement is a causal determinant of subsequent self-efficacy, and (3) the relationship is reciprocal.

Two further chapters (2 and 7) contained within this thesis explore the educational context and background to the studies as well as different aspects of efficacy beliefs. These chapters have already been published. Chapter 2 describes the innovative educational environment in which the studies were carried out, an all-boys high school in Parramatta, Western Sydney, Australia. It 'sets the stage' for the subsequent chapters. Chapter 7, finally, the role of *collective efficacy* and *proxy efficacy* beliefs in the performances of project-based learning teams comprising friends and acquaintances groups are explored. It presents a different take on the self-efficacy

construct. Please note, the findings presented in Chapters 3 and 6 and the Chapters 4 and 5 were based on two separate extended classroom studies respectively.

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Chapter 2

*Undertaking Educational Research Following the Introduction, Implementation, Evolution and Hybridisation of Constructivist Instructional Models in an Australian 'PBL' High School.**

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Abstract

The aim of this paper is to provide an overview of the introduction, implementation, evolution, hybridisation and initial research into the constructivist instructional models deployed within a secondary (high) school in Australia. A concomitant aim is to relate some of the consequences of school-wide pedagogical change which has included the implementation of Project and Problem Based Learning, the Flipped Classroom, and a derivative hybridised form, referred to here as 'Flipped PBL'. Moreover, after a decade of constructivist approaches, educational research was initiated to better understand some of the effects of these changes and to explore the reasons behind the successful implementation of the models. Whilst still in its infancy, the nature of this research and some of the preliminary findings are presented here.

[124 words]

Keywords: Problem-based learning; Project-based learning; Flipped classroom, Flipped PBL, Constructivist, Student-centred learning.

Introduction

Over the last decade, Parramatta Marist High School, a Catholic non-selective boys' secondary school in Western Sydney, Australia, has undergone substantial pedagogical change. In 2008, *project*-based learning was adopted in the middle school curriculum (Year 9 and then Year 10). Subsequently, a *problem*-based learning approach, derived from the "One Day, One Problem" model pioneered at Republic Polytechnic (RP), Singapore, was adopted as these students moved into their penultimate year of schooling, Year 11 (Alwis & O'Grady 2002). In 2013, a 'Flipped Classroom' approach was introduced for final year students. In 2016, the "One Day, One Problem" approach was refined into a Flipped PBL model. The intention in undertaking this fundamental shift towards constructivist pedagogies was to increase student engagement and to explicitly teach, model and assess important 'soft' or *21st Century* skills needed beyond school whilst maintaining academic rigour. In that time, the school's performance in state-wide standardised exit exams has grown considerably, peaking at 43rd in the state in 2014 and, in 2015, with every subject being above state average and reaching 6th in the state in Mathematics. After almost a decade, it was deemed an opportune time to undertake educational research to better understand what effects of this change, if any, can be related and also offer means for improvement of the models deployed within the school.

Consequently, in 2015, four members of the school staff, Adam Hendry, Gavin Hays, Kurt Challinor and Dan Lynch, commenced doctoral studies under Professor Henk G. Schmidt of Erasmus University, co-supervised by Assistant Professor Dr Jerome I. Rotgans, Lee Kong Chian School of Medicine at Nanyang Technological University, Singapore, in an attempt to better understand some of the multifarious effects of school-wide pedagogical change following the introduction,

implementation, evolution and hybridisation of constructivist instructional models deployed within the school. Furthermore, a research partnership was formed with an experienced researcher in Cognitive Load Theory and group dynamics, Dr Jose Hanham from Western Sydney University, to pursue other related research areas within the school.

Intentions and Challenges in Implementing Constructivist Instructional Models at Parramatta Marist

A continual and overarching intention of all the constructivist instructional models currently employed at Parramatta Marist is to develop the whole learner for both now and the future within what is the most technologically rich age in human history. Hence, the learning attempts to emulate the environment encountered by professionals in their discipline with the intention of increasing engagement and improving the practical and/or applied skills of students. Theoretically, by making the classroom more reminiscent of the 'real-world', students are encouraged to undertake projects and solve problems *like* a professional in a particular discipline. Critical to this process is the activation of prior knowledge and engaging with new knowledge; both of which are fundamental in order to solve problems that are 'new' to the learner as is the role of the teacher as a 'facilitator' and one who can stimulate the process of inquiry leading to new knowledge. Additionally, these models afford students an opportunity for greater self-direction within a 'safe' learning environment which is heavily scaffolded, commensurate with the age of participants, and therefore *not* minimally guided.

If we set aside the frequent debates surrounding the differences between project- and problem-based learning approaches to learning (Savery 2006) and their suitability to differing disciplines (Perrenet, Bouhuijs, and Smits, 2000), we can see

both PBL approaches afford students the opportunity to collaborate with peers, develop interpersonal, communication, reporting, presentation as well as problem-solving and critical thinking skills (Schmidt, Van Der Molen, Te Winkel and Wijnen 2009). Similarly, the flipped classroom places the student at the centre of the learning process and draws upon those elements discussed above that are relevant to that approach. All of the constructivist instructional models employed at Parramatta Marist since 2008 have emphasised the primacy of knowledge acquisition and its application with potentially beneficial by-products variously described as "soft", "21st Century" or "enterprise skills".

These reasons for the introduction of each of these models, their associated challenges, consequences and development are discussed below.

Project-Based Learning (2008 – present)

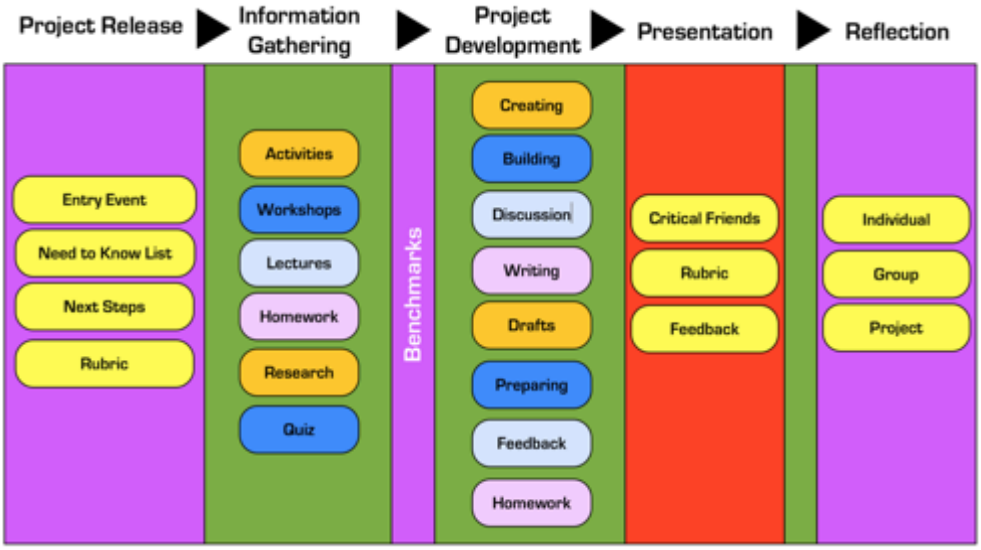
The initial reasoning behind the implementation of project-based learning was twofold. Firstly, the millennial era debate surrounding the relevancy of traditional approaches to teaching and learning in the age of the Internet and the exponential growth of technology was building momentum within the national educational context resulting, ultimately, in the launch of the Australian Government's Digital Education Revolution (DER) in 2007. The DER was aimed at increasing the use of ICT within Australian classrooms and provided laptops to all students in Years 9 to 12 as well as for the resourcing and support for teachers in implementing their use. Secondly, and closer to home, there was a noticeable lack of engagement amongst students in the middle high school years (years 9 and 10; ages 14-16) according to school staff. The impression that these students were the most disengaged within the school was subsequently borne out by Jenkins (2012) whose survey of over 2000 teachers in the United States found this grade/age group the most disengaged overall.

It was within this educational milieu that a study tour, led by members of the school executive, to the Napa New Tech High School in early 2007 resulted in the decision to implement project-based learning (PBL) in Year 9 for the 2008 academic year (starting in January in Australia). This visit to Napa also led to the establishment of links (and later the formalised partnership) with the New Tech Network; a not-for-profit foundation that provides training and ongoing support for over 200 PBL schools in the United States and Australia. Resources, in the form of planning time and professional development, were allocated to a group of around ten teachers or "early adopters" to ensure that the implementation was successful. The group attended PBL training in the United States to gain a deeper understanding of effective PBL practices. Project-based learning at Parramatta Marist was initially deployed across the middle school curriculum in every Key Learning Area (KLA) with the exception of some electives and accelerated courses (e.g. Mathematics), but was later rolled back into Years 7 and 8 in 2013 when teaching capacity could fully support this move.

Complementary subjects were and remain integrated and multi-disciplinary projects are created when syllabus outcomes or aims align. This integration of subjects (for example, History and English) resulted in the identification of the need to develop team teaching practices with colleagues from different disciplines and also led to a rethink of the available learning spaces. Consequently, to prepare for the change to PBL, 6 individual classrooms were combined to form 3 double-sized classrooms to accommodate one teacher and one class from each integrated discipline. The model follows the process shown in the infographic displayed in Figure 1.

Figure 1

Project-Based Learning as implemented in Years 7 – 10 at Parramatta Marist High (source: Gavin Hays)



A project is released to the students through an 'entry event', which provides an authentic trigger detailing what students must create at the culmination of the project. Students then have an opportunity to identify what they know and do not know in order to commence the project. As a living document, this 'Need to Know' list is amended and developed throughout the project and should provide students with direct links to the targeted curriculum. These documents along with the assessment rubric help to guide the process of inquiry. Furthermore, students are assessed throughout the project in myriad ways including individually and/or as a group, formatively and summatively, informally and formally, and are also afforded opportunities to assess their peers specifically in collaboration. A multiplicity of scaffolding and resources are offered to the students to both differentiate and enhance the learning, however, the most important resource in the room remains the teacher albeit now as a "facilitator". Projects typically last between 5-10 weeks with students working in mixed ability groups to achieve a range of formative benchmarks that

assist the construction of their summative end product. In the initial phase, the learning management system (LMS) utilised was Moodle, however, as the connection with the New Tech Network grew and was formalised, their purpose-built (for PBL) learning management system, known as 'Echo', was adopted.

Some of the initial reactions to the introduction of PBL from the school community were centred on the impact of an instructional approach that also focused on the teaching, modelling and assessing of skills as well as the content. However, once the assessment strategies were articulated and aligned to the projects in a way that was clearer to all stakeholders, there was little resistance which, in itself, was surprising given the school was not failing, however, it was not necessarily outperforming other similar schools.

Project Example – "In the Shadows of the Shoah"

An exemplary project undertaken centres on an integrated study of the Second World War, the Holocaust, and John Boyne's historical novel, *The Boy in the Striped Pyjamas*. This 10-week project is targeted at year 9 students (14-15 year olds) and integrates content and skills from the domains of English and History. The authentic trigger or driving question underpinning the project is *"How can we, as museum curators, design and construct an interactive exhibition that presents a narrative of the experiences of those who endured the Shoah, so that visitors understand its impact?"*

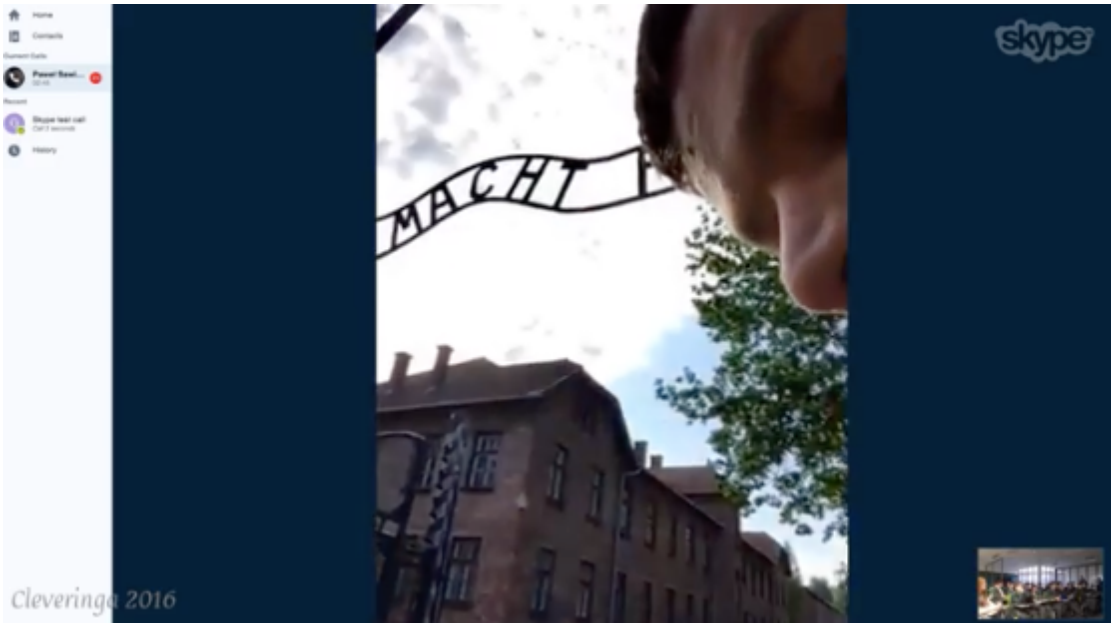
From the outset, this project was designed to enhance students' ability to apply their understanding of literary terms and techniques to their own writing through engaging with the novel whilst simultaneously pursuing historical study of

the Holocaust and war years in order to understand the context and setting more deeply.

The project also provided an opportunity for students to gain formative feedback from teachers as they prepared their summative end product - a museum exhibit. Firstly, students constructed a historical narrative about an imagined personal experience throughout (and beyond) the Second World War that demonstrated a strong understanding of the context of the characters within the novel through the inclusion of primary and secondary historical sources. Many of the stories developed by students were based on the real experiences from survivors who had migrated to Australia; contact with whom (and other survivor stories) had been learnt or facilitated through the Sydney Jewish Museum.

Figure 2

Skype interview with Pawel Sawicki (source: Maddie Cleveringa)



Secondly, students participated in a Skype discussion with Pawel Sawicki from the Auschwitz Concentration Camp Memorial in Poland (shown in Figure 2). Students were given the opportunity to interview Pawel to gain insights into the Holocaust and a deeper understanding of the realities of war as he took them on a virtual tour of the infamous concentration camp. Furthermore, students undertook a comparative study of the novel and film version as well as investigating related texts such as Anne Frank's Diary and *Rose Blanche* by Ian McEwan and Roberto Innocenti. As a consequence of these experiences, students were better able to empathise with Holocaust victims and convey emotion through more vivid imagery and descriptive language in their narratives and, subsequently, their museum exhibits.

Figure 3

Use of different methods to construct the museum artefacts (source: Kurt Challinor)

Finally, the summative task challenged students to combine their individual formative task into one continuous narrative that explored more thoroughly the life of Jewish victims, Prisoners of War and German soldiers and prison guards. Each group planned, researched and designed a realistic museum narrative trail exhibiting a variety of artefacts created with software such as Adobe Photoshop and Aurasma (augmented reality app). Furthermore, students had access 3D printers and laser cutters in the school's fabrication laboratory (FabLab) to help create physical artefacts leading to the curating of some outstanding museum exhibits as shown in Figure 3. Overall, this project provided students with an opportunity to explore and display deeper inter-disciplinary content knowledge (as shown in Figure 4) whilst the authentic links to real world learning afforded them the opportunity to enhance their skills in collaboration, communication and critical thinking.

Figure 4

Overall snapshot of an exhibit (source: Kurt Challinor)

Problem Based Learning (2010-2015)

As the initial group of PBL-trained students entered Year 10 and moved towards their penultimate year of schooling, they began to raise questions regarding what the teaching and learning would resemble for them in Year 11. A reference group composed of students, teachers and members of the school executive was convened. There was a feeling that the preliminary courses for the New South Wales (NSW) Higher School Certificate (HSC) would not lend themselves easily to project-based learning due to the state-sponsored syllabi being very content heavy and too restrictive. In 2009, another overseas study trip offered one possible solution. Members of the reference group, including one of the authors, encountered the "One Day, One Problem" model pioneered at Republic Polytechnic, Singapore (see Rotgans, O'Grady and Alwis 2011). The structuring of this model was appealing as it could offer a more focused look at aspects of the curriculum whilst continuing to build on those soft skills developed by students in Years 7 to 10. Consequently, the "One Day, One Problem" model was adopted across almost all courses (except some

Vocational Educational Training courses), however, to meet the indicative course hours required by the New South Wales Board of Studies, Teaching and Educational Standards (BOSTES), the Republic Polytechnic approach was adapted into what became known as the '1-5-1' PBL model. This designation was descriptive of the break up of hours within a learning module over a fortnightly timetable cycle. In general, each course had 13 fortnightly learning modules into which the traditionally–structured course curriculum was repackaged into open-ended and ill-structured problems (although this was dependent on the syllabus requirements of each course). Student learning in the 1-5-1 PBL model was initially supported through a Moodle-based LMS (with students using school owned laptops) tailored to the needs of the model, however, this was subsequently changed to Apple iTunesU when iPads were subsequently adopted. The structure and associated teaching and learning activities that were typically undertaken within that model are shown in Table 1.

To ensure the crafting of quality problems, the effective facilitation of modules and curriculum (re-)design, teaching staff participated in intensive professional learning programs delivered by members from Republic Polytechnic's Centre for Educational Development - something, ordinarily, offered to Polytechnic academic staff as part of their training. School staff have regularly attended this intensive training, based in Singapore, since 2009.

Table 1

The '1-5-1' Problem Based Learning Model structure (2010 – 2015)

Contact hours	Teaching and Learning activities
1 Hour (First contact)	Pre-Quiz Brainstorm that activates prior knowledge Direct instruction to introduce concepts or ideas Scaffolded activities Utilise a text (often created online or in iBook by staff)
5 hours (Full-day)	Check homework set Problem statement release Know/Need to Know list Group work on problem Facilitation of problem Scaffolded activities (optional) Worksheets (paper or online) Group Presentations Facilitator presentation of one potential solution Reflection journal Evaluation
1 hour (Follow-up lesson)	Post module quiz Class discussion on syllabus points and link to problem Direct instruction Assessment (e.g. exam style question)

The 1-5-1 structure initially met the needs of the students by continuing to expose them to (and report on) critical skills like problem solving, teamwork, presentation and communication whilst engaging with more sophisticated content. This model was in place between 2010 and 2015 until the introduction of the flipped classroom approach (described below) provided some insights as to how to better address those unforeseen consequences of the introduction of this model (also described below).

The Flipped Classroom (2013 – present)

In late 2012, a 'flipped classroom' approach was introduced for final high year high school students (year 12) completing their New South Wales (NSW) Higher School Certificate (HSC) in late 2013. This is the standardised exit exam that universities use to determine entries into their courses. Whilst there is no one, single, generally accepted definition for the flipped classroom, the approach can still be broadly described as the shifting of the acquisition of new content and concepts from the classroom to the home (or at least some time *prior* to the class, often in the form of a video), with class time being used to engage in more student-centred and active learning and the clarification and application of knowledge. All subjects studied for the HSC by students utilise the flipped classroom approach to deliver content. The students have course material delivered by a learning management system (Apple's iTunesU) through their own devices (iPads). This approach was adopted as it has the potential to offer a number of benefits. The transferring of some content delivery beyond the classroom as homework, particularly through the use of technology, frees class time for instructors to engage students in active learning experiences that have the potential to increase engagement and differentiation whilst providing an environment where student self-efficacy can develop and where students can become more self-directed learners. Additionally, the move to flipped classroom also offered a solution to better deliver competency based vocational educational training courses that were, due to the nature of their content and assessment, difficult to problematize.

A hybridised model - 'Flipped' PBL (2016)

The 1-5-1 PBL model was successfully utilised between 2010 and 2015 but two major issues arose as a consequence of its implementation, specifically a) the model reduced the flexibility of the timetable and consequent staffing, and b) it

became evident that students required more time to process information and apply their understanding (and devise solutions) in subjects with very content-rich syllabi. Two further developments within the school, however, occasioned an opportunity for the evolution of the model to address its perceived deficiencies and effects. Firstly, the very successful introduction of the 'Flipped Classroom' approach in 2013 for HSC students opened greater opportunities to deliver content *before* the class and spend contact hours *clarifying* and *applying* what has been learnt.

Figure 5

Flipped PBL in Year 11 as of 2016 (source: Kurt Challinor)

Note: The colour coding in Figure 5 denotes the sequence and timing of sessions in one module within a fortnightly timetable cycle. Therefore, following the flipped content pre-learning session timings are 100 minutes (blue); 200 minutes (green); 100 minutes (yellow) and 50 (red) minutes across four different days.

The evolution of the 1-5-1 model was also facilitated by a second development, the instigation of a Bring Your Own Device (BYOD) program across the school. This now meant content could be delivered to personal devices prior to the

commencement of the first class in a (new) fortnightly Year 11 ‘Flipped PBL’ module; ultimately, giving students the opportunity to watch an introductory video or other stimulus material and engage with the content *prior* to meeting with their facilitating teacher. This also now meant that both approaches to learning in the senior school could also be accommodated by Apple’s iTunesU LMS on student-owned iPads.

Moreover, rather than grappling with a problem and presenting a solution in one day, students are now required to present during a subsequent period and are thus afforded an interim period of self-study and collaboration (both online and in their own time at school) with group members. The structuring of this ‘Flipped PBL’ model, a term gaining some currency and similar approaches being adopted in other academic settings (Tawfik & Lilly, 2015), is shown in Figure 5. Thus, problem based learning at Parramatta Marist has evolved over the last seven years in response to the needs of students, staff and the school environment as well as to developments within and without the school to ensure it remains a dynamic and innovative pedagogy.

Problem Example – “UBER”

The following problem is indicative of how the state-sponsored curricula are problematised to engage the learners whilst still placing an emphasis on soft skills acquisition and assessment. In this instance, the taxi ride sharing service UBER offers students a contemporary business case study to explore the idea of *internal and external influences* on businesses within a particular environment. This problem was used in the second fortnightly module in the Year 11 Preliminary HSC Business Studies course. In the hybridised model introduced in 2016 (outlined above), students engage, initially, with flipped content prior to the first lesson in the cycle (in this case, a video on the potential impacts on a business of internal and external influences in

the business environment) and respond to questions that are submitted online to the teacher. Further exploration of the targeted content is explored in the "Flip: Clarify and Apply" stage where the teacher addresses gaps in the student knowledge. Students are also asked to apply what they know (for example, by engaging with other case studies that are generally dissimilar to UBER) and respond to stimulus material and participate in scaffolded activities using contemporary and relevant examples to ascertain the level of their understanding with the ultimate aim of ensuring that students have a good grounding in the content prior to the release of the problem in the subsequent lesson.

At the commencement of the "Problem: Understand and Solve" stage in the cycle, the UBER case study is released with the following problem statement: *Which one internal and one external influence will have the most impact on UBER's success in the Australian market?* At this point, students have an opportunity to identify what they know and do not know about the problem in a way that they have become familiar in Years 7 to 10.

Figure 6

Student group solution to UBER problem (source: Adam Hendry)

This "Need to Know List" helps direct each group through a range of resources, scaffolded activities and workshops (both teacher and student led) during this stage. This is followed by a period of self-study (and online collaboration) between group members to ensure they are ready to present their solution during the next stage of "Defend: Present and Exemplar". Student group presentations are normally expected to last 10 minutes with a question and answer session immediately following the presentation. An example of the visual aids used to support a student solution to the UBER problem statement is provided in Figures 6 and 7.

Figure 7

Student group solution to UBER problem (source: Adam Hendry)

Student solutions are marked using a standardised rubric that is structured in the following way: 12 marks for application of content in the problem solution; 3 marks for presentation; 3 marks for another nominated soft skill which is most suitable to that particular problem (e.g. numeracy); and 2 nominal marks awarded for the completion of two evaluations (one on the module, one on its facilitation). Following the completion and marking of group presentations, the teacher/facilitator presents an 'exemplar' that offers one possible (and informed) solution to the problem statement. The final phase of the cycle requires students to apply their knowledge under conditions reminiscent of more formalized testing in that discipline. In this particular problem, students are asked to prepare a business report addressing the following question: *"Using your own knowledge and relevant business case studies, discuss why it is critical for owners to be aware of the impact of internal and external influences*

on their business." Naturally, some course syllabi lend themselves more easily to being problematised. In this instance, the dynamism of the world's business environment ensures problems can remain evergreen with the updating of a relevant and contemporaneous case study.

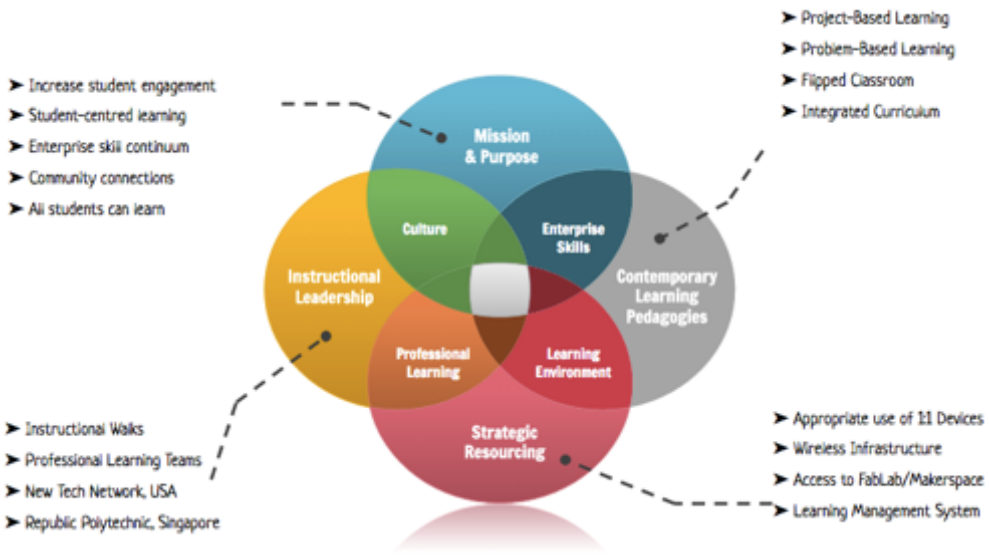
Reflections on Effecting School-wide Pedagogical Change

Over the last decade, a number of phenomena have been observed regarding the implementation and sustaining of the changes described above. Initially, the scope of our transformational agenda was limited to project-based learning in the context of engaging year 9 students in their learning. However, upon reflection, a number of aspects critical to its success have been identified to develop a coherent transformational framework, as shown in Figure 8. This transformational framework highlights the key organisational structures as they have developed over the last decade that include the identification and communication of the school's mission and purpose, developing instructional leadership practices, strategic resourcing, and the evolution of our contemporary learning pedagogies. Additionally, integrated are the cultural elements that have been essential in maintaining and sustaining overall academic growth.

Figure 8

Transformational framework in effecting whole school change

(source: Gavin Hays)



In effecting school-wide change the building of a learning culture or 'community' where student-centred educational practices within the school are clearly evident was an imperative. Specifically, the language used by both teachers and students is consistently aligned to the mission of the school and the various contemporary learning pedagogies. There is distinct focus on their use of this language, engagement and participation within the learning process. Moreover, an observable improvement in student enterprise skills, specifically in communication and presentation skills as well as increased collaboration (particularly online) with peers and teachers, has become the norm for students. Another clear outcome has been the growth in peer-coaching and ability of students to learn at their own pace with the help of teachers.

Another key learning has been the idea to effect meaningful change it must

occur on a large scale (i.e. not just in one classroom) as these approaches are constrained by the physical, environmental and educational structures. Strategic resourcing involved creating enabling opportunities to support and sustain the changes through the implementation of an extensive professional development programs for staff, which, in itself, can only be offered to an entire teaching staff. This has meant the introduction of timetabled professional learning periods for staff (often in interdisciplinary professional learning teams). As of 2017, this professional learning amounts to 320 minutes a fortnight. This has afforded all staff the opportunity to continue their professional growth and time to embrace the pedagogical changes taking place in the school. Moreover, both structural and procedural changes were made within the school to accommodate these pedagogical approaches (e.g. timetable changed to three 100 minute lessons a day) and the school established local, national and international connections in the pursuit of world's best practice. Furthermore, the creation of a flexible learning environment was required to support the culture created through providing organic opportunities for students to collaborate with peers and share ideas. Over the past decade, these approaches to learning and the philosophy that underpins them have become the 'norm' within the school environment.

There have been, and there remains, however, many challenges to the ongoing effective implementation of these approaches. Firstly, in the development of projects and problems to drive the learning, the first obstacle are mandatory, content-rich syllabi that by their very design suppose knowledge is *delivered to* and not *acquired by* students. One way this challenge has been addressed is through the integration of complementary subjects and the development of cross-curricular projects that have helped minimise duplicate or redundant content. Secondly, ensuring teacher training

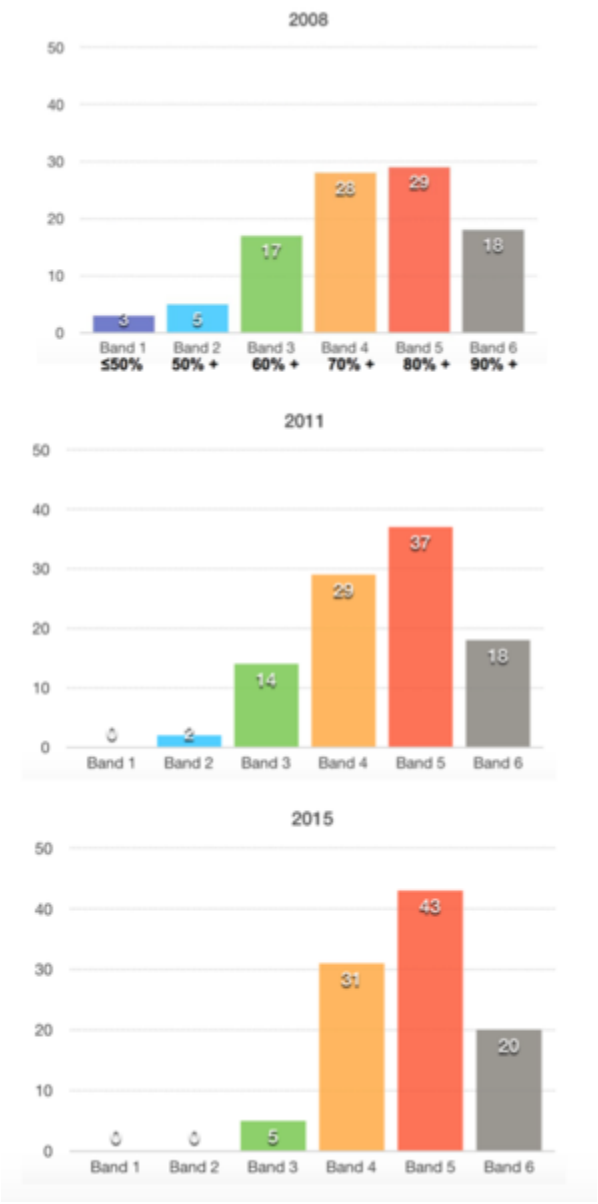
is effective, relevant and meaningful is also a challenge and hence, over the last 10 years, it has become necessary to provide differentiated professional development to staff, especially in areas of assessment reform, personalised learning and enhancing the quality of teaching practices. This ongoing, timetabled, comprehensive and cross-curricular professional development of staff has been crucial in the implementation of these pedagogies (it is true to say that the teacher remains the most important factor in improving educational outcomes for students!).

Possible Effects of School-wide Pedagogical Change

There appear to have been multifarious effects of school-wide pedagogical change over the last decade. Most interestingly, since the commencement of schoowide pedagogical change in 2008, there has been an upward trend in student performance in the HSC results – an external, statewide, standardised exit exam. The data shown in Figure 9 is representative of the demonstrable shift in student achievement towards higher performance 'bands' since the approaches to learning were implemented. That is, more students are achieving a Band 4 (70%+), Band 5 (80%+) and Band 6 (90%+) in all exams sat at the HSC year upon year. In particular, since 2008, there has been significant growth amongst students at the lower end with Band 1 (≤50%), Band 2 (50%+) and Band 3 (60%+) exam results all but eliminated at the HSC level. To give some context, the number of students sitting the HSC every year since 2007 has been 155 (on average) sitting an average of 5.5 exams each; this equates to around 850 exams sat for each cohort every year. Moreover, in 2014, the school was ranked 42nd in the state in the HSC (percentage of Band 6s achieved versus number of exams sat) and, in 2015, the school was ranked 6th in mathematics in the state; in 2016, it was ranked 4th.

Figure 9

HSC results in all exams per band (%) in 2008, 2011 & 2015



In the 2015 and 2016 HSC, 95% students achieved a band 4, 5 or 6 (70-100%) in all subjects at the HSC exams. Other state-wide statistical analyses that compare similar schools at HSC level (De Courcy Analyses 2011-2015) against previous performance in standardised state and/or national testing have also revealed that students at

Parramatta Marist have consistently achieved at or above expectation across *all courses* with 75% of subjects undertaken by students identified as having provided them with a learning gain above that which was expected. For a comprehensive all boys' school with a slightly above average socio-economic status (SES) rating from the Australian Curriculum, Assessment and Reporting Authority (a measure which was specifically designed to enable meaningful comparisons within the National Assessment Program) these results appear significant, however, the authors realise that identifying the contribution that each of the changes within the school have made (if any) to these results is, at present, quite difficult.

Additionally, to what extent, has a sense of *collective efficacy* – the idea that academic performance by similar students in the same school environment has led to a transfer of confidence beliefs from one year to the next – played a role in the growing performance of successive year 12 cohorts also remains unclear. Moreover, feedback from a recent survey of alumni from graduating cohorts educated in the PBL method, indicate that learning in a style that is becoming more prevalent in tertiary sector has improved their transition and subsequent achievement in courses undertaken – particularly in areas where PBL is practised like medicine, allied health and engineering. Another key takeaway is the notion that innovation and the implementation of constructivist approaches to learning are no barrier to success in traditional standardised exit exams as evidenced by the school's results.

Research Questions and Initiatives

Growing interest from both within and without the school to better understand the consequences of the changes and to pinpoint and better understand the cause of some of these effects, both real and perceived (anecdotal and/or observable), led to some preliminary action research by staff. It soon became apparent, however, that it

was not possible to clearly identify any singular reason for the effectiveness of implementation or the academic success described above without undertaking significant educational research. Conversely, it was recognised too that the combination of those factors discussed above (e.g. teacher training, collective efficacy, changes to the learning environment etc.) were, in their totality, responsible for the successful implementation and improving the educational outcomes for students and that even concerted efforts at educational research may only ever unpick part of this patchwork. It was also conceded there might be no apparent correlation between certain changes and their supposed effects. Regardless, in 2015, it was decided to initiate this research. Another initial hope, apart from revealing greater insights and some demonstrable links to specific factors, was that institutional research could also offer some means for improvement within the models.

It was on this basis that some research questions were framed and began to be explored in depth in 2016. Some of the possible research questions that arose included: how do students build confidence within a PBL setting? Can these feelings of efficaciousness be stimulated within the learning environmentally? Is there a way of measuring the effectiveness of the flipped classroom? How has technology enhanced the learning and can this be better harnessed to provide more timely diagnostic assessment? What motivates students to achieve and does the nature of learning play a role? How does motivation influence choice, persistence and performance within this PBL environment? Is there a more scientific basis on which we can select groups? In addition, what role has the increased professional learning of staff and the standardisation of learning and assessment practices played in improving academic results? Also, how can student skill development be adequately assessed?

Accordingly, the authors of this paper formulated specific research questions to form the basis of the micro-analytical research approaches they have initiated at Parramatta Marist. The focus of the research is in the areas of a) the situational development and measurement of self-efficacy in a PBL environment b) the development and validation of a new assessment tool - the Cognitive Recall Test (CRT) c) the development and validation of a reliable instrument to measure for the effectiveness of the Flipped Classroom approach, and d) achievement motivation within a PBL environment. Additionally, in partnership with a local university, research into efficacy beliefs is presently underway. This research is attempting, as a starting point, to better understand some critical aspects of school-wide pedagogical change. The intentions and nature of the research as well as any preliminary findings are discussed below.

Situational Development and Measurement of Self-efficacy in a PBL Environment

According to Bandura (1986, p. 391), self-efficacy can be defined as *"an individual's assessment of their capabilities to organise and execute courses of action needed to perform certain tasks and is concerned not with the skills one has but with judgments of what one can do with whatever skills one possesses."* Bandura and most other self-efficacy researchers have also recognised that this construct is sensitive to environmental phenomena and are situationally dependent. However, many studies, have not operationalised self-efficacy measures in a way to reflect this situationality. Consequently, self-efficacy may have been measured more like a trait than a construct with more state-like qualities. Hence, for this initial study, the aim was to better understand how *situational* is situational self-efficacy? Thus, survey data for general self-efficacy (GSE) was collected at four points during a five-week science project

(including the pre- and post-test administered two weeks prior and after), whilst a measure of situational self-efficacy (SSE) was collected before and after critical learning events at fourteen points in time within the five-week project itself. Both surveys were based on the Motivated Strategies for Learning Questionnaire (MSLQ) with slight variation in wording to distinguish between more general feelings of efficaciousness (‘course’) with those that are situational (‘lesson’). Participants were 186 early high school science students enrolled in a five-week project at Parramatta Marist. Surveys (Qualtrics) were completed online using personal devices. Data was analysed using Statistical Package for Social Sciences (SPSS), version 23, and structural equation modelling undertaken on select general and situational measures using SPSS Analysis of Moment Structures (AMOS) package (Version 5, Arbuckle, 2003). Furthermore, the results of confirmatory factor analyses were subject to multi-group invariance testing. Preliminary findings from one factor and two factor models comparing select pairs of general and situational self-efficacy measures indicate that they are indeed measuring two separate but related phenomena. This finding, albeit preliminary, may ultimately lead to a change in how this construct needs to be measured and a greater understanding of how students build confidence (particularly in relation to interest that is situationally generated) in a PBL environment.

The Development and Validation of a New Assessment Tool - the Cognitive Recall Test (CRT)

The idea of developing a reliable, valid and diagnostic assessment tool that can be administered quickly to measure conceptual knowledge (with the possibility of being automated in the future) was greatly appealing to the school-based research team working within a PBL environment where assessment still relied too heavily on conventional assessment formats with all their inherent problems, for example

multiple choice questions (see Glass & Sinha 2013); and, despite the focus moving from summative to formative assessment (Bell & Cowie, 2001; Yorke, 2003). Hence, the aim of this research was to explore *how can a more timely and diagnostic formative assessment to test student knowledge be developed and tested? And how can technology assist this process?* The Concept Recall Test (CRT) offered a potential solution. A CRT requires test takers to freely recall concepts they feel are relevant to a give topic with raters awarding one point for each correctly recalled concept when matched against a target list. The CRT works on the basis of the spreading activation of knowledge within a learner's semantic networks and on recall and not recognition. Administration of the CRT involves a standardized instruction: "*Please write down all the concepts or ideas you have about the following topic: ... Do not write full sentences; only keywords or bullet points will do*". After administration of the test, the concepts are scored manually using a targeted 'concept list'. One mark is assigned for each correct concept with raters only having to look out for correct concepts (not sentences such as in open-ended test questions).

In all studies conducted to date, the inter-rater reliability has been established across all three commonly used measures to determine agreement between raters: (a) percentage agreement, (b) Intra-class Correlation Coefficient (ICC), and (c) Cohen's Kappa. Moreover, across four studies in schools both in Singapore and Australia, the results indicate that the Concept Recall Test is a reliable and valid instrument to measure conceptual knowledge (with both convergent and construct validity being established). The further development of this assessment tool has significant potential in a PBL environment where a reliable measure of student knowledge at a particular moment in time is quite desirous. Additionally, the possible automation of this test in future may streamline this process thereby increasing its utility.

Developing and Validating a Reliable Instrument to Measure the Flipped Classroom

The 'flipped classroom' is a relatively recent constructivist-based approach to teaching and learning whose invention has been attributed to various sources (Mazur 1991; November & Mull, 2012; Schultz, Duffield, Rasmuseen, & Wageman, 2014; Baker, 2000; Lage, Platt, & Treglia, 2000). In more recent years, the flipped classroom has been popularised through the work of Bergmann and Sams (2012). Presently, there is no valid or reliable measure to ascertain the impact of this approach to learning. Hence, is it possible to *establish a reliable instrument that measures the effectiveness of the flipped classroom approach to learning?* From the seminal literature available, nine distinct 'domains' were established that represented the perceived characteristics of the Flipped Classroom as presented in the literature and as observed by instructors, these included: *Homework, Technology and Collaboration, Use of Class Time, Teacher Role, Engagement, Self-efficacy, Interest, Self-Directedness, Learning Extent*. For each of these domains, a number of items were composed to determine student perceptions, resulting in a 48-item instrument based on a 5-point Likert style scale. The participants were 136 senior students in their final year of Parramatta Marist. The survey was completed online using personal devices. The data was analysed using Statistical Package for Social Sciences (SPSS), version 23, and structural equation modelling to understand the loading on each domain was undertaken using SPSS Analysis of Moment Structures (AMOS) package (Version 5, Arbuckle, 2003). To determine test-retest reliability, the instrument was administered to students half way through their final high school year twice, 17 days apart. Concurrent validity of the survey instrument was determined by comparing teacher observations with student judgements. Preliminary findings indicated that this

measure is a valid means by which to assess student perceptions of the flipped classroom – at least in this context – and students do rate highly most aspects of this approach. In pursuit of this aim, the validity of this flipped classroom measure is being tested currently being deployed in other schools that utilise the flipped classroom in their Year 12 classes. Of course, further investigation is required and future studies could include whether a well-implemented flipped classroom is more highly valued than traditional classrooms; and, do students learn more and is performance improving?

Achievement Motivation Within a PBL Environment

The aim of this study is to investigate the question *what is the relationship between achievement motivation, task design and student academic achievement in a PBL environment?* One of the implicit assumptions of motivation research is that there is a direct relationship between *motivation* and *achievement* (Pintrich & De Groot, 1990; Pintrich, Smith, Garcia, & McKeachie, 1993; Wolters & Pintrich, 1998; Zimmerman, 2008). Both motivation and learning strategies have been weakly related to students' academic achievements. Overall, the research findings suggest that the relationships between motivation and learning strategies on the one hand, and achievement on the other, are less straightforward and more complex than anticipated. For this study, a general and situational measure of the development of achievement motivation has been constructed based on the MSLQ (with slight variation in wording similar to that used in the self-efficacy study above). This survey was administered to 185 Year 9 students in mid 2016. The data is, at present, being processed and no preliminary findings are available.

Western Sydney University study into 'Self, Proxy, Collective Efficacy in a PBL Setting'

Another current research initiative underway, with Dr Jose Hanham from Western Sydney University, is looking into the development of efficacy amongst PBL students. The aim of this study was to address the question *of how do students develop confidence beliefs in their own abilities (self-efficacy), in their peers and team members (proxy efficacy) and in the performance in their group (collective efficacy) in a PBL setting?* In this study, students were given specified roles in the same group (divided in acquaintance and friendship groups) in three different projects in three different Key Learning Areas (Geography, English, Religious Studies) and asked to rate how confident they were in themselves, their peers and the group to perform in their allocated role. Students were surveyed three times at the beginning; midpoint and end of three 5-week stand alone (not integrated) projects in the three knowledge domains outlined above. Performance data for individual students and groups was also collected throughout the project in each knowledge domain. The data for this study too has been collected and is also currently being processed. It is hoped that this study too might shed light on the development of critical beliefs of students, peer interaction, group dynamics and the relationship between confidence building and the predicting of performance within a PBL environment.

Conclusion and Recommendations

Whilst still in their infancy (and requiring a reasonably narrow focus) the current research initiatives have the potential to lead to further incremental improvements within the school based on solid evidence rather than intuition and observation alone – the main guiding principles behind change to this point in time. Moreover, the research may offer a meaningful contribution to the wider extant

literature in educational psychology and constructivist approaches to learning. This is particularly evident when considering the preliminary findings on the situational development of self-efficacy and the need for it to be measured in a way that befits the constructs supposedly dynamic and environmentally sensitive nature particularly in a PBL environment. Likewise, the validation of the Concept Recall Test and (it is hoped) the flipped classroom measure may increase the utility and understanding of both assessment and this newer approach to learning in a technologically rich age.

Additionally, by offering even this limited snapshot, it is hoped that readers gain an appreciation for the multiplicity of approaches to PBL worldwide and the growing international connections forged between educators, researchers and PBL institutions and the notion that innovative and constructivist approaches to learning which are carefully and thoughtfully implemented are no barrier to success (including traditional standardised exit exams); and, furthermore, that problem- and project-based learning and other constructive approaches to learning should be considered as *special ways of acquiring knowledge* with much greater opportunity for students to develop certain soft skills as by-products.

It has also become evident that it is necessary to pursue more institutional research to help refine the teaching and learning goals and processes where possible and also to understand the effect of this approach to learning on alumni. For example, discussion of a possible longitudinal study of PBL-trained alumni (graduating from 2011 onwards) has been raised and is of significant interest to a number of stakeholders.

Limitations

In offering this overview of the introduction, implementation, evolution, hybridisation and preliminary research into the constructivist instructional models

deployed within a secondary (high) school in Australia, the authors realise that there are many aspects which cannot be fully articulated or explored here. Furthermore, there are a number of limitations to what the research can reveal on a wider scale both within and beyond this school context.

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Chapter 3

*Fostering Self-efficacy: The Role of Instruction**

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Abstract

The purpose of this study was to examine to what extent self-efficacy is impacted by instruction. The study was conducted over a five-week science project in an Australian secondary school project-based learning environment with 177 male Year-8 high school students. A microanalytical measurement approach was used to collect self-efficacy judgements, and a latent-growth curve (LGC) analysis combined with time series analysis was conducted to investigate the extent to which self-efficacy grew as a result of the exposure to the five-week science course. Findings suggest that the significant growth of self-efficacy over the five-weeks can be ascribed to the instructional intervention and not to other factors. The implications and limitations of this study are discussed.

[114 words]

Keywords: Self-efficacy; Instruction; Latent Growth Curve Analysis; Microanalytical Measurement Approach

Introduction

The Purpose of the Present Study

The purpose of this study is to explore the development of self-efficacy over time within an authentic learning environment and the role instruction plays in fostering its growth. In this study, the relationship between self-efficacy and instruction was observed in a secondary school project-based learning environment. The focus of this study, therefore, was to investigate (1) to what extent does self-efficacy change over the course of instruction? And (2), to what extent is instruction itself a causal agent in this change? To study these questions, we used two methodological innovations –microanalytical measurement supporting a latent-growth curve approach in addition to time series analysis – which enabled us to combine the study of growth over time with the study of causation. The study was conducted over a five-week science project (in a project-based learning environment) not including the pretest, immediate posttest and delayed posttest. We expected that a time-series design and a latent growth curve analysis might reveal elements of the nature and impact of the relationship between instruction and self-efficacy.

Self-efficacy Theory

Albert Bandura, the father of Social Cognitive Theory (of which self-efficacy forms part), described self-efficacy as an assessment of one's capabilities to undertake the necessary actions required to perform certain tasks (Bandura, 1986). Hence, self-efficacy *"is concerned not with the skills one has but with judgments of what one can do with whatever skills one possesses"* (Bandura, 1986, p. 391). Such beliefs are said to influence the courses of action one may pursue as well as the levels of effort they expend, the extent to which they persevere (particularly in the face of adversity) and their resilience. As for the sources of self-efficacy, Bandura (1977, 1986, 1997)

posited that there are four main sources that create, develop, enhance or diminish feelings of self-efficacy. These sources are (1) *performance accomplishments* or '*mastery' (enactive learning) experiences*: the belief in one's competence and ability based on the interpretation and evaluation of past performances; (2) *vicarious experience*: to gauge one's own ability by observing and relating it to the performances of others; (3) *verbal and social persuasion*: being encouraged or convinced by others regarding one's level of ability; and (4) *emotional and physiological states*: one's mood or state of mind (e.g., anxiety) can impact feelings of self-efficacy. Of these four sources, it has been shown that the most powerful is performance accomplishments or mastery experiences (Usher & Pajares, 2008; Phan & Ngu, 2016).

Researchers have also asserted that self-efficacy is dynamic and the resultant product of the interplay between (a) personal (b) behavioural, and (c) environmental factors with this concept being known as 'triadic reciprocal determinism' (Bandura, 1977, 1986, 1989, 1997, 2012; Duncan & McKeachie, 2005; Gist & Mitchell, 1992; Mathieu et al., 1993; Wolf, 1997; Zimmerman, 2000). In line with its purported dynamism, it has also been asserted that feelings of self-efficacy within individuals vary across knowledge domains and circumstances and do not present uniformly across tasks and contexts but are situationally dependent (Bandura, 2012). However, other researchers consider self-efficacy to possess a more generalised or dispositional quality (Sherer & Maddux, 1982; Scholz et al., 2002; Schwarzer & Jerusalem, 1995). Therefore, one's ability to execute certain actions in a variety of circumstances appears to be an accumulation of efficacious experiences which were, once, related to task performance, but now, perhaps due to reciprocal determinism, extrapolated across domains and developed into a more 'trait-like' confidence; it is suggested too

that the opposite is also true, that negative experiences lead to a lack of confidence, in general, across multiple domains.

For more than 40 years, however, it has been self-efficacy's predictive validity in relation to both *specific* tasks undertaken by participants in studies as well as overall performance in different subject domains that has been the focus. This, then, naturally helps explain the ongoing interest in academic self-efficacy by educational researchers. Bandura (2012) reasserts the importance of self-efficacy to academic performance by stating that it plays an influential role at the operative level because the *"malleability of ability is strikingly illustrated in research demonstrating that individuals of higher self-efficacy outperform their counterparts of lower perceived efficacy at each level of ability"* (p. 24). Simultaneously, it is also easy to see, given the importance of past performance in shaping efficacy beliefs, that the focus has been placed mostly on academic result(s) of learning and the predictive validity of self-efficacy. This idea is supported by Honicke and Broadbent (2016) in their meta-analysis of 59 self-efficacy studies published between 2003 and 2015 (those eligible under their terms of reference), who found much support for the importance of academic self-efficacy as a determinant of subsequent academic performance. They assert that *"academic self-efficacy has consistently been shown to positively correlate with academic performance, with meta-analytic studies reporting moderate effect sizes"* (Honicke & Broadbent, 2016, p. 64). The enduring importance of self-efficacy is also illustrated by the repeated exhortations in studies and articles prompting researchers to undertake further (and broader) studies into the construct and those factors that influence it including the learning environment. For example, Lorsbach and Jinks (1999) state their belief that focusing on students' academic self-efficacy could alter student perceptions of the learning environment on the premise (based on

the research to that point) that a greater understanding of the reciprocal relationship between the learning environment and the self-efficacy beliefs of students should become the focus for learning environment research.

Given the importance of self-efficacy to learning and academic performance, a significant question is: how does self-efficacy develop and is it impacted by instruction over time in an authentic learning environment? This study attempts to address these questions.

Influence of Instruction on the Development of Self-efficacy

Whilst there is significant research into the antecedents, development, interrelation and predictive power of self-efficacy in learning, there has not been as great a focus on the contribution of instruction to its development. In saying that, a relationship between the development of self-efficacy and learning has been considered self-evident from its inception with the construct being considered sensitive to instructional interventions (Zimmerman, 2000) and because changes in student self-efficacy (between measures) in a particular domain are assumed to be the result of the learning process. The sensitivity of self-efficacy to 'instructional interventions' in experimental studies was demonstrated not long after Bandura's conceptualisation of it as a phenomenon (for example, see Bandura & Schunk, 1981, and Schunk, 1982). Perhaps, as a consequence of the assumption, influenced by the results of early experimental studies, that self-efficacy *must* develop as a result of the ongoing instructional processes within a learning environment, the focus had moved towards more fertile ground surrounding the predictive validity of self-efficacy in relation to performance and achievement and its role as a mediating variable and not so much what impacts upon self-efficacy itself.

Thus, the focus of the initial research has been predominantly the *effects* of self-efficacy on learning and less so on the *mechanisms* of instruction that contribute to its development. However, over time, as researchers began to focus on the instructional and learning environments themselves, a number of studies particularly in the last 25 years have unearthed some pieces of this puzzle. The nature and findings of key studies that outline the current state of play in regards to instruction and self-efficacy are outlined below.

Moriarty et al. (1995) examined the importance of self-efficacy as a mediating variable between learning environments and achievement in a primary school (year 5) classroom (aged 9-10 years). In the study, 179 students were allocated randomly to a cooperative, competitive or individualistic learning environment with data collected at the mid- and endpoints. Students were involved in these assigned classes twice a week for the duration of the study, switching between the cooperative, competitive or individualistic learning environment at the halfway point of the 10-week study. The researchers found that the performance of particular tasks under competition was enhanced when students have previously worked in the cooperative learning, but they also believed this may be difficult to sustain as self-efficacy declined.

Dunlap (2005) investigated whether instruction, in this instance, problem-based learning, can have a positive impact on student self-efficacy. In this study, a non-experimental, single-group time-series research design was used with 31 undergraduate university computer science students undertaking a 16-week capstone course. The method involved the use of a pre- and posttest as well as guided reflective journals (5 in total) to describe student experiences (coded by the researchers). Dunlap found that the collaborative nature of the problem-based course provided students with explicit feedback, serving as a source of efficacy information that

enhanced their self-efficacy.

Another study, Mills (2009), explored the impact of a project-based learning environment on the self-efficacy of foreign language learners. Studying 46 university students undertaking a French beginners course with a pre-test and posttest (at the beginning and end of the semester), Mills found that the instruction methods provided students with an enhanced learning experience and increased their self-efficacy beliefs concerning the mastery of the French language over the semester. In a similar study, Meluso et al. (2012), investigated the concept of enhancing 5th graders' science content knowledge and self-efficacy through game-based learning. Studying 100 fifth-graders, engaged intermittently over a 4-day period in game-based learning, the researchers investigated the effects of collaborative and single game player conditions on science content learning and science self-efficacy. Whilst there were no differences between the two playing conditions, there was a significant increase in science content learning and self-efficacy when the single player and collaborative player conditions were collapsed, thereby highlighting how instruction (in this case, games based-learning) can enhance self-efficacy and knowledge acquisition.

Alt (2015) examined the contribution of a constructivist-learning environment to academic self-efficacy in higher education, in a study involving 167 second-year undergraduate social sciences students from two colleges in Israel. As was routine, all students were enrolled in two elective courses, one using a problem-based learning approach and the other, a lecture-based approach, with both running over a 14-week semester. After administering a single survey at the end of the semester, Alt found that students perceived the problem-based learning environment as more constructivist and possessed greater academic self-efficacy relative to the lecture-based environment.

A longitudinal study conducted by Holzberger et al. (2013) explored teachers' self-efficacy by studying the reciprocal effects of teachers' self-efficacy and instructional quality. The study design combined a self-report measure of teacher self-efficacy which included both teacher and student ratings of instructional quality. Data were collected from 155 German secondary mathematics teachers and 3,483 high school students at two measurement points one year apart. In this study, researchers found that teachers' self-efficacy were influential on, and a consequence of, the educational process.

Hushman and Marley (2015) examined how instructional guidance influenced student scientific literacy and science self-efficacy on 60 primary school students. The scientific topic under study was related to physics, more specifically, the concept of dependent, independent and control variables. During a summer camp at an American university, students were placed randomly in three groups–direct instruction, guided instruction or minimal instruction–and asked to design as many experiments as possible in a 15-minute period. Whilst Hushman and Marley (2015) found the students in the guided instruction group performed equally well in knowledge measures as the direct instruction group, the same group outperformed the other groups when designing experiments as well as showing the greatest positive change in their self-efficacy beliefs.

Along with the experimental studies outlined above, a number of evaluative and meta-analytic studies in that same period have provided summaries and assessments of the empirical evidence regarding the relationship between self-efficacy and instruction. For example, Pintrich and Schunk (1996) found that self-efficacy beliefs declined as students progress through school, with the greatest decline being experienced during the transition into secondary school. Both psychological and

sociological explanations have been formulated to explain this weakening of self-efficacy beliefs. However, according to Pintrich and Schunk (1996), the more sociological explanations tend to stress that the changes in the nature of the learning environment in secondary school are, broadly speaking, chiefly responsible for this decline. An ensuing examination of research into the development of academic self-efficacy by Schunk and Pajares (2002) reaffirmed this position and outlined the reasons for the 'role of schooling' in the decline of self-efficacy as being attributed to a number of factors including the increasing competitive nature of schooling as one progresses, norm-referenced testing as well as the transition from primary to secondary school including less teacher interaction on a one-to-one basis. Bandura (1997) too found that the nature and sequencing of instruction can have a deleterious effect on the self-efficacy of learners, particularly those who fail to keep pace with their peers. In regards to teachers, Bandura (1997) also stated that highly efficacious teachers create learning environments that promote self-efficacy in their students but those who feel less efficacious *"construct classroom environments that are likely to undermine students' judgments of their abilities and their cognitive development"* (Bandura, 1997, p. 241). Zimmerman (2000), concluded that self-efficacy, when studied as a mediating variable in training studies, proved itself *"responsive to improvements in students' methods of learning and predictive of achievement outcomes"* (p. 89). Additionally, Zimmerman (2000) highlights that student self-efficacy beliefs were responsive to changes in the instructional experience especially in those environments involving greater self-regulation. Likewise, almost a decade later, Usher and Pajares (2008) pointed out that investigations of the sources of self-efficacy have focused mainly on high school and university students with few examining the sources of (and tracking changes to) self-efficacy longitudinally

particularly during periods of transition in education (e.g., from primary to secondary). In the same review of self-efficacy studies, Usher and Pajares (2008), suggested that the *"learning environments in which competition is fostered leads students to make frequent comparisons of how their ability compares with that of others"* (p. 782) and this would lead to a decrease in self-efficacy.

Holzberger et al. (2013), in their study, also encourage future research into teachers' self-efficacy that uses a longitudinal design with varying time frames in order to identify possible mediator variables and therefore consider other aspects of teacher competence beyond self-efficacy when examining the effects of instructional quality.

The literature on the influence of instructional practices on self-efficacy as reviewed here, suffers from a number of shortcomings. First, it has proven difficult to relate instruction causally to self-efficacy. There have been a number of experimental studies in which the influence of extraneous influences was controlled for (e.g., Hushman & Marley, 2015; Meluso et al., 2012). However, the majority of studies involved single-group classroom studies without adequate controls, leaving the issue of causality unresolved (e.g., Alt, 2015). Second, one may assume that self-efficacy with regard to a particular school subject needs a certain time-lapse to increase. A student needs to experience how well they are doing in that area before adequate self-judgements can be made. It is doubtful that a learning event of only a few minutes, hours or days would serve that purpose (e.g., Hushman & Marley, 2015). Longitudinal studies, spanning several weeks, months or more, would be more appropriate to demonstrate the emergence of self-efficacy over time as students gain experience and observe themselves responding to the tasks at hand. One of the few studies that sought a long-term perspective was Holzberger, et al., (2013). Third, self-

efficacy is a developmental concept. It is supposed to increase over time. It is therefore questionable whether a pretest-posttest approach, such as Mills (2005) or a posttest-only approach (Alt, 2015) are the best ways to capture this developmental process in its trajectory. Fourth, the ways in which self-efficacy is measured varies. Dunlap (2005), for instance, surveyed students using the General Perceived Self-Efficacy Scale (Schwarzer & Jerusalem, 1995) as well as guided reflective journals written by students that were subsequently coded by the researcher for self-efficacy content. A fifth and final shortcoming is the lack of authenticity of some of the studies, which are not or cannot be undertaken in a natural or real classroom setting (e.g., Hushman & Marley, 2015).

In a recent meta-analysis of 59 self-efficacy studies, Honicke and Broadbent (2016) concluded: *"...academic self-efficacy is a highly malleable construct that is influenced by the learning environment"* and correlates more strongly with performance over time as students gain more information about their academic capabilities (and which to adjudge their self-efficacy) as the learning experience proceeds; however, whilst the outcome appears clear, what exact influence the environment has on self-efficacy remains elusive at present because, as reiterated above, studies to date have mostly been operationalised to measure self-efficacy at the beginning and end of the instructional process or intervention and not during or in relation to the instructional process itself. The absence of studies that explore the causal relationship between the two means it remains speculative whether instruction can really foster self-efficacy. With this in mind, it is clear; more research is needed into the impact of instruction on self-efficacy given the significant implications for both educational theory and practice. Our contribution discussed below tried to remedy some of these shortcomings.

Measurement Approach: A Microanalytical Time-Series Design

The study and measurement of psychological constructs considered important for learning presents educational researchers with some challenges; firstly, how to study these constructs knowing the difficulties of doing so within a variable-laden learning environment? And, secondly, if studied in isolation (as best as possible), how can they extrapolate their findings to a naturalistic classroom setting where these constructs are normally developed? Educational researchers have successfully used rigorous experimental designs in controlled, randomized and artificial settings over many years to better understand these psychological constructs. However, in the quest for greater internal validity, the consequence has often been a reduced external validity. A two-group quasi-experimental design (often with a non-random control group that is not exposed to the treatment) is even so an approach with limited use in authentic classroom settings, as you cannot withhold a treatment to some students. Similarly, a one-group pretest-posttest design sometimes used by researchers to study educational interventions also has its limitations. Such studies confine themselves to input-output measures and have a number of potential threats to their internal or causal validity (e.g., Mahasneh & Alwan, 2018), including *time passed* leading to external factors besides the intervention, effecting changes in participants' behaviours; the *maturation* of participants over the course of the study; and, a growing *familiarity* or *experience* with the instruments leading to a change in responses in later surveys. Given these apparent threats, one-group designs are considered the weakest type of experiments (Cook & Campbell, 1979). A final consideration for both experimental and quasi-experimental designs is that they can sometimes be intrusive.

This situation has led other educational researchers to adopt a variety of

research designs to provide a more ‘complete’ picture as well as explore new ways of understanding those psychological constructs considered important for learning.

In the current study, a times-series design was therefore adopted. Described by Campbell and Stanley (1966), this methodology involves a periodic measurement process on some group or individual, which is followed by the introduction of experimental change into this time series of measurements; it is considered the exemplar for longitudinal studies. A time-series design can also reveal the underlying naturalistic process and the pattern of change over a period of time. A further innovation used in this study was pairing a time-series research design with a microanalytical approach. This discrete, non-intrusive and repeated-measurement approach affords researchers the opportunity to study psychological constructs within the context of the learning environment and investigate changes over time in finer detail (see Rotgans and Schmidt, 2017). The data collected at multiple points in time can then be analysed using a latent-growth curve modelling approach that enables exploring the growth trajectory in self-efficacy as a function of exposure to the instructional approach.

Hypotheses

The focus of this study was on the development of self-efficacy in relation to instruction in a secondary school project-based learning environment. We assumed that continued exposure to a particular science subject (in this case, chemistry) in the context of five-week projects in small groups, would enable students to become more conversant with the topic over time, would provide feedback with regard to their performance, and would enable them to compare their own performance with that of peers. These factors necessarily must lead to increase in self-efficacy in students. Second, we assumed that it was the instruction received, not simply time passed,

maturation, or increased experience with responding to the measurement instrument that was responsible for this increase. In line with the time-series approach, we surveyed early high school students prior to the commencement of their five-week project-based learning chemistry event. During their learning event, students were surveyed at the same time every week regarding their self-efficacy in relation to the chemistry project. This was followed by an immediate and a delayed posttest (one week and three weeks after the conclusion of the project respectively).

Method

Educational Context

The study was undertaken at a Catholic, comprehensive (non-selective), all boys' secondary (high) school located in Western Sydney, NSW, Australia. The school employs project-based learning in the junior and middle school curriculum in academic years 7 – 10 (ages 12 – 16) across all teaching disciplines. The school first deployed project-based learning in Year 9 (ages 14 to 15) in 2008 and progressively phased it across Years 7 to 10 (ages 12 to 16). The school uses a problem-based learning approach in Year 11 (age 17) and flipped classroom in the final year of secondary schooling, Year 12 (age 18). The school day is organised into three 100-minute lessons on a fortnightly rotation (for a more comprehensive discussion please see Hendry et al., 2017).

Participants

The sample consisted of 177 male early high school students (Year 8) in total. Their average age was 13 years (*SD* = .38).

Project Description

The science syllabus topic that formed the basis of this project was 'physical and chemical changes'. This topic focuses on understanding, comparing and

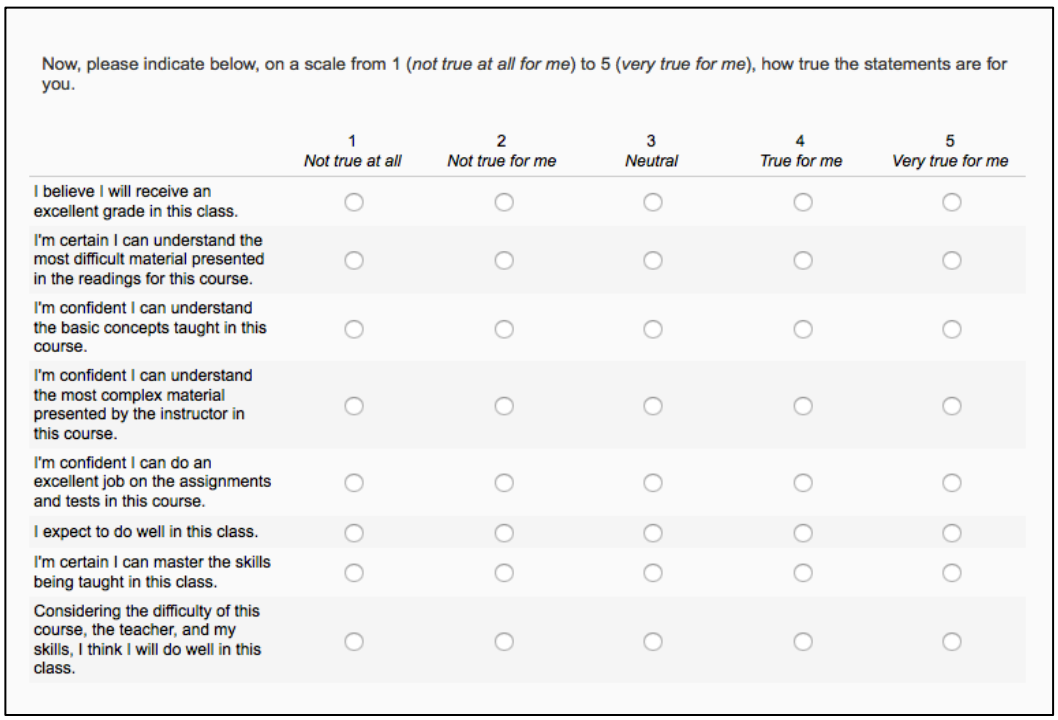
contrasting physical and chemical changes, for example, comparing changes in terms of the arrangement of particles and reversibility of the processes. Students, organised into groups of five, look at the discoveries about the properties of elements, compounds and mixtures, chemical reactions in the production of a range of substances; relate changes in the physical properties of matter to heat energy and particle movement that occur during observations of evaporation, condensation, boiling, melting and freezing; and, understanding that in a chemical change, new substances are formed, which may have specific properties related to their use in everyday life. The project's summative task (or 'end product') was a proposal for a fireworks display detailing the scientific concepts that underpin their concept understanding. A parent at the school was an external thought partner and marker given their professional background was in pyrotechnics. See Appendix A for a more detailed description of the project.

Measurements

The data in this study was collected through a self-report measure with all items scored on a 5-point Likert-type scale, from 1 (*not true at all*) to 5 (*very true of me*). The self-efficacy measure was composed of an 8-item scale taken from the larger *Motivated Strategies for Learning Questionnaire* (MSLQ) developed and validated by Pintrich et al. (1993). As shown in Figure 1, the questionnaire asked participants to rate their confidence beliefs for performance in the *course* or in the *class* (terms familiar in this context referring to performance in the subject, overall). The reliability of the scale was determined by generating Cronbach's Alpha for the eight questions. The alpha values for the pretest, the immediate posttest and the delayed posttest were $\alpha = .92$, $\alpha = .95$ and $\alpha = .94$ respectively.

Figure 1

Screenshot of General Self-efficacy Survey in Qualtrics



Now, please indicate below, on a scale from 1 (*not true at all for me*) to 5 (*very true for me*), how true the statements are for you.

	1 *Not true at all*	2 *Not true for me*	3 *Neutral*	4 *True for me*	5 *Very true for me*
I believe I will receive an excellent grade in this class.	○	○	○	○	○
I'm certain I can understand the most difficult material presented in the readings for this course.	○	○	○	○	○
I'm confident I can understand the basic concepts taught in this course.	○	○	○	○	○
I'm confident I can understand the most complex material presented by the instructor in this course.	○	○	○	○	○
I'm confident I can do an excellent job on the assignments and tests in this course.	○	○	○	○	○
I expect to do well in this class.	○	○	○	○	○
I'm certain I can master the skills being taught in this class.	○	○	○	○	○
Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class.	○	○	○	○	○

Procedure

The measures used in this study were administered online through student-owned devices using Qualtrics surveying software (Qualtrics, Provo, UT). The first author was present during the administration of all measures to ensure individual questionnaires were completed on student devices (in this instance, all students had iPads or laptops). The study was conducted over a 12-week period with eight measures taken in total. A pre-test was administered three weeks prior to commencement of a five-week Year 8 Science project on 'physical and chemical changes'. Students were surveyed once weekly for the duration of the project. This was followed by an immediate posttest one week after the conclusion of the project; and then a delayed posttest was administered three weeks after the immediate post-

test. All eight measures were administered during Tuesday morning roll call within the corresponding weeks outlined above.

Analysis

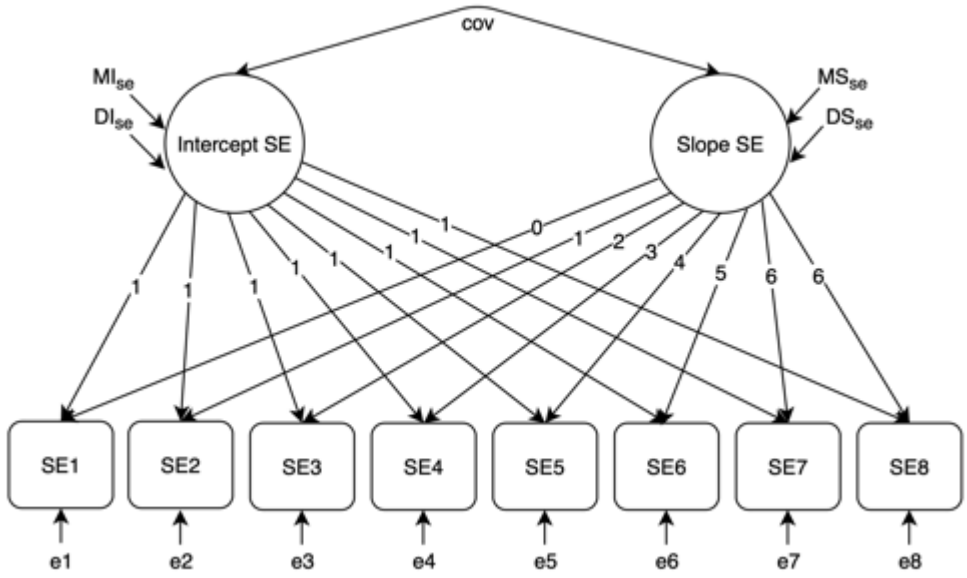
A latent growth-curve (LGC) analysis with time series analysis was conducted to investigate whether self-efficacy grew as a result of the exposure to the five-week science course. All analyses were conducted using Mplus 7.3 (Muthén & Muthén, 1998–2012). First, a missing-data analysis was conducted. There were missing data due to absence of students at one or more lessons (e.g., illness). The extent of the missing data was as follows: Measure 1 = 2%, measure 2 = 3%, measure 3 = 2%, measure 4 = .5%, measure 5 = 1%, measure 6 = 3%, measure 7 = 4%, measure 8 = 4%. To deal with this type of missing data, we used the robust maximum likelihood (MLR) and mean-adjusted X^2 statistics in Mplus (Byrne, 2012). An LGC model approach was used to examine how self-efficacy changes over time (Duncan et al., 2006).

The LGC analysis was carried out in two steps (Byrne, 2012). We first tested a growth model for self-efficacy to model intra-individual and inter-individual differences in change over time (the time series model). To do this, two latent factors were defined to represent the intercept (initial level of self-efficacy) and the slope of the growth trajectory (see Figure 2). The factor loadings of the eight observed measures and the intercept factor were fixed to 1 to define the starting point of the growth trajectory. The factor loadings of the observed measures and the slope factor were fixed at 0, 1, 2, 3, 4, 5, 6, 6 respectively, to model an expected linear trend over the six measurement points and no change between the first and second measure and the last two measures, which represent the time series design (i.e., one expects no

change before and after the intervention). In other words, these factor loadings only allow for a change in self-efficacy between measurements 2 to 7.

Figure 2

A Latent Growth-Curve Time-Series Model for Self-efficacy (SE) showing Intraindividual and Interindividual Differences in Change Over Time (Measurement points 1 through 8)



The means of the two latent factors (initial level and slope) were freely estimated. The mean estimate of the intercept factor (Mi) represents the mean initial level of the growth trajectory, and the estimate of the intercept variance (Di) represents the degree of individual variability at the initial level. Similarly, the mean estimate of the slope factor (Ms) represents the mean slope of growth trajectory, and the slope variance (Ds) represents inter-individual variability in the rate of change over time (see Byrne, 2012). To examine the goodness-of-fit for the model, we generated the Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), and Comparative Fit Index (CFI) along with

the X^2 statistic. Cutoff values of .06 (RMSEA), .09 (SRMR) and .95 (CFI) were used in the analysis (Hu & Bentler, 1999).

To allow contrasting findings of our time series design, we generated a second model in which we changed the slope parameters to *not* represent a time series (here called the unlimited growth model). That is, we did not assume that the level of self-efficacy was stable before and after the intervention. To that end, we fixed the factor loadings for the slope to 0, 1, 2, 3, 4, 5, 6, 7. Note, the first factor loading is by definition always adjusted to zero (Byrne, 2012), thus we could only simulate a continued growth after the intervention. However, this still enabled to directly test the time series assumption and growth dependency of self-efficacy as a result of the intervention. If our data are conform the time-series, one would expect that the time series model would result in a significantly better model fit than the unlimited growth model. To compare both models we resorted to differences in chi-square test and comparing the Akaike AIC values of both models. A smaller Akaike AIC value is considered indicative of a better fitting model (Wagenmakers & Farrell, 2004).

Results

For this study, a latent growth-curve (LGC) analysis with time series analysis was conducted to investigate whether self-efficacy grew as a result of the exposure to the five-week science course. The results are depicted below; see Table 1 for the zero-order correlations between the self-efficacy measurements as well as the descriptive statistics. The time series model for self-efficacy fitted the data well: $X^2(28) = 45.02$, $p = .02$; CFI = 1.00; RMSEA = 0.06 (90% CI: 0.02–0.09); SRMR = 0.11; AIC = 882.90.

Table 1

Latent Growth Curve Analyses with Time Series Analysis Zero-Order Correlations between the Self-efficacy (SE) Measurements (1-8) and Descriptive Statistics

Variable	SE1	SE2	SE3	SE4	SE5	SE6	SE7	SE8
SE1	-							
SE2	.82**	-						
SE3	.81**	.87**	-					
SE4	.80**	.88**	.90**	-				
SE5	.77**	.85**	.91**	.91**	-			
SE6	.77**	.86**	.86**	.89**	.93**	-		
SE7	.73**	.79**	.87**	.86**	.91**	.89**	-	
SE8	.74**	.82**	.87**	.88**	.91**	.90**	.93**	-
Mean	3.45	3.52	3.57	3.57	3.59	3.64	3.65	3.63
SD	.66	.66	.72	.76	.74	.74	.72	.72

Note

*P < .05

**P < .01

The mean and variance of the initial level were significantly different from zero (MI_{SE} = 3.48, p <.0001; DI_{SE} = 0.43, p < .0001), as were the mean and variance of the slope (MS_{SE} =.03, p <.0001; DS_{SE} = .002, p = .0001). The correlation between initial level and slope was not significant (r_{IS} = -0.003, p = .98). The results of this analysis show that there was a significant overall increase in participants' self-efficacy over the five-week period.

As a next step, we tested the unlimited growth model in which we allowed self-efficacy to continue to increase after the intervention. This resulted in a

significantly worse model fit: $X^2(28) = 53.42$, $p = .003$; CFI = .98; RMSEA = 0.07 (90% CI: 0.04–0.10); SRMR = 0.11; AIC = 892.76. The chi-square was significantly larger ($p < .01$) and the AIC was substantially larger, suggesting that the time series model fitted the data better. In line with the time series design, these findings suggest that the significant growth of self-efficacy over the five-weeks can be ascribed to the instructional intervention and not to other factors.

Discussion

In the Introduction section we have argued that many studies seeking to demonstrate the influence of instructional practices on student self-efficacy, suffer from one of two problems: (1) They are either insufficiently authentic, that is, they use contrived experimental designs in a non-classroom setting lasting a few hours (e.g., Hushman & Marley, 2015). It is unlikely that self-efficacy, a purportedly slow process developing in parallel to someone's knowledge of a domain really grows on such limited time scale. What is needed is research that studies the development of self-efficacy over a longer stretch of time in an authentic classroom context. (2) They measure changes in self-efficacy in a single group of students without sufficient controls (e.g., Alt 2015). These studies tend to use a pretest-posttest design, leaving open the possibility that observed changes have causes unrelated to the instructional treatment. Our study attempted to avoid both of these two pitfalls. We studied the development of self-efficacy in 177 male high-school students over a period of 5 weeks, measuring self-efficacy once a week. To control for extraneous influences, we applied a time-series design, in which we also measured self-efficacy over two periods without instruction, three weeks before and three weeks after the course. The study was conducted during a course of chemistry using project-based, interactive, instruction.

The data were analyzed using an innovative approach combining latent-growth modeling with time-series data. The assumption of the model was that, if instruction would have a causal effect on self-efficacy, we would observe larger growth of self-efficacy during the course than in the pre- and post-instructional periods. The data fitted this model well. It showed that significant growth of self-efficacy was observed during the course of instruction, absent during the phases in which no instruction was provided. This leads us to the conclusion that our project-based chemistry course indeed caused a higher self-efficacy in students.

The question arises as to why instruction in *this* learning environment has led to a significant growth in the self-efficacy of the participants over the course of the study? The answer may lay in the nature of active learning in a constructivist classroom (project-based in this instance) and how they create, develop and cultivate the four sources of information upon which the learner derives their feelings of self-efficacy; the four sources being (1) *performance accomplishments* or *mastery (enactive learning) experiences*: the belief in one's competence and ability based on the interpretation and evaluation of past performances; (2) *vicarious experiences*: to gauge one's own ability by observing and relating it to the performances of others; (3) *verbal and social persuasion*: being encouraged or convinced by others regarding one's level of ability; and (4) *emotional and physiological states*: one's mood or state of mind (e.g., anxiety) can impact feelings of self-efficacy. It could be argued that the influence of these sources is made more evident in a project-based learning classroom because of the nature of learning in such classrooms. Learning is mainly undertaken in groups, scaffolded and cooperative in nature. Some earlier studies indicated the potential contribution that cooperative learning environments made to the development of self-efficacy. Moriarty, et al., (1995), for instance, did find that

cooperative learning environments led to higher self-efficacy and achievement. Dunlap too (2005) found that the collaborative nature of the problem-based course provided students with explicit feedback, serving as a source of efficacy information that enhanced their self-efficacy. Schaffer et al. (2012) also found that a positive change in self-efficacy beliefs did occur in their study of undergraduate engineering students in project-based teams. Building on their findings, these authors called for subsequent studies to consider an improved design and data structure to further *"investigate how individual characteristics and team context influence individual self-efficacy"* and *"to better understand if and how students learn to collaborate while working on multi-disciplinary project design teams"* (p. 91).

It could also be argued that practices embedded in a project-based learning environment contribute to making sources of self-efficacy information more apparent. For example, in terms of *vicarious experience*, the learner in a project-based learning environment is better able to gauge one's own ability in this setting through greater opportunities to observe their peers, interact with them and relate their performances to others when working routinely and repeatedly in groups and often across multiple knowledge domains. Similarly, *verbal and social persuasion*, that is, being encouraged or convinced by others regarding one's level of ability, is also more frequent and evident as this source of information is both the responsibility of group members as well as the teacher(s) in the project-based learning environment. This may also be true of the most significant source of self-efficacy information, *performance accomplishments* or *mastery experiences*, which is enhanced in a project-based learning classroom as feedback is derived from more sources in the classroom and mastery is part of the cooperative learning process. Here too it is worth noting Usher and Pajares' (2008) contention, especially when considering the

development of self-efficacy during those formative years of adolescence, that *"if peers exercise a powerful influence, persuasive messages from competent peers may carry more weight during late childhood and adolescence than messages from adults"* (p. 783). This, in turn, may have significant implications for both this study as well as active, student-centred, team-based approaches to learning in pre-tertiary schooling.

Additionally, the scaffolding of learning required in project-based learning may have contributed to the increase in student self-efficacy in this study. This is in line with Jansen et al. (2015), who suggest that self-efficacy develops if the constructivist classroom is appropriately scaffolded, monitored, and the learning being properly facilitated to ensure positive mastery experiences. Similarly, Pleiss et al. (2012) confirmed this when they explored how introductory project-based learning courses affected the self-efficacy of first-year engineering students. They found that the self-efficacy beliefs of students are significantly influenced by perceived course goals, which, in turn, are determined by the level of scaffolding and dynamism of facilitation; moreover, the gradual increase in student autonomy in a project-based learning environment contributed to an increase in self-efficacy beliefs.

For both this study and in a wider context, it may be worthwhile considering the impact of instruction on self-efficacy in a project-based environment in relation to the knowledge domain under study. Jansen, et al., (2015), studied students' self-concept and self-efficacy in the sciences and the differential relations to antecedents and educational outcomes, and found that science self-efficacy was more strongly affected by inquiry-based learning opportunities. Similarly, Merritt et al. (2017) reviewed nine studies into the use of problem based learning in Maths or Science and found that problem-based learning is an effective method for improving K–8 students'

science academic achievement, including knowledge retention, conceptual development, and attitudes; however, they noted that the majority of studies were based on Science and not mathematics. Finally, a more recent study bv Mahasneh and Alwan (2018) aimed to investigate the effects of project-based learning on student teacher self-efficacy and achievement. Their results indicated that there was a significant difference in the growth of self-efficacy beliefs and achievement in student teachers that undertook a project-based chemistry unit when compared to the control group who were taught via traditional methods. In the case of this study, as Science was the topic under study in the project, this too may have had an influence on the growth of self-efficacy.

Our study has a number of shortcomings. First, the effect of instruction on the growth of self-efficacy although significant was actually rather small. On a five-point scale, it increased over the 8 measurements from 3.45 to 3.65. There may be several reasons for this. We noticed that quite a large group of our 177 participants, almost one-third, showed no change at all. It may be possible, that for those students the topic was difficult and remained difficult over the course of time. When you notice that you learn less than your fellow-students, self-efficacy is unlikely to increase. Second, maybe the development of self-efficacy in a particular school subject is an even slower process than we expected, regardless of findings to the contrary as noted above. The study of growth in self-efficacy would perhaps need the inclusion of an even longer time frame than the one applied in our study. Third, students may have underestimated the time it took to complete the project and this may have impacted their self-efficacy (see Papinczak et al., 2008, for similar findings). A fourth limitation of our study is that we relied on self-report while measuring self-efficacy. It is possible that some students have poorer introspective skills than others, adding to

bias in the data. In addition, students may provide inaccurate responses to look good. Social desirability in self-report measures may play a larger role than often assumed, in particular when self-presentation contributes to teacher judgements of one's competence (Fisher & Katz, 2000). An obvious solution would be to look for even less obtrusive measures of self-efficacy. A challenge will be to find such behavioural equivalents of self-efficacy; so far the literature does not mention them. Fifth, although we believe to have shown that project-based instruction adds to self-efficacy, we have not demonstrated which specific instructional practices are particularly helpful in fostering self-efficacy. Is it the collaboration on tasks in the classroom and peer feedback? Is it the feedback of the teacher or team teachers? Is it greater engagement and ownership of the learning process? Is it the scaffolding and facilitation of learner in a constructivist environment? These questions need to be addressed by means of further research.

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Chapter 3: Appendix A

Description of Project Under Study

The Science project used in this study was entitled 'Flying Colours'. It was a stand-alone five-week Science project (i.e., not integrated with other subjects as is common practice at the school when there is overlapping or complementary content and skills). Students were organised into groups of five. The 'entry event' used to launch the project was a request from a local councillors (with connections to the school) to put together a proposal for a unique fireworks display that did minimal damage to the environment and surrounding buildings. It was to be presented to one local councillor.

Additionally, a parent of a student at the school was invited in as an external thought partner given their professional background in pyrotechnics. The councillor and parent were also involved in assessing the project against a rubric (with the two teachers completing the 'panel'). As indicated in the project description above, the underlying science syllabus topic that formed the basis of this project was 'physical and chemical changes'. This topic focused on understanding, comparing and contrasting physical and chemical changes, for example, comparing changes in terms of the arrangement of particles and reversibility of the processes. Students also look at the discoveries about the properties of elements, compounds and mixtures, chemical reactions in the production of a range of substances; relate changes in the physical properties of matter to heat energy and particle movement that occur during observations of evaporation, condensation, boiling, melting and freezing; and, understanding that in a chemical change, new substances are formed, which may have specific properties related to their uses in everyday life.

Further to this, students had to apply these scientific principles to firstly test different chemicals safely and under supervision (i.e. flame tests); plan a safe fireworks display using chemical properties (e.g. different metals/chemicals to be included in display for colour and effect), assess the displays ecological and environmental impact as a consequence of the chemicals used (e.g., the chemical and physical weathering of surrounding landmarks as a consequence of their fireworks display); and then, put together a presentation to be shown to the panel.

An individual formative assessment was set midway through the project and was an online quiz on physical and chemical changes undertaken through the school's learning management system. The project's summative task (or 'end product') for a colourful fireworks display was a group task and required a detailed explanation of the scientific concepts that underpin their concept.

Chapter 4

Promoting Self-efficacy in a Project-based Classroom: What is the Influence of Critical Learning Events?

Abstract

The purpose of the study presented here was designed to examine the influence of critical learning events within a project-based classroom on the development of self-efficacy in learners. The study was conducted over a five-week biology project in an Australian secondary school project-based learning environment with 186 male Year-7 high school students. A microanalytical measurement approach was used to collect self-efficacy judgements over the course of the program. There were 101 participants included in the sample for a general self-efficacy measure (students present on all four measurement occasions) and 67 participants included in a situational self-efficacy measure (students present on all 8 measurement occasions before and after 4 critical learning events). Findings suggest that change in situational self-efficacy in response to critical learning events promoted the growth of general self-efficacy over the five-week project-based learning. The implications and limitations of this study are discussed.

[158 words]

Keywords: Self-efficacy; Critical Learning Events; Project-based learning

Introduction

The Purpose of the Present Study

The purpose of this study was to explore how a motivational construct considered crucial for learning–namely *self-efficacy*–develops over time within a classroom setting; in this case, an 'active' project-based learning environment. To that end, we will report on a study in which we measured the construct of self-efficacy repeatedly in a microanalytical way during a five-week, project-based, biology course and observed the ensuing changes. After an introduction of what project-based instruction entails, we will briefly discuss the literature on self-efficacy. Next, we will examine the potential influence of 'critical learning events' on the development of self-efficacy in the classroom.

The Context of the Present Study: Project-based learning

Project-based learning is an active-learning pedagogical approach where the curriculum is presented to the learner in the guise of an 'authentic' project. During a project, students work in groups and engage with new and increasingly complex concepts to present a solution or 'end-product' that could have real-world implications or even implementation (Thomas, 2000). This idea of contextualising learning and leveraging student interest through 'teaching by projects' has been around for over a century (Dewey, 1897). However, it was in the latter part of the twentieth century that a general consensus about what constitutes project-based learning was reached. In this consensus, projects are the main mode of instruction with each having a 'driving question' that ties together the key underlying conceptual (often multidisciplinary) knowledge and activities that drive student learning. In addition, the goals and central activities of projects require students to investigate, transform and construct knowledge (beyond their current skills and knowledge)

together with their peers, with the teachers taking more of a facilitative role in the learning process (Savery, 2006; Thomas, 2000).

A snapshot of learning in a project-based learning environment is drawn from this study where the project was centred on the scientific concept of 'cells' and the associated concept of 'classification' with the underlying driving question of 'How and why do we classify living things?' The summative task (or 'end-product') after five weeks was to produce an information card on animals for primary school-aged visitors to a local wildlife sanctuary. Across the cohort, a set of cards was produced for use in the park. To launch the project (known as an 'entry-event'), a letter from the wildlife sanctuary was delivered to student groups (see Appendix A, Figure A1). This scripted critical learning event (used to initiate all projects), like all subsequent critical learning events (more about which below), is designed to activate prior knowledge, stimulate student interest and drive student engagement with the learning priorities. Immediately following the entry event, students participate in a metacognitive strategy routinised in project-based learning called (in this context) the 'Knows' and 'Need To Knows' list; this list is used by students in their groups to identify collective gaps in their knowledge (both processual and conceptual) and outlining their next steps in effecting the project. This list is compiled, personalised, and subsequently updated by each group and used as a guiding document for the project.

Another critical learning event specific to this project was a laboratory practical involving a fish dissection in the school science laboratories just after the mid-point of the project. This was followed by an incursion involving keepers from a local wildlife sanctuary visiting the school with native animals. Students were able to handle the animals (e.g., non-venomous native snake) and engage in discussions with

experts, peers and teachers regarding their classification (e.g., kingdom, class, order, phylum etc.). Outside these planned learning events in the project, students have the freedom to undertake different scaffolded activities, explore different resolutions and solutions, engage in debates with group members, participate in (and lead) workshops with peers, interact and receive feedback from outside experts and professionals. The teacher's role is to facilitate student learning and support them in achieving their goals (presenting their animal information card in a way accessible to younger children) in line with the stated learning outcomes of the project. Theoretically, at project's end, students should be able to address the underlying driving question using scientific concepts, terms and examples from theirs and other groups.

Literature Review of Self-efficacy

In this section we briefly discuss the literature on self-efficacy. This construct has been subject of intense research given its demonstrated impact on learning. *Self-efficacy* involves a self-judgement as to how successful one will be in completing a particular task with the skills that one possesses (Bandura, 1986). Essentially, these beliefs not only influence the particular courses of action a person chooses to pursue but also, the amount of effort that they expend, their levels of perseverance in adverse circumstances and resilience, as well as their ability to cope with the demands associated with that course of action (Chemers, Hu & Garcia, 2011). Bandura and other self-efficacy researchers (Bandura, 1977, 1986, 1989, 1997, 2012; Duncan & McKeachie, 2005; Gist & Mitchell, 1992; Mathieu, Martineau, & Tannenbaum, 1993; Wolf, 1997; Zimmerman, 2000) believe that the construct of self-efficacy varies across domains and situational conditions rather than manifests uniformly across tasks and contexts as is the case with general traits. They consider self-efficacy as a *situationally arising* psychological process; a response to the task at hand. Other

researchers, however, have conceptualised a more generalised or dispositional quality to self-efficacy that refers to a global confidence in an individual's ability to cope across a variety of demanding or unique circumstances (Sherer & Maddux, 1982; Scholz, Dona, Sud & Schwarzer, 2002; Schwarzer & Jerusalem, 1995). In this thesis, as outlined in Chapter 1, we have called these different conceptualizations *situational self-efficacy* and *general self-efficacy*.

Another debate evident in the literature is centred on the relationship that self-efficacy has with learning (often viewed in terms of achievement) and the directionality of its influence. For example, is self-efficacy a consequence of learning or does learning result from self-efficacy or both? Most studies assume a one-directional relationship between self-efficacy and learning (Pajares, 1996; Zuffiano et al., 2013) whilst other studies indicate self-efficacy was mainly determined by previous academic achievement (Diseth, 2011). This issue will be dealt with in Chapter 6 of this thesis. In a previous study, we have demonstrated that (general) self-efficacy grows under the influence of instruction (Hendry, Rotgans & Van der Molen, 2020, submitted). In this chapter, we are interested in the contributions of critical learning events as a driver of such growth. We assume that *situational* self-efficacy is a specific response to specific critical learning events whose nature teaches students how capable and comfortable they seem to be with the topic at hand. In addition, we assume that *general* self-efficacy emerges from the accumulation of positive changes in situational self-efficacy, that is: the more positive change in self-efficacy critical learning events bring about, the higher self-efficacy at the end of a course.

Effects of Critical Learning Events and their Facilitation on Changes in Student Self-efficacy

In this study we have focused our measures wrapped around what we have

termed ‘critical learning events’. These events consist of, for example, exercises, activities, assignments and experiments (in science) and can be differentiated from more routine classroom tasks in several ways. Firstly, these events are designed to highlight perceived gaps in the learner’s knowledge base; prolong a learner’s engagement with a difficult concept; extend their knowledge when appropriate and/or link (and measure) the learning of students to specific key learning objectives. Secondly, these events can also be used to explore new ways of applying knowledge acquired during the project/process and be used as ‘benchmarks’ to track and determine student progress. Thirdly, these learning events are often deliberately collaborative in nature adding another dimension given working with others to affect an outcome is both challenging (to one’s confidence in achieving the task set) yet rewarding. Lastly, these planned instructional actions are initiated (primarily by the teacher) at junctures considered important during the learning process and increase the likelihood of provoking a (greater) response in the learner. It is therefore the nature, timeliness, duration, and the linkage of these tasks to key learning objectives, released by the teacher to groups at certain points in the project (determined by the progress of students) that make them ‘critical’.

As learners engage with the task at hand during the critical learning event, their knowledge increases and is applied with their performance observed/measured and feedback provided. Following the (successful) completion of the task, it is expected that there is a growth in the learner’s situational self-efficacy as compared with a measure taken before the critical learning event. This, in turn, may build a more general sense of self-efficacy in relation to the topic or even the course/discipline itself.

In summary, in the present study, we set out to do two things. First, we aimed

to observe possible changes in situational self-efficacy measured before and after four critical learning events. A detailed description of each critical learning event is given in the 'Project description' in the methods section. Our first hypothesis was that, as a result of the exposure to such event situational self-efficacy would increase from pre- to post-critical learning event. Second, we measured *general* self-efficacy four times over the five-week course. Our hypothesis was that general self-efficacy would increase as a result of instruction over time, a replication of our previous study (Hendry, Rotgans & Van der Molen, 2020, submitted). Third, and most importantly, we hoped to demonstrate that changes in situational self-efficacy as a result of the confrontation with critical learning events, would influence (change in) general self-efficacy. Since these constructs were measured in a rather noisy and busy educational environment (noisy with regard to the number of potential confounders; busy, because of a lack of control over intruding events typical for everyday school life) our attempt must be considered exploratory and descriptive.

Method

Educational Context

The study was undertaken at a Catholic, comprehensive, all boys' secondary (high) school located in Western Sydney, NSW, Australia. The school employs project-based learning in the junior and middle school curriculum in academic years 7 – 10 (ages 12 – 16) across all teaching disciplines. The school first deployed project-based learning in Year 9 (ages 14 to 15) in 2008 and progressively phased it in across Years 7 to 10 (ages 12 to 16). The school uses a problem-based learning approach in Year 11 (age 17) and Flipped Classroom in the final year of secondary schooling, Year 12 (age 18). The school day is organised into three 100-minute lessons on a fortnightly rotation. Please see Chapter 2 for a more comprehensive discussion.

Overview of the Study

The study was conducted over a five-week period. A questionnaire containing a survey on self-efficacy was administered throughout the project. We measured general self-efficacy four times: once before the project's commencement, twice during the project, and once after the project's conclusion. Situational self-efficacy was measured eight times: once before and once after every activity undertaken by students during the project. This constituted four pairs of measures (eight in total) positioned either side of the four 'critical learning events' that were expected to engender a response in students.

A microanalytical measurement approach was used in this study. This approach typically involves the repeated administration of short self-report measures in response to a critical learning event. When aided by technology, this method of measurement is discrete and can be administered in close temporal proximity to the outcomes being measured (Pajares, 2003), with responses collected almost immediately. It also provides researchers with a more *"detailed operational window of what happens during a task"* (Rotgans & Schmidt, 2018, p. 534) by painting a more nuanced picture of the development and interaction of variables under study and the environment in which this occurs. This measurement method also has significant utility as it can be used in either a single intervention or in response to multiple critical learning events within the context of a classroom.

Participants

The sample consisted of 186 male early high school students (Year 7) in total. Their average age was 12.2 years (SD = .40). There were 101 participants included in the sample for the general self-efficacy measure (students present on all four measurement occasions). There were 67 participants included in the situational self-

efficacy measure (students present on all 8 measurement occasions before and after 4 critical learning events). All other students' data had to be discarded because of illness, absence, technical issues, inability to respond to some of the questionnaires, participation in extra-curricular school activities (e.g., travelling to representative sports) and a local weather event (flooding) that prevented some students from attending school on the day a survey was administered.

Project Description

The science syllabus topic that formed the basis of the 5-week project was 'cells' with sub-topics such as cell theory, the development of microscopes, plant and animal cell structures and classification being studied (a more comprehensive description of the project is given in Appendix A). Over the five weeks of this study, there were 8 lessons of science out of a total of 75 lessons for all courses in that period (this included one lesson a week for sporting activities); equating to over 13 hours of face-to-face contact with their teacher. Therefore, the discipline of science represented 10% of a student's academic load, which is commensurate with other schools and compliant with the supervising educational board's requirements. Measures were taken discretely throughout the project often around different critical learning events. Of those measures taken either side of critical learning events, four pairs (8 in total) were selected for inclusion in this study as they provided the most complete sets of responses captured both prior to and after those critical learning events. The four critical learning events included in this study are outlined below.

Critical Learning Event 1: 'Confectionary' cell model activity. To introduce students to the concept of cell structure and organelles, this critical learning event requires student groups to put together a model using confectionary (candy, lollies or jellies; the naming of which may vary according to the reader's context) to depict the

various parts of an animal and plant (eukaryotic) cells. Students are asked to explore each type of cell, discover the function of each organelle and select the confectionary that best represents constituent parts of each cell. Once the models are put together, they record each function and sketch each cell in their notebooks (or on devices). Groups are then selected to present their model to the class (projected using a digital visualiser) and explain the function of each organelle. Once this activity is completed, students may share and consume the contents of their cells.

Critical Learning Event 2: Laboratory practical, Microscope set up and exploration. To understand cells first hand (and participate in scientific inquiry), student groups are required to set up a bifocal microscope (and lamp) and explore its usage and capabilities (e.g., various magnitude of lenses) before labelling a supplied diagram of a microscope to help with its use in the subsequent activity. Once students have familiarised themselves with the microscope, each student cuts a sliver of plant material (e.g., onion), applies a stain and prepares a wet mount slide ready to be viewed under the bifocal microscope. Again, students are asked to record what they see (as a scientist would routinely do) and sketch the plant cell structures as seen under the microscope.

Critical Learning Event 3: Pencil case classification activity. A critical aspect of the discipline of biology is understanding how and why things are classified (and on what basis). A simple tool that is often used in classifying living organisms is a dichotomous key. A dichotomous key is a method of identification whereby living things are repeatedly divided into two groups based on the distinctive features of that particular organism until a clear classification can be made. In this instance, however, students use the defining characteristics and peculiarities of the inanimate contents of their pencil case to produce a dichotomous key for fellow students. The unexpected

and serendipitous nature of what is found in one's pencil case offers both challenges (in classifying) and quite often results in much mirth. The underlying purpose of this activity is to highlight both the need to classify as well as the many issues that result when it is attempted. This activity is therefore used to segue into an introduction of the Linnaean system of binomial nomenclature and some more recent attempts (and controversies) at updating such naming systems. Following the pencil case dichotomous key, student groups are given a challenging plant taxonomy activity that requires them to use dichotomous keys to identify various plant samples.

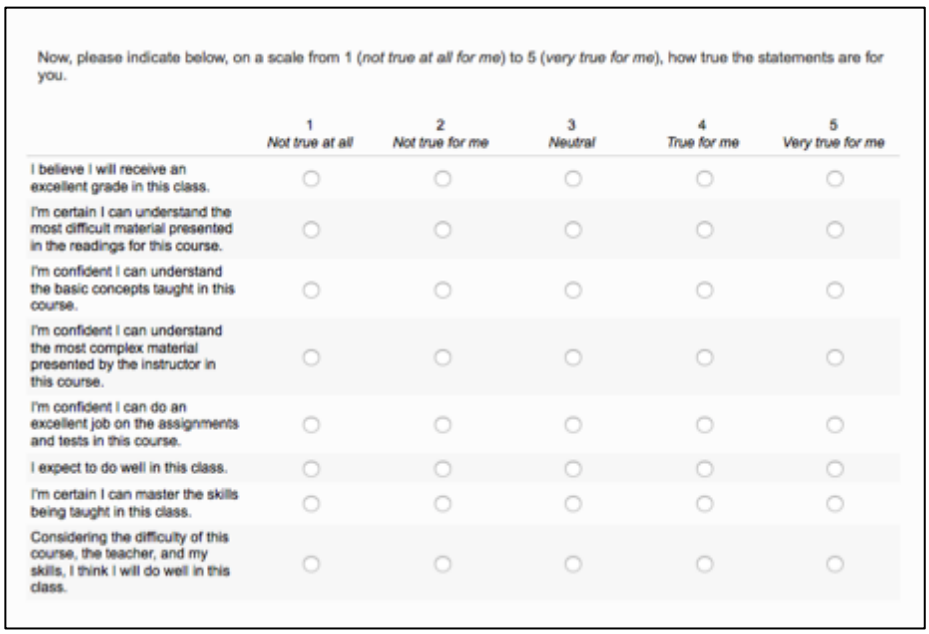
Critical Learning Event 4: Laboratory practical: Fish dissection. Laboratory and science practical work is a critical element of the work of scientists. As budding biologists, students participated in the dissection of a fish in their groups. Students were required to eviscerate the fish and identify all its organs as well as its bodily structures (e.g., skeletal structure). Students then were asked to sketch and record what they see.

Measurements

Self-efficacy questionnaires. For the purpose of this study, the *general self-efficacy measure* was composed of an 8-item scale taken from the larger *Motivated Strategies for Learning Questionnaire* (MSLQ) developed by Pintrich, Smith, Garcia, and McKeachie (1993). As shown in Figure 1, the questionnaires asked participants to rate their confidence beliefs for performance in the *course* or *class* (terms familiar in this context referring to performance in the subject, overall). All items were scored on a 5-point Likert scale, ranging from 1 (not true at all) to 5 (very true for me). The reliability of the measure was established by means of Cronbach's Alpha: Measurement 1 $\alpha = .88$, measurement 2 $\alpha = .93$, measurement 3 $\alpha = .95$, and measurement 4 $\alpha = .94$. The results suggest adequate reliability of the measure.

Figure 1

Screenshot of general self-efficacy survey in Qualtrics



Now, please indicate below, on a scale from 1 (*not true at all for me*) to 5 (*very true for me*), how true the statements are for you.

	1 *Not true at all*	2 *Not true for me*	3 *Neutral*	4 *True for me*	5 *Very true for me*
I believe I will receive an excellent grade in this class.	○	○	○	○	○
I'm certain I can understand the most difficult material presented in the readings for this course.	○	○	○	○	○
I'm confident I can understand the basic concepts taught in this course.	○	○	○	○	○
I'm confident I can understand the most complex material presented by the instructor in this course.	○	○	○	○	○
I'm confident I can do an excellent job on the assignments and tests in this course.	○	○	○	○	○
I expect to do well in this class.	○	○	○	○	○
I'm certain I can master the skills being taught in this class.	○	○	○	○	○
Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class.	○	○	○	○	○

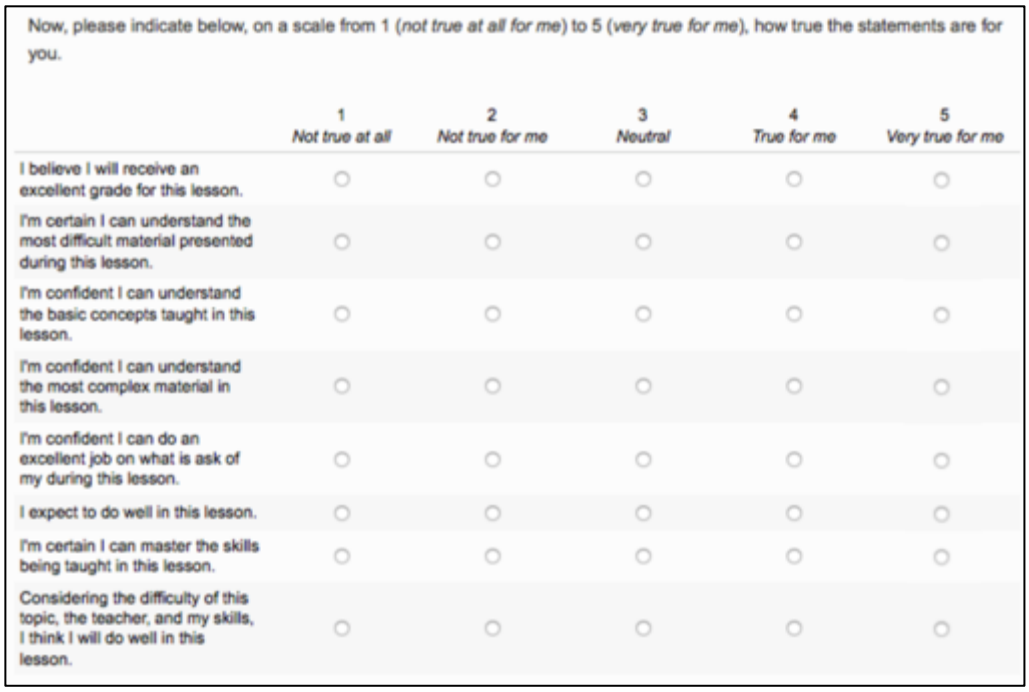
The *situational self-efficacy measure* was composed of the same 8-item scale taken from the larger *Motivated Strategies for Learning Questionnaire* (MSLQ) developed by Pintrich, et al., (1993) but has been adapted specifically to measure situational feelings of efficaciousness. As shown in Figure 2, the questionnaires asked participants to rate their confidence beliefs for performance in the *lesson* (a term familiar in this context referring to the immediate session of learning). *Confirmatory factor analysis of situational self-efficacy measures*. Since the situational self-efficacy measure was a newly designed questionnaire, we conducted confirmatory factor analyses to establish the construct validity of the new measure. To that end, parameter estimates were generated using maximum likelihood and tests of goodness of fit.

Chi-square accompanied by degrees of freedom, p-value and root mean square error of approximation (RMSEA) were used as indices of absolute fit between the model and the data. In addition to the absolute fit indices, the comparative fit index

(CFI) and standardised root mean square residual (SRMS) were generated. See Table 1 for the results of the confirmatory factor analysis. The model fit indices suggest that the data fitted the models well. This is evidence for the construct validity of the newly devised situational self-efficacy measure. In addition, the results of the reliability analysis suggest adequate reliability of the measure.

Figure 2

Screenshot of situational self-efficacy survey in Qualtrics



Now, please indicate below, on a scale from 1 (*not true at all for me*) to 5 (*very true for me*), how true the statements are for you.

	1 *Not true at all*	2 *Not true for me*	3 *Neutral*	4 *True for me*	5 *Very true for me*
I believe I will receive an excellent grade for this lesson.	○	○	○	○	○
I'm certain I can understand the most difficult material presented during this lesson.	○	○	○	○	○
I'm confident I can understand the basic concepts taught in this lesson.	○	○	○	○	○
I'm confident I can understand the most complex material in this lesson.	○	○	○	○	○
I'm confident I can do an excellent job on what is ask of my during this lesson.	○	○	○	○	○
I expect to do well in this lesson.	○	○	○	○	○
I'm certain I can master the skills being taught in this lesson.	○	○	○	○	○
Considering the difficulty of this topic, the teacher, and my skills, I think I will do well in this lesson.	○	○	○	○	○

Procedure

The measures used in this study were administered online through student-owned devices using Qualtrics surveying software (Qualtrics, Provo, UT). The researcher was present in class during the administration of all measures and instructed the students when to respond to the individual questionnaires on their devices (in this instance, all students had iPads). Table 2 shows how the general self-

Table 1

Model fit indices and Cronbach's alpha of the Situational Self-efficacy scale measurements

Measurements	(df)	X^2	p	RMSEA (95CI)	CFI	SRMR	α
1	(17)	36.04,	.06	.09 (.05 -.12)	.98	.04	.91
2	(19)	20.49,	.37	.02 (.00 -.08)	1.00	.02	.94
3	(19)	32.08,	.03	.07 (.02 -.11)	.98	.03	.93
4	(18)	37.52,	.01	.09 (.05-.13)	.98	.03	.94
5	(18)	31.32,	.03	.07 (.03-.12)	.98	.03	.92
6	(19)	24.67,	.17	.05 (.00-.10)	.99	.02	.95
7	(12)	25.35,	.02	.09 (.04-.13)	.99	.02	.96
8	(18)	34.39,	.01	.08 (.04-.12)	.98	.03	.95

efficacy questionnaire was administered on four occasions with a pretest and administered two weeks before the commencement of the 5-week project and the post-test two weeks subsequent to the project's conclusion. The general self-efficacy questionnaire was administered on two other occasions during the five-week project itself (in weeks 2 and 4). These were administered at the commencement of the first lesson during that week of the project. Table 3 shows how the situational self-efficacy questionnaire was administered and data collected at eight points in time before and after critical learning events (described in the method sections) during the five-week project. This resulted in four pairs of measures with each pair measuring self-efficacy before and after the intervening critical learning events.

Table 2

Measurement points during project of General Self-efficacy (with description)

Timing of measure	Measure	Details of measurement
Pre-test	Time 1	This measure was taken two weeks prior to the commencement of the five-week science project (before a two week semester break)
Week 2	Time 2	This measure was taken during the second week of the five-week science project under study.
Week 4	Time 3	This measure was taken during the fourth week of the five-week science project under study.
Post-test	Time 4	This measure was taken two weeks after to the conclusion of the five-week science project (yet prior to the release of project marks)

Table 3

Measurement points during project of Situational Self-efficacy (with critical learning events described)

Timing of measure during project	Measure before and after critical learning event	Description of critical learning event
Week 1	Time 1	Introductory activity: Students (in groups) were given large selection of different confectionery and asked to select lollies/candy that represented best organelles found in both animal and plant cells (ensuring a distinction between the two). Models were made for each (with a small plate being used to represent the cell wall/membrane), sketched and presented/explained to class with model projected using digital visualiser.
	Time 2	
Week 2	Time 3	Practical: Students conducted experiment with microscope in the school science labs. After being introduced to microscope parts and set-up in preceding activity, students set-up, familiarised and practised magnification and focusing with prepared slides of both plant and animal. Students then cut, prepared and stain onion cells in wet mount slide for viewing under microscope.
	Time 4	
Week 3	Time 5	Classification activity: creation of dichotomous key using contents of individual student's pencil case. Students are introduced to the concept of a dichotomous key and asked to open their own pencil case and create one based on its contents. The final draft was shared with other groups. Following on, students participated in challenging plant taxonomy dichotomous key activity.
	Time 6	
Week 4	Time 7	Practical: Students undertook (in groups) a fish dissection in the school science labs. Students identified and drew different organs; dissected and placed cells from different organs on glass slides; and, viewed under microscope and drew cells under magnification.
	Time 8	

Analysis

The four general self-efficacy measures and the eight situational measures were analysed applying repeated measures analysis of variance. To relate the size of changes caused by the four critical learning events, we computed differences scores by subtracting pre- from post-critical-learning-event self-efficacy scores, and averaged these over the four events. Subsequently, we computed difference scores subtracting the first general self-efficacy scores from the last two, indicating growth during the course. To study whether change in situational self-efficacy was predictive for the amount of change in general self-efficacy, we correlated mean change in situational self-efficacy with the two general self-efficacy differences scores.

Results

General Self-efficacy

There was a significant main effect for general self-efficacy across the four measurement occasions: Wilk's $\Lambda = .814$, $F(3, 98) = 7.44$, $p < .001$, $\eta^2 = .19$. This outcome suggests that the pattern of general self-efficacy was significantly different across the four measurement occasions. See Table 4 for the descriptive statistics. Post-hoc pairwise comparisons revealed that, general self-efficacy increased significantly between measures 2 and 3 ($p < .001$), and across the nine-week period between the first and the last measurement ($p = .03$). This last measure was, however, slightly but significantly lower than measurement 3 ($p < .014$). Overall, these findings suggest that, during the course, self-efficacy increased significantly. The reader should bear in mind however that the differences are small.

Situational Self-efficacy

There was a significant main effect for situational self-efficacy across the eight measurement occasions: Wilk's $\Lambda = .59$, $F(7, 60) = 5.99$, $p < .001$, $\eta^2 = .41$. This

Table 4

Descriptive Statistics for General Self-efficacy for Four Measurements in this Study (N=101)

Descriptive Statistics	Measurement 1	Measurement 2	Measurement 3	Measurement 4
	(N=101)	(N=101)	(N=101)	(N=101)
General Self-efficacy *Mean*	3.78	3.86	4.02	3.91
General Self-efficacy *SD*	0.61	0.63	0.65	0.64

outcome suggests that the pattern of situational self-efficacy was significantly different across the eight measurement occasions (four pairs of measures with four intervening critical learning events). See Table 5 for the descriptive statistics. Post-hoc pairwise comparisons revealed that, situational self-efficacy increased significantly between measures 1 and 2 ($p < .01$). These two measures were recorded either side of the first critical learning event (confectionary cell model-making) in the first week of the project. No other significant difference was evident between those pairs of measures taken before and after other critical learning events 2, 3 and 4. Overall, a consistent trend in the direction of larger scores after the critical learning event is observable, but the differences are not significant.

Changes in General Self-efficacy Related to Situational Self-efficacy

We found that change in general self-efficacy measured almost at the end of the course was unrelated to change in situational self-efficacy (Pearson correlation $r = .035$). However, the general self-efficacy measure taken two weeks after the course

correlated significantly with the amount of change produced by the critical learning events ($r = .238$, $p < .01$).

Table 5

Descriptive Statistics for Situational Self-efficacy for Eight Measurements (Four Pairs) before and after Critical Learning Events in this Study (N=67)

Measures	1	2	3	4	5	6	7	8
	(N=67)		(N=67)		(N=67)		(N=67)	
	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
Situational Self-efficacy *Mean*	3.80	3.94	3.96	3.98	3.91	3.97	4.08	4.12
Situational Self-efficacy *SD*	0.54	0.61	0.57	0.52	0.56	0.64	0.60	0.62

Discussion

In a previous study (Hendry, Rotgans & Van der Molen, 2020, submitted), we found that growth in self-efficacy with regard to a chemistry subject was promoted by a course about this topic. In the present, exploratory, study, we assumed that this growth was particularly influenced by what we have called 'critical learning events,' assignments that students would receive during the course and through which they would be able to assess their current level of *situational* self-efficacy. Our assumption was that successfully completing a new assignment would increase self-efficacy. In addition, we hypothesized that the amount of change produced by the confrontation with these events would be predictive of the change in general self-efficacy. To that end, we measured the construct of self-efficacy repeatedly during a five-week, project-based, secondary school biology course and observed the ensuing changes. A microanalytical measurement approach to learning in a real classroom environment

was adopted with measures taken before and after four critical learning events. This approach was taken, as it was believed that any subtle or fine-grain differences in both the dispositional and situational variant of self-efficacy beliefs could be mapped against each other and in response to the learning events. During the study, general self-efficacy was measured on four occasions including pre- and post-tests taken two weeks either side of the project and twice during the project itself. Situational self-efficacy was measured eight times either side of four critical learning events (four pairs of measures).

Results revealed that there was a significant main effect for general self-efficacy, suggesting that the pattern of this construct was significantly different across the four measurement occasions. Post-hoc pairwise comparisons suggested that, during the course, general self-efficacy increased significantly, a replication of a previous study (Hendry, Rotgans & Van der Molen, 2020, submitted). For the situational construct, there was a significant main effect for situational self-efficacy, suggesting that the pattern of this construct was significantly different across the eight measurement occasions (four pairs of measures with four intervening critical learning events). Post-hoc pairwise comparisons revealed that situational self-efficacy increased significantly between measures 1 and 2 but no other significant effect was found between those pairs of measures taken before and after other critical learning events. Changes in situational self-efficacy between post-and pre-critical learning events were however positively related to change in general self-efficacy over the course, suggesting that critical learning events, affording students to assess their level of mastery situationally, contribute to increases in general self-efficacy.

What do these findings imply? First, we were able to point at critical learning events as a possible source of increasing self-efficacy. Elsewhere (Hendry, Rotgans &

Van der Molen, 2020, submitted), we have argued that project-based learning, with its emphasis on peer collaboration and active learning, may make sources of self-efficacy information more apparent. According to Bandura (1977, 1986, 1997) there are four sources upon which student may base their self-efficacy judgements: (1) *performance accomplishments* or *mastery experiences*: the belief in one's competence and ability based on the interpretation and evaluation of past performances; (2) *vicarious experiences*: to gauge one's own ability by observing and relating it to the performances of others; (3) *verbal and social persuasion*: being encouraged or convinced by others regarding one's level of ability; and (4) *emotional and physiological states*: one's mood or state of mind (e.g., anxiety) can impact feelings of self-efficacy. It is likely that at least two of them, vicarious experiences and social persuasion, are available in project-based learning to a larger extent than in conventional instruction. In particular, because assignments are often group assignments, critical learning events may be particularly suited to provide self-efficacy information. If critical learning events are indeed a source of useful information for self-efficacy to grow, then it would be wise for educators to include those events to a larger extent as part of their instruction. An interesting area of study would be to find out which characteristics of such events are particularly useful to bring about change in situational self-efficacy.

Limitations of this study

There are a number of shortcomings of this study. First, the differences found in both situational and general self-efficacy, although significant, are actually quite small. There are a number of possible explanations for our failure to find more sizable effects. The most obvious is that the critical learning events used in this study were not potent enough to produce such effects, resulting in limited change in general self-

efficacy. Alternatively, perhaps self-efficacy is a characteristic of students that only grows gradually over time, and one may not expect too much of a five-week course in terms of producing change. In addition, the initial self-efficacy judgements with regard to the topic at hand were already quite high (mean scores approaching 4 out of 5), so there was little room for improvement anyway. A more serious issue limiting conclusions is the fact that we ended up with complete protocols of 67 out of 186 students. All other students' data had to be discarded because of illness, absence, participation in extra-curricular school activities (e.g., travelling to representative sports) and flooding (!) that prevented some students from attending school on the day a survey was administered. In a rather noisy classroom setting, the quality of data collected may be subject to such unexpected extraneous influences difficult to control by the investigator. It makes our study preliminary and exploratory.

Conclusion

The purpose of this study was explorative and designed to examine the extent to which critical learning events promote the development of self-efficacy within a project-based learning classroom. The findings of the study, conducted over a five-week science project, suggest that these learning events indeed seem to contribute to the growth of self-efficacy. However, due to unexpected dropout of a considerable number of students, dropout unrelated to the purpose of this study, this conclusion can only be tentative. Since critical learning events seem to fit well with the claims of self-efficacy researchers (Bandura, 1977, 1986, 1997), and since we found some evidence suggesting that they indeed contribute to change, their further study seems imperative.

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Chapter 4: Appendix A

Detailed Project Description

The project in this study was centred on the scientific concepts of 'cells' and the associated concept of 'classification'. Its duration was five weeks and participants were year 7 secondary school students (average age was 12.2 years; *SD* = .40). In a project-based learning environment, state-endorsed syllabi are repackaged into projects to engage students with the subject matter, achieve the desired outcomes, and, it is hoped, afford them the opportunity to develop skills. As is common in such active-learning environments, the project contained a number of critical learning events that would ordinarily form part of a project-based learning instructional approach at the school as well as those engaging activities tailored to this particular project. Besides those critical learning events described in the paper already, below are other elements of the science project under study.

Project Launch

Driving Question

The 'driving question' for this particular project was *how and why do we classify living things?*At the conclusion of the project, students should be able to address this question given it is the primary learning objective (derived from the syllabus).

Entry Event and Know/Need to Know List

In this educational setting, a project is always launched with an 'entry event' that is designed to engage the learner in an authentic learning task as well as activate prior knowledge. It may take the form of a letter, note, video, reading competition details or, for example, be initiated by a guest speaker. In line with the idea that

within a project-based learning environment, a ‘problem’ initiates the learning process, the entry event (often referred to as a ‘Problem Statement’ in other contexts) outlines the problem that requires a resolution. In this project, the entry event takes the form of a letter from keepers at a local wildlife park who require more age-appropriate information packs (for younger patrons) on various animals held at the park (see Figure A1).

An associated activity routinely undertaken in concert with the entry event is the ‘know/need to know list’. This list was constructed firstly individually, then in student groups and/or as a whole class, and it is designed to activate students’ prior knowledge and allow them to articulate that as well as identify what requires further research or exploration and what *they need to know* to undertake the project successfully. An additional column, known as ‘next steps’, is added to this list to help students prioritise their individual and group needs and plan the most effective use of their time. This list is considered a living document to be updated and checked and as an anchor point for each group. Whilst the ‘entry event’ and ‘need to know list’ are two activities considered critical learning events in a project-based learning environment, they were not included in this study.

Lecturing, Tutorials and Workshops

Throughout the project there were some instances of lecturing but this was limited, very brief (given the age and number of the students in each class) and mostly confined to the beginning and/or end of the lesson. Small group tutorials and workshops were a much more frequent occurrence and were often organised on an *ad hoc* basis in response to the needs of students at any particular time. Students who required greater learning support could also be selected to participate in workshops or small group tutorials.

Figure A1

Letter from local wildlife park used as Science project entry event

Date:

Dear Year 7 Students,

We are writing to you to assist us in creating information packs for the animals in our wildlife park. Our current information is out of date and we have found that it is not very relevant for younger visitors to our park.

We need you to make information packs for the animals at the wildlife park. As we have so many animals here we would like your group to select one animal. To ensure coverage, we ask that each group targets different animals.

To assist you with your information pack please include the following:

- Images
- Information about the animal
- Classification and evidence to support this
- Characteristics of the species
- Features of living things
- Any relevant information

Thank you in Advance,

The Team at (*name removed*) Wildlife Park

Other Activities and Scaffolds

During this project, there were scaffolded activities that were made available to support the learner but they were not compulsory or necessarily utilised by all students. There were also other events that required student participation or attendance but students were not able to complete surveys at that time as it was

deemed impractical. For example, the same local wildlife park that was named in the entry event led an incursion at the school whereby they introduced students to different animals and discussed their particular classification. Some of these other events and scaffolded activities are evident in the screenshot of project as recorded in the school Learning Management System.

Formative Task

The formative task is an individualised task that captures data for assessment and reporting purposes. It is also used to monitor the progress of the student during the project and is usually placed mid-way through the project. The data captured also assists teachers to plan small group tutorials and workshops. In the case of this project, an online test (on cells and classification) was conducted with the results shared with both teacher and student.

Summative Task

The summative task (or ‘end-product’) after five weeks was to produce an information card on a different animal for primary school-aged visitors to a local wildlife sanctuary. Across the cohort, a set of cards was produced for use in the park.

Chapter 5

How Different Are General and Situational Self-efficacy?

Abstract

The purpose of this study was to examine to what extent general self-efficacy and situation-specific versions of the same construct should be considered manifestations of the same underlying latent factor. In addition, it was studied how well these general and situation-specific measures predicted achievement. To that end, three general and five situation-specific versions of the self-efficacy scale of the Motivated Strategies for Learning Questionnaire (Pintrich et al., 1993) were administered during a five-week course on cell biology in which 186 students of an all-boys high school had to undertake a number of relevant specific tasks for which their situational self-efficacy was assessed. Subsequent to the course, a measure of achievement was administered. Each of the eight measures of self-efficacy showed sufficient construct validity, as exemplified by good model fit. This demonstrated that one latent factor was underlying each of the measures. Subsequently, one general self-efficacy and three related situational measures were submitted to a confirmatory factor analysis to find out the extent to which the four measures were invariant across occasions. This turned out to be the case. The structure of the all measures was identical; evidence that they all measured self-efficacy and not something else. Attempts to load items from the general self-efficacy and related situational measures onto one latent factor failed. A two-factor model provided a more parsimonious fit than a one-factor model. This suggests that the general and the situation-specific versions of the self-efficacy measures must measure different aspects of the construct. Finally, using path analysis, we related three general and five situation-specific self-efficacy measures taken over the course of the cell-biology lessons to each other and to an academic achievement measure. We noticed that general self-efficacy was a

medium strong predictor of academic achievement. The situational self-efficacy measures turned out to be dependent upon the closest preceding general measure, and had no direct relationship with academic achievement as measured at the end of the course. It was concluded that general and situational self-efficacy are measuring different aspects of the learning situation, and that, contrary to opinions championed in the literature, general self-efficacy is a more robust predictor of academic achievement than situational self-efficacy.

[356 words]

Keywords: Situational Self-efficacy; General Self-efficacy; Structural Equation Modelling

How Different Are General and Situational Self-efficacy?

Self-efficacy is a construct central to success in education and elsewhere. It is thought to consist of two elements. One is a judgement of confidence in future performance; a belief in one's ability to succeed in specific situations. Those who are high in self-efficacy tend to consider a difficult task as something to be mastered rather than to escape from (Bandura, 1977). Self-efficacy is thought to be developed though previous experiences with similar tasks. The other element is a behavioural one. Self-efficacy is thought to determine whether an individual will be able to cope with adversity and how long effort will be sustained in the face of obstacles (Stajkovic & Luthans, 1998).

The suggestion that arises from these definitions of self-efficacy is that it seems to be tied to specific tasks rather than being a general dispositional attribute of students. Bandura (1986) himself defines self-efficacy as *"an individual's assessment of (…his or her…) capabilities to organise and execute courses of action needed to perform certain tasks (*p. 391)." Other self-efficacy researchers also stress that self-efficacy is related to a *specific task* at hand and it is not to be conceived as a general dispositional quality of a person that applies to many different contexts (Bandura, 1977; Bandura, 1986; Bandura, 1989, 2012; Duncan & McKeachie, 2005; Gist & Mitchell, 1992; Mathieu et al., 1993; Wolf, 1997; Zimmerman, 2000). In an early article, Bandura (1982) even recommends a microanalytic approach to the measurement of self-efficacy; self-efficacy should be measured separately for tasks varying in difficulty, complexity, or stressfulness; a point of view reiterated recently (Bandura, 2018).

A number of studies measuring self-efficacy have taken Bandura's definition to heart and studied the concept with reference to a particular task or skill. For

instance, Wood et al. (1990) measured self-efficacy of complex decision-making for a specific simulated task. During a business environment simulation, 60 participants were asked how confident they were that they could get the group they were managing to achieve each of the levels of productivity described. Similarly, Sue-Chan and Ong (2002), measured the impact of goal assignment on self-efficacy of 143 university students. Participants were asked how many schedules (out of 14) they were confident in completing during the trial. Niemivirta and Tapola (2007) measured self-efficacy and its relationship to interest and task performance by surveying 100 ninth-grade students three times in 24 minutes, enabling them to explore how self-efficacy develops as the task progressed.

Despite the general consensus among researchers that self-efficacy is situationally determined and should be measured accordingly, existing measures are often operationalised to measure self-efficacy as a trait - a characteristic of a person that is more or less invariant over situations (Chen et al., 2001). For instance, Wolf (1997) measured self-efficacy in group problem solving by surveying 288 hospital food service workers and while acknowledging that self-efficacy is task-specific, she asked subjects to respond to self-efficacy for group problem-solving in general. Zhao et al. (2005) measured entrepreneurial self-efficacy by surveying 265 master of business administration (MBA) students across five universities. Also here, the measurement was about general entrepreneurial self-efficacy and not a measure referring to a specific task or skill. Likewise, in a much-cited study, Compeau and Higgins (1995) measured computer self-efficacy by surveying 1,020 business people. Although these authors underscore that self-efficacy should be measured with respect to a specific task or skill (1995, p. 206), they nevertheless measured the construct in

terms of general computer self-efficacy. See for more examples following a similar approach: Eastin and LaRose (2000) and Klassen and Durksen (2014).

In summary, in the literature one can find studies in which self-efficacy was treated as a general, almost dispositional trait, and studies in which it was measured as a state, linked to a particular task at hand. The question posed in this article therefore is, whether these differences in specificity have an influence on the nature of the construct itself. First, should situational and more general measures of self-efficacy be considered manifestations of the same underlying motivational construct or is it possible that a general measure of self-efficacy measures something different from a situation-specific measure? A test of whether or not both measures load on the same latent factor would provide an initial answer to the question whether or not general and specific self-efficacy are both manifestations of the same underlying psychological construct. Second, assuming that general and situation-specific measures are *not* referring to the same underlying construct, why then assume that different situation-specific measures of self-efficacy are in fact defined by the same underlying construct? A factorial invariance test would answer the question whether situation-specific self-efficacy is so context-specific that every measurement is unique. Third, closely related is the issue of predictability of achievement. Literature suggests that self-efficacy predicts achievement (Chemers et al., 2001; Honicke & Broadbent, 2016; Multon et al., 1991). But is this to the same extent true for general as for situation-specific self-efficacy? To study the relative predictability of achievement by the general and situation-specific measures employed, we developed and tested a path model relating the different measures of self-efficacy to a measure of achievement.

To address these issues, we developed a general and a situation-specific version of the self-efficacy scale from the *Motivated Strategies for Learning*

Questionnaire or MSLQ (Pintrich et al., 1993). Both versions were administered multiple times at various points in time during a five-week course on high-school cell biology, the general self-efficacy measures pertaining to expected success with regard to the particular school subject as a whole and situational measures pertaining to specific activities *within* this school subject. Finally, we regressed an achievement test on the self-efficacy path model.

Method

Participants

The study was undertaken at a Catholic, comprehensive, all boys secondary school located in Western Sydney, NSW, Australia. The school employs project-based learning in the junior and middle school curriculum in academic years 7 to 10 (ages 12 to 16) across all teaching disciplines. The original sample consisted of 186 students. Throughout the course 150 students provided sufficient data for further analysis. Their average age was 12.2 years (*SD* = .40).

The Cell-Biology Course

The science syllabus topic that formed the basis of the five-week project was 'cells,' with sub-topics such as cell theory, the development of microscopes, plant and animal cell structures and classification. During the course, students worked in teams of five and participated in six planned activities (or 'critical learning events') during the project. Table 1 contains short descriptions of these activities. Over the five weeks of this study, there were eight 100-minutes of science lessons, equating to over 13 hours of face-to-face contact with their teachers.

Materials

For the purpose of this study, two self-efficacy scales were used. One scale was intended to measure general self-efficacy (aimed at the course) and the other

measured situation-specific self-efficacy. Both scales were derived from the Self-efficacy subscale of the *Motivated Strategies for Learning Questionnaire* (MSLQ) developed by Pintrich et al. (1993).

Table 1

Time Table of Project Activities and Scheduled General (GSE) and Situational Self-efficacy (SSE) Measurements

Week	Measurement	Project activities
2 weeks prior	GSE 1	N/A
1	SSE 1.1 *(Prior to activity)* SSE 1.2 *(After activity)*	1. Put together a model using confectionary--candy, lollies, jellies--to depict the various parts of animal and plant (eukaryotic) cells.
2	GSE 2 SSE 2.1 *(Prior to activity 1)* SSE 2.2 *(After activity 1; prior to activity 2)* SSE 2.3 *(After activity 2)*	N/A 1. Set up a bifocal microscope (and lamp) and explore its usage and capabilities (e.g. various magnitude of lenses) before labelling a supplied diagram of a microscope. 2. Cut a sliver of plant material, apply a stain and prepare a wet mount slide ready to be viewed under the bifocal microscope.
3	*Other measures taken*	*Not included in this study*
4	GSE 3	N/A
5	Achievement test	

General Self-Efficacy (GSE). The GSE-scale consisted of the eight original self-efficacy items of the MSLQ (see Table A1 in Appendix, left column). The items were scored on a 5-point Likert-type scale, ranging from 1 (*not true at all*) to 5 (*very true for me*). Hancock's coefficient *H* was calculated as a reliability measure. The coefficient *H* is considered a more accurate measure of reliability than the much-used Cronbach's alpha (Hancock & Mueller, 2001; Sijtsma, 2009). Its recommended cut-off value is .70. The coefficient *H for the three GSEs* varied between .89 and .93.

***Situational Self-Efficacy* (SSE).** For the SSE, the eight original self-efficacy items of the MSLQ were slightly modified to measure situation-specific self-efficacy. This was achieved by only changing the wording from "course" in general to "lesson" specific. See Table A1 in Appendix, right column, for the changes. The items were scored on a 5-point Likert-type scale, from 1 (*not true at all*) to 5 (*very true for me*). The coefficient *H for the five SSEs varied* between .93 and .95, which suggest adequate reliability of the measure.

Achievement. Participants' achievement was measured by means of the administration of a *concept retrieval technique* (Hays, 2019; Rotgans & Schmidt, 2014; Yew et al., 2011). The concept retrieval technique is a test that requires students to retrieve from memory as many concepts as possible relevant to the topic of the course. It is based on the idea that students, while learning, develop over time richer and more tightly integrated sematic networks of concepts of a domain (Collins & Loftus, 1975; Glaser & Bassok, 1989). The better integrated and the more comprehensive these semantic networks are, the more concepts will students be able to retrieve. The technique has been demonstrated to have high (interrater) reliability and high construct and predictive validity (Hays, 2019).

Procedure

The general self-efficacy measures were taken three times at regular intervals during the course. The five situational self-efficacy measures were taken throughout the project with reference to specific projects. Table 1 contains a schedule of the various measurements during the course and the specific project activities to which the situational self-efficacy measures pertained. For more information regarding the contents of the course and the concomitant activities see Chapter 4 (Appendix A). The self-efficacy measures were administered online using Qualtrics surveying software (Qualtrics, Provo, UT). The researcher was present in the science laboratories during the data collection and instructed the students when to respond to the questionnaires.

Analysis

All analyses were conducted using Mplus 7.3 (Muthén & Muthén, 2005). First a missing-data analysis was conducted. There was only one type of missing data: missing data due to absence of students at one or more lessons (e.g., illness, late for school). The magnitude of missing data ranged between 0% (at the start of the course) and 8%. To deal with this type of missing data we used the robust maximum likelihood (MLR) and mean-adjusted χ^2 statistics in Mplus (Byrne, 2013).

We decided, to avoid redundancy, not to include all GSE and SSE measures in the initial confirmatory factor analyses (CFAs), tests of invariance, and model fitting, but only measures taken halfway during the course: GSE 2 and SSE 2.1, SSE 2.2, and SSE 2.3. (Similar analyses for the other variables with similar outcomes are available from the authors.)

First, we conducted four confirmatory factor analyses (CFAs) for each measurement administration, i.e. one for the GSE and one for each of the three SSE measurements. To examine the goodness-of-fit for the models, we generated the Root

Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), and Comparative Fit Index (CFI) along with the χ^2 statistic. Cut-off values of .06 (RMSEA), .09 (SRMR) and .95 (CFI) were used in the analysis (Hu & Bentler, 1999).

In a second analysis, we tested factorial invariance of a longitudinal model, which incorporated initially the three SSE measurements. This factorial invariance analysis enabled testing whether the relations between latent variables and their manifest SSE indicators (i.e., their items) are invariant across occasions (Widaman et al., 2010). If they are invariant, it is considered supportive evidence for the assumption that the three SSEs represent the same underlying construct irrespective of occasion. The analysis is conducted by fixing the corresponding factor loadings for each manifest indicator across the three latent variables and comparing the model fit of this restricted model with a freely estimated model in which the factor loadings are not fixed. If there is no significant difference between the restricted and the freely estimated model, it suggests that the factorial structure is invariant between measurement occasions and thus suggests that the situational self-efficacy measured across time represents the same construct. In an additional analysis the GSE was included, to see whether factorial invariance would hold even for the general measure. Invariance across occasions would be considered strong evidence that, even despite a different focus, a whole course versus a specific task, the same theoretical construct of self-efficacy was measured.

As a third step, it was tested whether the situational and general measures loaded on one common factor or on two distinctively different factors. This was done by selecting pairs of GSE and SSE measurements (GSE 2 and SSE 2.1, GSE 2 and SSE 2.2, and GSE 2 and SSE 2.3). It was hypothesised that if a two-factor solution resulted

in a significantly better model fit than a one-factor solution, it would suggest that the general and situation specific measurements of self-efficacy are distinctively different constructs. If, however, a one-factor and a two-factor model did not show significant differences in model fit, it was taken as evidence that there is no empirical difference between the general measure of self-efficacy and the situation-specific measure of self-efficacy. By consulting three different statistics we tested whether there were significant differences between the one- and the two-factor models. First, we used the common difference in chi-square test statistic to examine whether one model fitted better than the other. Second, we examined the difference in CFI vales between both model solutions. According to Cheung and Rensvold (2002) a ΔCFI of .01 is considered significant. Third, we consulted the Akaike Information Criterion (AIC) values to compare the relative fit of the one-vs. two-factor models. The AIC is generally used in structural equation modelling to select among competing non-hierarchical models estimated with the same data (Kline, 2015). The model with the smallest AIC values is chosen as the one most likely to replicate. This is the model with relatively better fit and fewer free parameters compared with competing models (p.220). As such, a smaller AIC value is associated with a better fitting model.

Finally, we tested a path model of self-efficacy regressed upon achievement under the following assumptions: (1) The GSEs measured during the course influence each other as students develop a better understanding as to what is expected from them. (2) Accordingly, academic achievement is better predicted from GSEs administered later in the course. (3) SSEs are solely dependent on a prior measured GSE. (4) Since SSEs are a response to specific tasks, they do not necessarily predict overall academic achievement.

Results and Discussion

Table 2 contains the descriptive statistics of the GSEs and the SSEs. Table 3 contains their product-moment correlations.

Table 2

Means, Standard Deviations, and Ns for the General Self-efficacy Measures and the Situation-Specific Self-efficacy Measures

	Mean	Standard Deviation	N
GSE 1	3.78	.59	150
GSE 2	3.93	.64	150
GSE 3	3.88	.63	150
SSE 1.1	3.87	.53	150
SSE 1.2	3.96	.58	150
SSE 2.1	4.00	.65	150
SSE 2.2	3.98	.56	150
SSE 2.3	3.93	.53	150
Academic Achievement	4.59	2.57	150

To avoid redundancy, we only report here four confirmatory factor analyses that determine the model fit of GSE 2 and its related SSE measures: To what extent do the items belonging to each of these measures represent a single factor? See Table 4 for an overview of the results. The results suggest that the data fitted the models well. Not only the GSE 2 measure (which has been validated before as part of the original MSLQ), but also the situation-specific (SSE) measures of self-efficacy resulted in good model fits. Clearly, both the GSE 2 items and the SSE items each belong to one latent factor.

Table 3

Pearson Product-Moment Correlations Between General Self-efficacy Measures and the Situation-Specific Self-efficacy Measures

	GSE2	GSE 3	SSE 1.1	SSE 1.2	SSE 2.1	SSE 2.2	SSE 2.3	Achieve-ment
GSE1	.69**	.57**	.62**	.56**	.68**	.65**	.50**	.32**
GSE2	-	.69**	.73**	.74**	.93**	.77**	.63**	.36**
GSE3		-	.59**	.61**	.67**	.70**	.63**	.41**
SSE 1.1			-	.81**	.74**	.63**	.55**	.33**
SSE 1.2				-	.73**	.60**	.51**	.25**
SSE 2.1					-	.75**	.64**	.33**
SSE 2.2						-	.77**	.39**
SSE 2.3							-	.30**

*Note. ** Correlation is significant at the 0.01 level (2-tailed)*

Second, tests of factorial invariance were conducted, first for the three situational measures SSE 2.1, SSE 2.2, and SSE 2.3. Such test is used to test whether the items load on the three latent factors in the same way. The respective factor loadings were fixed and the model fit compared with a freely estimated model.

Table 4

Model Fit Statistics for the General Self-efficacy Measure (GSE 2) and the Situation-Specific Self-efficacy Measures (SSE 2.1, SSE 2.2, and SSE 2.3)

Model-Fit Indices	GSE 2	SSE 2.1	SSE 2.2	SSE 2.3
Chi-square	$\chi^2(19, N=150) =$ 32.08, $p = .03$	$\chi^2(19, N=150) =$ 65.42, $p < .01$	$\chi^2(19, N = 142) =$ 41.75, $p < .01$	$\chi^2(19, N =137)$ 33.78, $p = .01$
RMSEA (90%C.I.)	.07 (.02-.11)	.13 (.09-.16)	.09 (.05-.13)	.08 (.03 -.12)
CFI	.98	.95	.97	.98
SRMR	.03	.04	.03	.03

The difference in chi-square test suggests that there was no significant difference between the restricted and unrestricted model: $\Delta\chi^2=10.87$, $\Delta df = 14$, $p = .70$. This outcome suggests that the factorial structure of the SSEs was stable over occasion and that the three situation-specific self-efficacy measures represent one and the same theoretical construct. A second test included also the general version of the self-efficacy measure, GSE 2. The difference in chi-square test suggests that there was no significant difference between the restricted and unrestricted model for the four measures. This finding suggests that the GSE 2 is a manifestation of the same theoretical construct as the situational versions: all measure self-efficacy.

The latter finding does, however, not imply that they all measure the same aspect of the theoretical construct. This would only be the case if all items, general and situational, load on the same factor. As a third step in the analysis, therefore, we examined for the general and each of the situational measures separately, whether a one-or a two-factor model would provide a better fit of the data. This was done by

selecting pairs of GSE 2 and the SSE measures and comparing the model fits associated with two model solutions: Model 1 in which all items of the GSE and the respective SSE loaded on one single factor, and Model 2 in which the respective items loaded on two factors, one GSE and one SSE factor. The results of this analysis are depicted in Table 5.

Table 5

Model Comparisons, One-Factor vs. Two-Factor Models General Self-efficacy (GSE) and Situational Self-efficacy (SSE) Pairs.

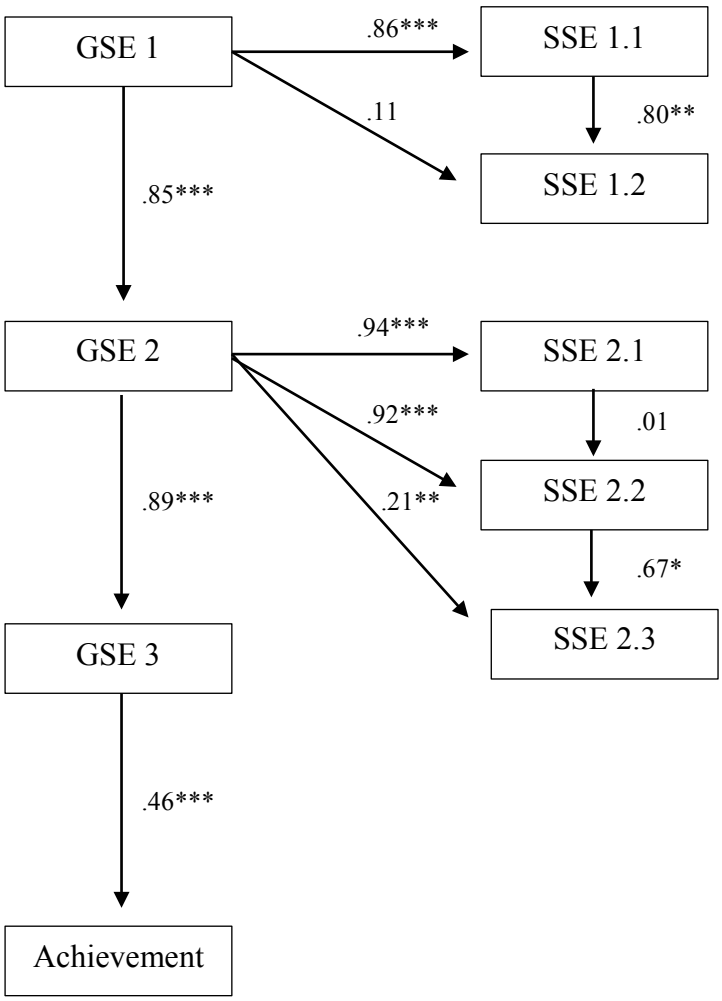
Pair	Factors	Model fit	*AIC*	$\Delta\chi^2$	Δdf
GSE 2-SSE 2.1	One factor	$\chi^2(102, N=150) = 422.64, p<.01$	3899.45	16.49	1
	Two factors	$\chi^2(101, N=150) = 406.15, p<.01$	3884.97		
GSE 2-SSE 2.2	One factor	$\chi^2(102, N=150) = 364.70, p<.01$	3722.72	43.23	1
	Two factors	$\chi^2(101, N=150) = 321.47, p<.01$	3681.50		
GSE 2-SSE 2.3	One factor	$\chi^2(102, N=150) = 361.28, p<.01$	3685.41	73.79	1
	Two factors	$\chi^2(101, N=150) = 287.49, p<.01$	3613.62		

The results demonstrate that for all pairwise comparisons, a two-factor model, in which the GSE and SSE were separate, resulted in significantly better fitting models. All chi-square tests suggest that the one-factor solution was significantly worse than a two-factor solution. In addition, the ΔCFI was larger than .01 and this difference increased exponentially for more distant pairs. Finally, all AIC values were in favour of the two-factor model over a one-factor solution. Overall, the findings

demonstrate that a measure of general self-efficacy loads on a significantly different factor than a situation-specific measure of self-efficacy.

Figure 1

Path Model Relating the General Self-efficacy Measures (GSE 1 to GSE 3) and the Situation-Specific Self-efficacy Measures (SSE 1.1 to SSE 2.3) to Academic Achievement as Measured by the Concept Retrieval Technique (CRT)



Finally, a prediction model, regressing the achievement measure CRT on the self-efficacy measures, was tested. The model was based on the assumptions outlined in the Analysis section. Figure 1 contains the graphical representation of the variables included and their relationships, expressed as beta weights. This model fitted the data reasonably well: $\chi^2(17, N = 186) = 74.25$, $p < .001$; CFI = .98; RMSEA = .13 (90% CI: .10-.17); SRMR = .04. This particular configuration of self-efficacy measures explains 21% of the variance in Academic Achievement. The model allows for a number of conclusions. (1) The general version of the self-efficacy measure is a robust predictor of academic achievement. (2) The general measures taken early in the course do not predict academic achievement as well as those taken later in the course. This suggests that growing experience with the subject matter of the course helps improve the accuracy of the self-efficacy judgement over time. (3) Situational self-efficacy measures should be considered offshoots of the closest preceding general measure, however, the further away in time, the less the influence of the general measure. (4) The situational measures are only related to academic achievement through their relationship with the general measures.

General Discussion

The objective of the present study was to examine to what extent a version of self-efficacy defined as a more or less stable predisposition of a person (GSE), and situation-specific versions of the same construct (SSE) should be considered manifestations of the same underlying psychological construct. In addition, it was studied how well these general and situation-specific measures predicted achievement. To that end, three general and five situation-specific versions of the self-efficacy scale of the MSLQ (Pintrich et al., 1993) were administered over a period of a six-week course on cell biology in which students had to undertake a

number of relevant specific tasks for which their situational self-efficacy was assessed. Subsequent to the course, a measure of achievement was administered. All measures of self-efficacy showed sufficient construct validity, as exemplified by good model fit. This demonstrated that, in line with previous findings of Pintrich et al. (1993), one latent factor was underlying each of the measures. Subsequently, one GSE and three related SSEs were submitted to a confirmatory factor analysis to find out the extent to which the four measures were invariant over occasion. This turned out to be the case; each instrument measured self-efficacy in the same way, i.e., displaying the same loadings on the same items over occasion. The structure of the GSE and the related SSEs was identical; strong evidence that they all measured self-efficacy and not something else.

Interestingly, attempts to load items from the GSE and related SSEs onto one latent factor failed decisively. In all three attempts, a two-factor model provided a more parsimonious fit than a one-factor model. This suggests that the general and the situation-specific versions of the self-efficacy measures must measure subtly different aspects of the construct. How these findings can be reconciled with the previous finding of factorial invariance among these measures is a topic for further study.

Finally, using path analysis, we related three GSEs and five SSEs taken over the course of the cell-biology lessons to each other and to an academic achievement measure administered at the end of the course under study. We noticed that general self-efficacy, that is a recurrent judgement of one's competence with regard to mastery of the particular subject matter, was a rather strong predictor of academic achievement. The situational self-efficacy measures turned out to be dependent upon the closest preceding GSE, and entertained no direct relationship with academic achievement as measured at the end of the course. This would of course not preclude

the possibility that they would adequately predict achievement directly related to the tasks given to the students.

What do these findings suggest? The first is that those advocating the measurement of self-efficacy as a situation-specific construct at the expense of a more general version of it, among them Bandura himself (Bandura, 1977, 1982; Bandura, 2012, 2018), may be overstating their case. We found that on the contrary, more general self-efficacy measures were superior in predicting achievement than the more task-specific versions of it. Of course, proponents of the task-specific nature of self-efficacy may argue that self-efficacy with regard to cell biology is also task-specific and therefore, no discrepancy between their point of view and our findings exist. However, Bandura himself advocates a microanalytic approach to measuring self-efficacy; it should be measured separately for tasks varying in difficulty, complexity, or stressfulness, much in the way we and other researchers have attempted (Niemivirta & Tapola, 2007; Sue-Chan & Ong, 2002; Wood et al., 1990). Besides, many other constructs relevant to learning, such as interest (Hidi & Renninger, 2006), curiosity (Silvia, 2017), and achievement motivation (Ferrell et al., 2016; Wang et al., 2017) are often tied to specific subject matter. Construing such variables as content-independent traits has shown to be less than helpful.

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Chapter 5: Appendix A

Table A1

General self-efficacy (i.e., original MSLQ scale) and the situation-specific self-efficacy items. Adapted from Pintrich et al. (1993).

General Self-efficacy scale (GSE)	Situation-specific Self-efficacy scale (SSE)
I believe I will receive an excellent grade in this *course*.	I believe I will receive an excellent grade in this *lesson*.
I'm certain I can understand the most difficult material presented in the readings for this *course*.	I'm certain I can understand the most difficult material presented in the readings for this *lesson*.
I'm confident I can understand the basic concepts taught in this *course*.	I'm confident I can understand the basic concepts taught in this *lesson*.
I'm confident I can understand the most complex material presented by the instructor in this *course*.	I'm confident I can understand the most complex material presented by the instructor in this *lesson*.
I'm confident I can do an excellent job on the assignments and tests in this *course*.	I'm confident I can do an excellent job on the assignments and tests in this *lesson*.
I expect to do well in this *course*.	I expect to do well in this *lesson*.
I'm certain I can master the skills being taught in this *course*.	I'm certain I can master the skills being taught in this *lesson*.
Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this *course*.	Considering the difficulty of this *lesson*, the teacher, and my skills, I think I will do well in this *lesson*.

Chapter 6

The Causal Relationship Between Academic Self-efficacy and Academic Performance: A Four-Wave Cross-Lagged Panel Analysis

Abstract

Academic self-efficacy is defined as a student's judgement about his or her ability to attain educational goals. Academic self-efficacy has predominantly been used to predict academic achievement. The objective of the present study was to investigate how academic self-efficacy and knowledge acquisition are causally related. Three hypotheses were tested simultaneously using a four-wave cross-lagged panel analysis involving students from an all boys school in Australia (N = 186). The first hypothesis assumed that academic self-efficacy causally influences subsequent achievement. The second hypothesis considered academic self-efficacy to be a consequence of prior knowledge acquisition. The third hypothesis predicted that academic self-efficacy and knowledge are reciprocally related to each other. The results of the analysis lend support to the first hypothesis and not to the second and third hypothesis: academic self-efficacy determines the extent to which students acquire knowledge regarding a topic. Implications of these findings for self-efficacy research and theory are discussed.

[151 words]

Keywords: Academic self-efficacy; knowledge acquisition; autoregressive cross-lagged panel analysis; causality

Introduction

Students' beliefs about their abilities to complete a given task is one of the most powerful predictors of academic success (Chemers et al., 2001; Pajares, 1996; Pajares & Graham, 1999; Schunk, 1985; Van Dinther et al., 2011; Zimmerman, 1995). This capability of making self-judgements about one's ability in educational settings is often referred to as academic self-efficacy (Honicke & Broadbent, 2016; Pajares & Schunk, 2001). Research findings have consistently demonstrated that academic self-efficacy and academic performance are moderately and positively correlated. For instance, Brady-Amoon and Fuertes (2011) conducted a cross-sectional study involving 271 liberal arts college students and reported a correlation of $r = .22$ ($p < .01$) between self-efficacy and GPA scores. Somewhat higher correlations were found in a study by Krumrei-Mancuso et al. (2013), $r = .36$ ($p < .01$) involving 579 first-year college students' self-efficacy and first semester grades. Also, in a longitudinal study by Cheng and Chiou (2010), with 124 college accounting students, self-efficacy correlated positively with academic performance at three points in time: $r = .32$. $r = .40$, $r = .38$ ($p < .01$). In a recent meta-analysis, examining the correlations between self-efficacy and academic performance among 51 studies, a similar outcome was observed; the average correlation was $r = .33$ (Honicke & Broadbent, 2016).

Despite the consistent positive correlations found between academic self-efficacy and academic performance, and the suggestion that these correlations imply that academic self-efficacy is a cause of achievement, in fact nothing more can be said about the causal directionality of the effect. There is research that demonstrates the reverse that performance outcomes determine to a large extent academic self-efficacy. For instance, Klassen (2004) conducted a study with secondary school mathematics

students and found a substantial positive correlation between previous mathematics grades and academic self-efficacy of $r = .44$ ($p < .01$). These findings were replicated in a more recent study by Lee et al. (2015) in which first semester GPA correlated positively ($r = .30$, $p < .01$) with academic self-efficacy a year later. Considering these findings, one cannot rule out the possibility that academic self-efficacy is not only determined by previous mastery experiences but may be merely a proxy for past performance with limited predictive power (Heggestad & Kanfer, 2005).

To investigate the issue of causality, research is needed to explore whether academic self-efficacy leads to academic outcomes or whether academic outcomes determine the extent to which someone feels self-efficacious. There is a third possibility that needs to be considered, namely that the relationship between these variables is reciprocal. It is plausible that not one leads to the other, but that performance on a test signals content mastery to the student and that this boosts the feeling of self-efficacy, which in turn is an impetus to do well on a subsequent test, and so on. In short, to advance the field further and inform educational practice, it is important to clarify this issue of causality between academic self-efficacy and academic performance and whether they are reciprocally related (c.f., Honicke & Broadbent, 2016).

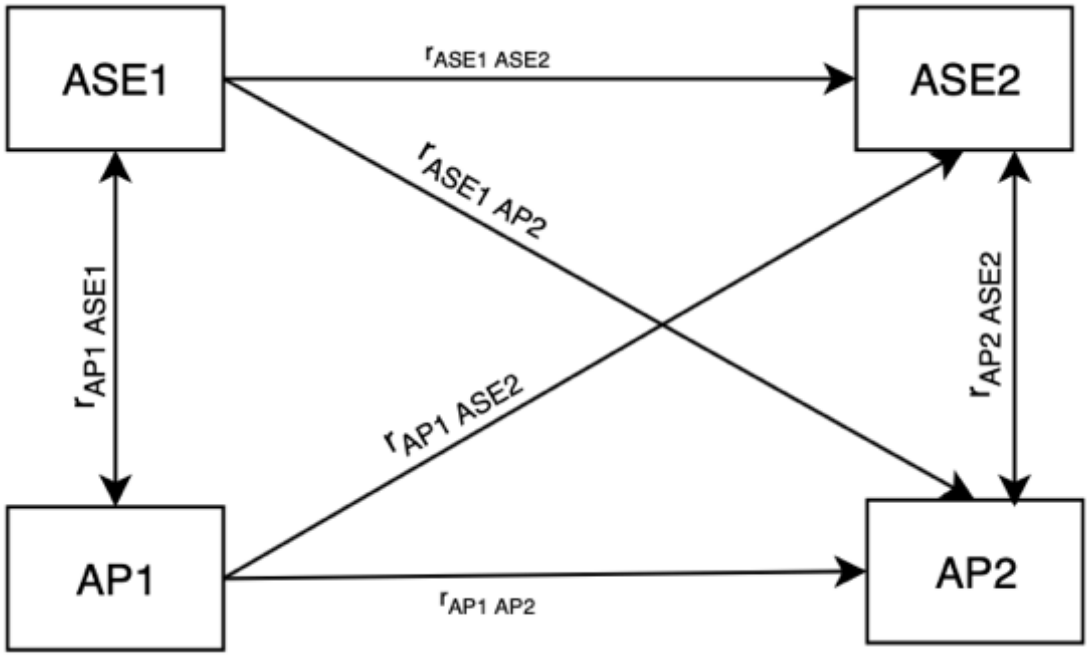
It should be stressed at this point that the manner in which these variables are causally related has significant educational implications. If it turns out that academic achievement is the causal factor in determining the extent to which students feel self-efficacious, the major practical implication would be to provide extensive performance feedback to students to enhance their self-efficacy for the topic in question. However, if on the other hand self-efficacy largely determines how well students perform, other antecedent variables need to be considered that influence self-

efficacy, such as verbal and social persuasion and encouragement and emotional support (Bandura, 1986, 1997, 2001).

A suitable methodological approach to study the issue of causality in classroom settings is "cross-lagged panel analysis" (Pajares, 1996; Villafañe et al., 2016). An example of such approach can be found in a recent study by Talsma et al. (2018). In their analysis, two waves of data were included measuring self-efficacy and academic performance at two points in time. See Figure 1 for an overview of their crossed-lagged design. With these data it is possible to analyse the *cross-paths* to explore how the variables are causally related.

Figure 1

Conceptual Model of a Two-Wave Cross-lagged Design for Academic Self-efficacy (ASE) and Achievement Performance (AP).



As Figure 1 exemplifies, the model includes two measures of academic self-efficacy (ASE) and two measures of academic performance (AP). The test–retest correlations of academic self-efficacy and academic performance are represented by $r_{ASE_1 \cdot ASE_2}$ and $r_{AP_1 \cdot AP_2}$. The relationship between academic self-efficacy at time 1 and academic performance at time 2 ($r_{ASE_1 \cdot AP_2}$) versus the relationship of academic performance at time 1 and academic self-efficacy at time 2 ($r_{AP_1 \cdot ASE_2}$) are the critical coefficients and central to the analysis. If academic self-efficacy is the precursor of academic performance, then $r_{ASE_1 \cdot AP_2}$ should exceed $r_{AP_1 \cdot ASE_2}$. In contrast, $r_{AP_1 \cdot ASE_2}$ should be greater than $r_{ASE_1 \cdot AP_2}$ if academic performance is a precursor to academic self-efficacy. If both are significantly different from zero and non-significantly different from each other, then this can be read as support for the reciprocal influence of both variables on each other. Finally, if both would be non-significantly different from zero, one would have to conclude that no causal relationship exists or that other, unobserved, variables influence academic self-efficacy and academic performance.

Since, Talsma et al. (2018) used data from existing studies, their analysis is classified as a *meta-analytic* cross-lagged panel analysis. The results of their study suggest that academic performance had a stronger positive effect on academic self-efficacy (standardized $\beta = .21$, $p < .001$) than academic self-efficacy on academic performance (standardized $\beta = .07$, $p < .001$). The authors interpret this outcome as proof for the reciprocity between both variables (p.142). Although the authors are correct that reciprocality has been established since both paths were statistically significant, one also should evaluate the magnitude of the path coefficient since it provides additional insights in the strength of association. In their study, the path coefficient between academic self-efficacy and academic performance was

substantially lower, in fact three times lower than the path coefficient between academic performance and academic self-efficacy. Based on these data, one can infer that academic performance determines academic self-efficacy. There are a few additional methodological limitations that need to be highlighted.

First, although a meta-analysis is considered the gold standard when it comes to synthesising results from multiple studies, there were only 11 studies included in the Talsma et al. (2018) study, which limits the validity of the results (please note, these 11 studies were whittled down from 5487 relevant identified studies after the authors removed duplicates and determined those that fitted their design brief). An additional complication is that the results of these 11 studies were highly heterogeneous (I^2 ranging from 31% to 89%). Heterogeneous outcomes are often the result of differences between studies in terms of instructional method, methodological design, use of variables and instruments. These differences may cause a significant amount of variability that makes it challenging to interpret the data and draw reliable conclusions (Higgins & Thompson, 2002).

A second limitation of the study is that only two waves of data were included. When investigating the question of reciprocity, having access to only two waves of data is less than ideal and only allows addressing the question of causality. To fully investigate reciprocity, at least three waves of data are needed: academic self-efficacy → academic performance → academic self-efficacy and academic performance → academic self-efficacy → academic performance. A study that used three waves of data was conducted by Olivier et al. (2019). In this study, 671 students from seven elementary schools participated. Three waves of math self-efficacy and teacher-rated math performance data were collected at the 4^{th}, 5^{th} and 6^{th} grade respectively. The results of the cross-lagged panel analysis suggest that both academic self-efficacy and

academic performance were related to each other over time. Closer inspection of their path model suggests that the influence of academic self-efficacy on academic performance was slightly higher (standardized $\beta = .21$, $p < .001$ and $\beta = .17$, $p < .001$ respectively) as compared to academic performance on academic self-efficacy (standardized $\beta = .14$, $p < .001$ and $\beta = .11$, $p < .05$ respectively). According to the authors, these findings provide overall support for self-efficacy theory since they demonstrate the long-lasting effect of academic self-efficacy on students' achievement over the three years of schooling and also the reciprocal effect of academic performance on subsequent judgements of academic self-efficacy.

Although these findings are generally in-line with self-efficacy theory, the study has potential shortcomings that need to be addressed. First, the academic performance data used in their cross-lagged panel analysis was based on teacher judgements of students' math performance. As the authors admit, this is a significant limitation because it is a subjective measure of academic performance; a standardised test or official performance grade would have been a more accurate measure of academic performance. A second limitation is that according to Bandura (1997) and colleagues, students' academic self-efficacy is a construct that is context- and task-dependent (Pajares, 1996; Villafañe et al., 2016). Measuring general self-efficacy, without specific reference to a topic, over three years of schooling may be a too expansive measure of self-efficacy. It is therefore questionable if this general measure of academic self-efficacy, used in combination with teacher-judgements of students' performance over a three-year period, constitutes an appropriate operationalisation of self-efficacy theory.

The objective of the present study was to build on the above studies by addressing their limitations. First, we conducted a study utilising a multi-wave cross-

lagged panel analysis for which four waves of academic self-efficacy/academic performance data were collected. Having four waves of data enabled adequate exploration of causality and the reciprocity effect as compared to a two-wave design. See Figure 2 for an overview of the four-wave design. Second, we addressed the issue of context and task dependency of academic self-efficacy by restricting our investigation to a specific chemistry unit on the topic: physical and chemical changes (See Appendix A for a description of the topic). In addition, students' academic performance was assessed by means of an objective test, rather than teachers' judgements. Finally, the four-wave design enabled us to test three hypotheses simultaneously.

The first hypothesis tested the "standard hypothesis of self-efficacy," which predicts that academic self-efficacy determines academic performance (Brady, Amoon & Fuertes, 2011; Cheng & Chiou, 2010; Elias & MacDonald, 2007; Krumrei-Mancuso et al., 2013; Merolla, 2017; Richardson et al., 2012). The second hypothesis is the "by-product hypothesis of self-efficacy," which predicts that academic self-efficacy is a by-product of knowledge gains: academic performance determines academic self-efficacy (Heggestad & Kanfer, 2005; Klassen, 2004; Lee et al., 2015). The third hypothesis is the "reciprocity hypothesis of self-efficacy" and predicts that academic self-efficacy determines academic performance, which in turn determines academic self-efficacy and so on (Honicke & Broadbent, 2016; Talsma et al., 2018; Villafañe et al., 2016).

Method

Participants

The study was undertaken at a Catholic comprehensive all boys' secondary school located in Western Sydney, NSW, Australia. The sample consisted of 186

male students. Their average age was 13 years (*SD* = .38). All participants were enrolled in a chemistry project based on the state-endorsed syllabus topic of *Physical and Chemical Changes*. This study was carried out with the approval of the local Diocese, the institution responsible for the governance of the school (in which the study was conducted) as well as the granting body for ethics approval.

The desirable sample size was computed based on the studies discussed in the Introduction section. The correlations between self-efficacy and academic performance ranged from .07 to .44, with a mean correlation of .26. The sample size can then be computed with the formula (Hulley et al., 2013):

$$n = [(Z_\alpha + Z_\beta)/C]^2 + 3$$

(https://sample-size.net/correlation-sample-size/) where = Z_α is the standard normal deviate for α, Z_β is the standard normal deviate for β, and $C = 0.5 * \ln[(1+r)/(1-r)]$. From this it follows that n should be at least equal to 114. This suggests that our samples are sufficiently large.

Materials

Academic Self-efficacy (ASE). The academic self-efficacy scale was adopted from the *Motivated Strategies for Learning Questionnaire* (MSLQ) developed by Pintrich, Smith, Garcia, & McKeachie, (1991). The scale consisted of the eight items (e.g., "I believe I will receive an excellent grade in this course"). The items were scored on a 5-point Likert-type scale, ranging from 1 (*not true at all*) to 5 (*very true for me*). Hancock's coefficient *H* was calculated as a reliability measure. The coefficient *H* is considered a more accurate measure of reliability than the much-used Cronbach's alpha (Hancock & Mueller, 2001; Sijtsma, 2009). Its recommended cut-off value is .70. The coefficient *H* for the four measurements was H_1 = .86, H_2 = .93,

H_3 = .95, and H_4 = .95.

Academic Performance (AP). Participants' knowledge acquisition was measured by means of a *Concept Retrieval Technique,* or CRT (Hays, 2019). The CRT is an established free-recall knowledge measure that requires participants to write down all the concepts and ideas they can recall about a given topic. A further instruction is that only keywords or bullet points are admissible and not full sentences. The CRT is a valid and reliable measure that is capable of measuring the growth of students' knowledge over time, focusing on the number of relevant concepts students attain during learning (Rotgans & Schmidt, 2014). The CRT was scored against a list containing all admissible concepts (the "answer key"), devised by subject experts beforehand. The list was based on the main concepts or ideas extracted from the learning resources students had to read regarding the topic at hand. The answer key was used to score each student's CRT by two independent raters. For each correct concept, participants were awarded one point. Inter-rater agreement (Cohen's kappa) for the four CRTs was κ_1 =.89, κ_2 =.92, κ_3 = 1.00 and κ_4 = 1.00. Inter-rater discrepancies were resolved through discussion.

Procedure

Data were collected during a five-week chemistry unit. There were a total of eight (100-minute) chemistry lessons during that period of time. The science syllabus topic that formed the basis of the project was physical and chemical changes. The topic was taught by means of Project-Based Learning, which entailed that students participate in a project entitled 'Flying Colours' with the task of putting together a proposal for a unique local fireworks display that did minimal damage to the environment and surrounding buildings. The proposal was to be presented to one local councillor and parent who was a pyrotechnics expert. The underlying science syllabus

topic that formed the basis of this project was ‘physical and chemical changes’ and focused on understanding, comparing and contrasting physical and chemical changes, for example, comparing changes in terms of the arrangement of particles and reversibility of the processes (See Appendix A for a more detailed description). Students worked relatively independently in small teams of five students. The teacher acted as a facilitator and provided regular feedback to the individual teams and students as well as ensuring the project briefcase on the learning management system was updated. The academic self-efficacy measures and academic performance measures were administered every alternating lesson online using the Qualtrics surveying software (Qualtrics, Provo, UT). This was done at the beginning of the lesson, before it commenced. The first author was present during all administrations and provided the instructions to the students following a protocol. During the administrations, students were not allowed to communicate with each other or consult any resources. Once they completed the questionnaire and the knowledge test, they commenced with the lesson.

Analysis

All analyses were conducted using Mplus 7.3 (Muthén & Muthén, 1998-2012). First, an analysis of missing data was conducted. Missing data was due to absence of participants at one or more of the sessions (e.g., illness, late for class). The magnitude of the missing data for the sessions was: First session 9% (17 students absent), second session 19% (36 students absent), third session 20% (37 students absent) and for the fourth session 14% (25 students absent). To deal with this type of missing data we used the robust maximum likelihood (MLR) and mean-adjusted χ^2 statistics in Mplus (Byrne, 2012). As students were nested within their classes (6 classes participated), we applied the “complex” option in Mplus, which provides a

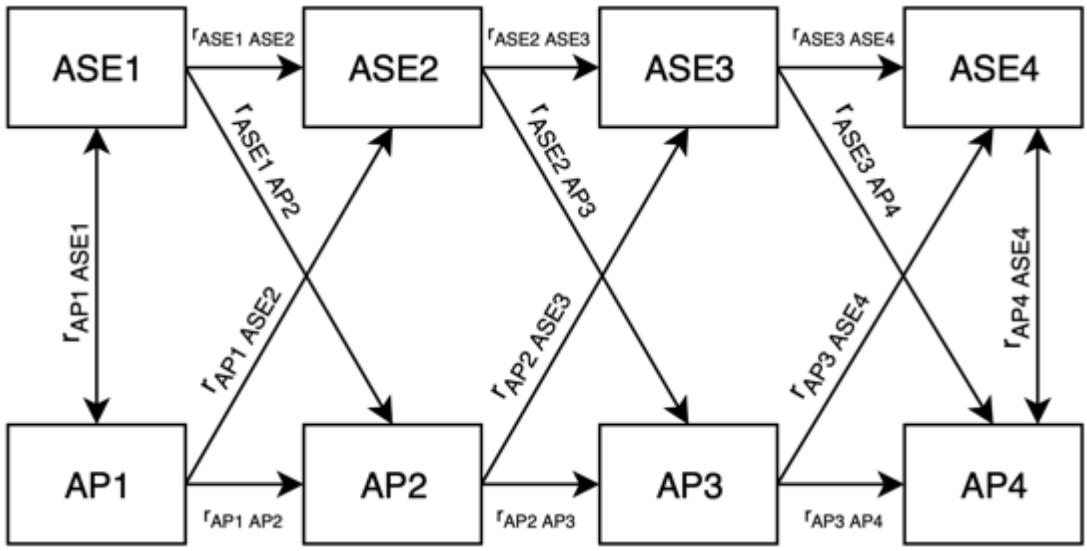
standard error adjustment.

We then tested an autoregressive cross-lagged model (see Figure 2). To examine the goodness-of-fit for the model, we generated the Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), and Comparative Fit Index (CFI) along with the χ^2 statistic. Cut-off values of .06 (RMSEA), .09 (SRMR) and .95 (CFI) were used in the analysis (Hu & Bentler, 1999).

This model enabled us to examine the (causal) relations between the variables of interest academic self-efficacy (ASE) and academic performance (AP) across four waves of data. See Figure 2 for an overview of this approach.

Figure 2

Conceptual Model of a Cross-Lag Design for Academic Self-efficacy (ASE) and Academic Performance (AP) for Four Waves of Data.



The model depicted in Figure 2 shows the measurements of academic self-efficacy (ASE1 to ASE4) and the measures of academic performance (AP1 to AP4).

The test–retest correlations of ASE and academic performance are represented by $r_{ASE_1 \cdot ASE_2}$, $r_{ASE_2 \cdot ASE_3}$, $r_{ASE_3 \cdot ASE_4}$ and $r_{AP_1 \cdot AP_2}$., $r_{AP_2 \cdot AP_3}$, $r_{AP_3 \cdot AP_4}$. The relation between academic self-efficacy at time A and academic performance at time B (e.g., $r_{ASE_1 \cdot AP_2}$) versus the relation of academic performance at time A and academic self-efficacy at time B ($r_{AP_1 \cdot ASE_2}$) are the critical coefficients and central to the analysis. If academic self-efficacy is the precursor of academic performance, then $r_{ASE_A \cdot AP_B}$ should exceed $r_{AP_A \cdot ASE_B}$. In contrast $r_{AP_A \cdot ASE_B}$ should be greater than $r_{ASE_A \cdot AP_B}$ if academic performance is a precursor of academic self-efficacy. If both are significantly different from zero and non-significantly different from each other, then this can be read as support for a reciprocal influence of both variables. Finally, if both cross-effects would be non-significantly different from zero, one would have to conclude that no causal relation exists or that other, unobserved, variables influence academic self-efficacy and academic performance.

Results

As an initial step we tested whether the data fitted the auto-regressive cross-lag model. The results suggest that the data fitted the model well: $\chi^2(14) = 23.77$, $p = .049$; CFI = .98; RMSEA = .06 (90% CI: .01-.10); SRMR = .04. See Table 1 for an overview of the zero-order correlations and descriptive statistics.

Inspecting the model, both autoregressive paths for academic self-efficacy (ASE) and academic performance (AP) were all significant; that is, the standardized path coefficients between the first measure and the second and the second and the third measure etc. were statistically significant ($p < .001$). We then inspected the relations between ASE and AP. See Figure 3 for an overview of the results. Of particular interest are the crossed relations between the previous ASE measure and the following AP measure and the previous AP measure and the following ASE measure.

The model demonstrates that only the measure of ASE predicted the subsequent measures of AP, with the exception of the first measure: ASE1 → AP2, standardized $\beta = .01$, $p = .94$, ASE2 → AP3, standardized $\beta = .27$, $p < .001$, and ASE3 → AP4, standardized $\beta = .24$, $p < .001$. The path coefficients leading from AP to ASE were all not statistically significant: AP1 → ASE2, standardized $\beta = .04$, $p = .46$, AP2 → ASE3, standardized $\beta = .04$, $p = .45$, and AP3 → ASE4, standardized $\beta = .02$, $p = .70$.

Table 1

Zero-Order Correlations and Descriptive Statistics (M and SD) for the Four Measure of Academic Self-efficacy (ASE) and Academic Performance (AP)

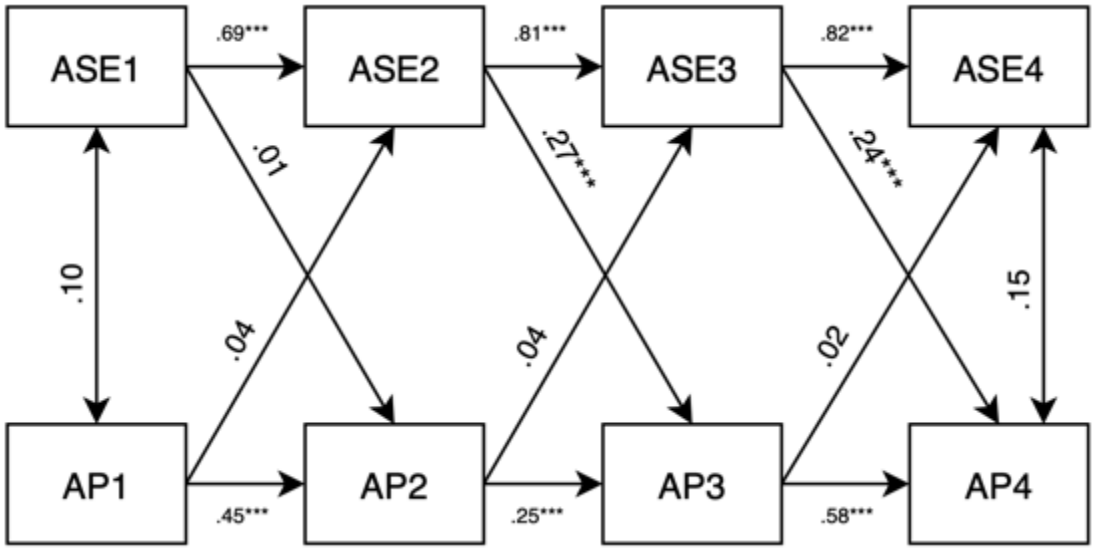
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) ASE_1	-	.68**	.63**	.55**	.08	.18*	.20*	.41**
(2) ASE_2		-	.78**	.72**	.14	.30**	.37**	.41**
(3) ASE_3			-	.80**	.09	.21*	.33**	.40**
(4) ASE_4				-	.14	.17	.36**	.44**
(5) AP_1					-	.26**	.20*	.31**
(6) AP_2						-	.63**	.63**
(7) AP_3							-	.64**
(8) AP_4								-
M	3.74	3.80	3.93	3.86	.94	5.30	5.02	4.56
SD	.63	.65	.66	.67	.91	3.43	3.46	2.76

Note: * $p < .05$, ** $p < .01$

Figure 3

Autoregressive Four-Wave Cross-Lagged Panel Model for Academic Self-efficacy (ASE) and Academic Performance (AP) for Four Waves of Data.

Note: *$p < .05$, **$p < .01$, ***$p < .001$



Discussion

The objective of the present study was to elucidate the causal relationship between academic self-efficacy and academic performance. To that end, we conducted a cross-lagged panel analysis with four waves of data, collected during a project-based chemistry unit spanning five weeks. Three hypotheses were tested: (1) the "standard hypothesis of self-efficacy" which predicts that academic self-efficacy determines academic performance; (2) the "by-product hypothesis of self-efficacy" which predicts that academic self-efficacy is the by-product of knowledge gains; academic performance determines academic self-efficacy; and (3) the "reciprocity hypothesis of self-efficacy" which predicts that academic self-efficacy determines academic performance, which in turn determines academic self-efficacy, etc.

Our data lend support for the "standard hypothesis of self-efficacy." The only significant cross paths in our model were from academic self-efficacy to academic performance. None of the cross paths from academic performance to academic self-efficacy were statistically significant. Thus, we could neither find supporting evidence for the hypothesis that level of academic achievement causes level of academic self-efficacy (e.g., Heggestad & Kanfer, 2005; Klassen, 2004), nor that reciprocal interactions between academic self-efficacy and academic performance existed (e.g., Olivier et al., 2019).

Before we further elaborate on these findings, we first have to provide a clarification regarding the first cross path from academic self-efficacy to academic performance. All paths were significant, with the exception of the first academic self-efficacy measure on the subsequent performance measure. However, this is not surprising considering that the first measure of academic self-efficacy was administered at the very start of the project, before it commenced. Hence, students could not have been fully aware of what to expect, which most likely affected their ability to make an accurate judgement of how self-efficacious they expect to be during the unit. It is conceivable that students had to derive their judgement from their 'general chemistry self-efficacy' beliefs. The fact that it did not predict subsequent academic performance (one week later) once again underscores the notion that academic self-efficacy is context- and task-dependent (Bandura, 1997; Pajares, 1996; Villafañe et al., 2016).

The finding that we only observed significant causal relations between academic self-efficacy and academic performance, without reciprocity, appears somewhat counterintuitive. One would expect that if a student does well on a test, it would strengthen the student's self-efficacy beliefs for the topic in question. In turn,

feeling more self-efficacious is expected to lead to more task engagement (Fredricks et al., 2004), which must lead to better learning and performance on a subsequent test. This is in line with the suggestions provided by Olivier (2019). In their study they found positive and significant cross paths in their three-wave cross-lagged panel model, which they interpreted as evidence in support of reciprocity. However, there are two issues that need to be considered when making this claim. First, it is not sufficient to only examine whether the cross paths are statistically significantly different from zero; one also has to consider the magnitude of the correlation (i.e. the effect). It is interesting to note that in the Olivier (2019) study, the cross paths leading from academic performance to academic self-efficacy were consistently lower, almost half the effect size of the correlations between academic self-efficacy and academic performance, than? similar findings of the Talsma (2018) study. Thus, their outcome is not that much different from the present study: it appears that the effect of academic self-efficacy is a stronger predictor of performance than academic performance as predictor of self-efficacy. This leads to the second issue.

This second and more critical issue is that in most studies that examined the causality question, the effect of the *instructional method* on academic self-efficacy is often overlooked (c.f., the Talsma (2018) study mentioned earlier in which the instructional methods of the included studies were highly heterogeneous). According to Bandura (1986, 1997, 2001), there are four sources of self-efficacy: (1) *mastery experience* (e.g., successfully completing a task, or performing well on a test); (2) *vicarious experience* (e.g., benchmarking one's performance to someone similar; if a student performs better on a test than all other students in class, he/she feels more self-efficacious); (3) *verbal and social persuasion* (e.g., encouragement by someone else to perform well on a task; a teacher providing encouraging feedback to a

student); and (4) *emotional physiological arousal* (e.g., a student feeling anxious or stressed to perform a task, which can be interpreted by the student as lacking skill or ability to perform the task and negatively impacts self-efficacy).

We argue that the presence or the absence of these four sources of self-efficacy are largely determined by the instructional landscape. If the causality issue is studied in the context of a conventional lecture-based curriculum, the most prevalent source of academic self-efficacy is mastery experience. That is, receiving feedback about one's performance predominantly comes from tests and exams. However, if the instructional environment is more self-directed, as it was the case with our sample, where students worked independently in small teams, under limited supervision of an instructor, and received periodic group and individual feedback from the instructor, other sources of self-efficacy become more obvious. It is conceivable that in our project-based learning setting, students were less reliant on mastery experiences as source of their academic self-efficacy, which would explain the low and non-significant correlations between academic performance and academic self-efficacy. In fact, the CRTs we administered did not provide formal performance feedback, other than that students themselves may have sensed how well they did (i.e., how many concepts they were able to retrieve). Instead, the students were exposed to many of the other sources of academic self-efficacy. For instance, students would have encountered vicarious experiences by comparing their learning and understanding of the topic with other peers in their group and in class when sharing and discussing the project assignments. Second, students were frequently exposed to verbal and social persuasion by the instructor when he/she checked on the progress of the groups and the individual students. Moreover, it is likely that students within a group encouraged and supported each other to complete the tasks. Third, it is well known that active-

learning environments, such as project-based learning, make students feel more autonomous and self-directed, which reduces stress and anxiety as compared to lecture-based environment with high-stake exams (Lam et al., 2009; Otake et al., 2009; Stefanou et al., 2013; Stefanou et al., 2004; Yuliani & Lengkanawati, 2017). In summary, we propose that in learning environments that support multiple sources of self-efficacy, there is less dependence on mastery experience as the main source of self-efficacy than in more classic learning environments. We suggest that this may explain why academic performance was not a significant predictor of academic self-efficacy in our sample and why no reciprocal relation with academic performance could be established. Needless to say that this explanation is only temporary and requires empirical testing by means of an experiment in which the four sources of self-efficacy are systematically manipulated. A final potential shortcoming of our study is that we only had access to male students. Although most studies that investigated the effects of gender differences on self-efficacy showed generally no significant effects (Busch, 1995a, 1995b), it cannot be ruled out that there are some and thus warrant further investigation.

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Chapter 6: Appendix A

Description of Project Under Study

The Science project used in this study was entitled 'Flying Colours'. It was a stand-alone five-week Science project (i.e., not integrated with other subjects as is common practice at the school when there is overlapping or complementary content and skills). Students were organised into groups of five. The 'entry event' used to launch the project was a request from a local councillor (with connections to the school) to put together a proposal for a unique fireworks display that did minimal damage to the environment and surrounding buildings. It was to be presented to one local councillor.

Additionally, a parent of a student at the school was invited in as an external thought partner given their professional background in pyrotechnics. The councillor and parent were also involved in assessing the project against a rubric (with the two teachers completing the 'panel'). As indicated in the project description above, the underlying science syllabus topic that formed the basis of this project was 'physical and chemical changes'. This topic focused on understanding, comparing and contrasting physical and chemical changes, for example, comparing changes in terms of the arrangement of particles and reversibility of the processes. Students also look at the discoveries about the properties of elements, compounds and mixtures, chemical reactions in the production of a range of substances; relate changes in the physical properties of matter to heat energy and particle movement that occur during observations of evaporation, condensation, boiling, melting and freezing; and, understanding that in a chemical change, new substances are formed, which may have specific properties related to their uses in everyday life.

Further to this, students had to apply these scientific principles to firstly test different chemicals safely and under supervision (i.e. flame tests); plan a safe fireworks display using chemical properties (e.g. different metals/chemicals to be included in display for colour and effect), assess the displays ecological and environmental impact as a consequence of the chemicals used (e.g., the chemical and physical weathering of surrounding landmarks as a consequence of their fireworks display); and then, put together a presentation to be shown to the panel.

An individual formative assessment was set midway through the project and was an online quiz on physical and chemical changes undertaken through the school's learning management system. The project's summative task (or 'end product') for a colourful fireworks display was a group task and required a detailed explanation of the scientific concepts that underpin their concept.

Chapter 7

*Project-based learning Groups of Friends and Acquaintances: The Role of Efficacy Beliefs**

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Abstract

This school-based study explored the role of collective and proxy efficacy beliefs in the performances of project-based learning teams comprising friends and acquaintances. Participants were 162 male students in Grade 8 who attended a Catholic high school, located in Sydney, Australia. Students were organized into 20 acquaintance groups and 21 friendship groups. Each group comprised 4 students who were completing project-based learning assignments in Geography, Religious Studies, and English. Data were self-reports and teacher-assessed group performance scores. Data collection occurred 3 times over a five-week period. Multilevel modeling was used to examine relationships between variables in the study. Statistically significant interactions involving group type, collective efficacy and proxy efficacy were identified in Geography and Religious Studies. Implications are that it may be advantageous for teachers to assign students to friendship groups, provided they nurture collective efficacy, and that proxy efficacy may negatively affect group performance, depending on the context.

[149 words]

Keywords: Collective efficacy; Friendship; Project-based learning; Proxy efficacy

Introduction

Historically, whole-class teaching, which refers to teacher-led instruction of an entire class, has been the dominant mode of instruction in classrooms (Galton, Hargreaves & Pell, 2009). As a consequence, it appears that relatively few studies have been carried out in school settings where working in groups is the predominant mode in which teaching and learning takes place (Baines, Blatchford & Webster, 2015). This study was carried out in a single high school in Sydney, Australia because it was known that project-based learning was the main mode of instruction for students in the junior high school years, grades 7 to 10, and in which most teaching and learning was in project groups. The nature of project-based learning in the school is consistent with project-based learning approaches described by proponents (see Savery, 2006), i.e., with projects extending over a 5 to 10-week period with organised and scaffolded learning activities designed to support groups of students (usually 3 to 5) to achieve desired outcomes within certain prescribed boundaries, and with a summative task as the defined 'end product'. At the beginning of each project, students were provided with detailed assessment rubrics. Students were assessed, both individually and as part of a group, in associated content knowledge and skills in each project. Individual assessment through formative tasks occurred at the mid-point of each group assignment, and the group assessment occurred through a summative task, submitted at the end of a 5 or 10-week period. For a more detailed discussion of how project-based learning is implemented at the school where this study was conducted, please see Hendry, Hays, Challinor, and Lynch (2017).

A perennial dilemma for teachers when implementing group-based activities, is whether to assign students to work with friends or acquaintances (Hanham & McCormick, 2008, 2009, 2018; Mitchell, Reilly, Bramwell, Solonsky, & Lilly, 2004;

Swenson & Strough, 2008). We were interested in whether the assignment of students to friendship or acquaintance groups was related to the performance of these groups on project-based learning assignments. We were also interested in relationships between social-cognitive variables, specifically, collective efficacy and proxy efficacy, and the performance of friendship and acquaintance groups on project-based learning assignments. The current literature on project-based learning has identified the need for research to explore the roles of students' efficacy beliefs in project-based learning settings (Hendry et al., 2017).

Friendship and acquaintance groups

Friendship groups are voluntary relationships anchored by a shared history, mutual regard, and strong interpersonal connections of group members. Acquaintance groups generally involve people who have limited interpersonal knowledge and/or previous direct contact with others in the group (Jehn & Shah, 1997). The decision to allocate students to friendship or acquaintance groups is likely to be pertinent when project-based learning is the main mode of instruction, given that students generally spend most of their time working on group-based activities.

Friendship plays a critical role in child and adolescent development (Newcomb & Bagwell, 1995; Rubin, Bukowski, & Parker, 2006), having direct and indirect influences on students' goals, behaviours, academic performances, adjustment, and engagement in school (Berndt, 2002; Barry & Wentzel, 2006; Wenztel, Barry & Caldwell, 2004). A recent meta-analysis, which examined relationships between friendship and academic outcomes in school settings (Wentzel, Jablansky & Scalise, 2018), found that students working with friends was positively associated with use of cognitive skills (e.g., problem-solving) and academic performance (e.g., achievement scores). These findings support long-held notions (see

Hartup, 1996; Hartup & Stevens, 1997) that friendship groups can provide an important context for the development of students' problem-solving skills and academic-achievement capabilities.

Friends generally have a more extensive shared history and know each other more intimately than non-friends (Ladd & Emerson, 1984). Consequently, friends may be expected to have a better grasp of each other's prior knowledge and perspectives than non-friends. Compared with acquaintances, friends also tend to feel more comfortable with each other (Newcomb & Bagwell, 1995), exhibit a greater willingness to offer suggestions (Hartup, 1998), and build on each other's ideas (Azmitia & Montgomery, 1993). Furthermore, it has been suggested that criticisms offered by friends during group discussions generally are likely to be more appropriate than those proffered by non-friends (Zajac & Hartup, 1997), with friends more inclined to use negotiation and disengagement to resolve conflicts than non-friends (Newcomb & Bagwell, 1995). Effectively sharing, building, and critiquing ideas, and resolving conflicts are key components of successful group work (Webb & Palincsar, 1996). Importantly, they are also critical in helping students consolidate and restructure prior knowledge (Webb & Mastergeorge, 2003).

Although friends appear to afford academic benefits, it is important to acknowledge that friendship groupings can and do have problems and may not always be superior to acquaintance groupings. Friendship can vary in quality (Berndt, 2002); not all groups of friends are oriented toward academic learning and engagement in school. Some friendships can be plagued by dysfunction, dominance and conflict (Burk & Laursen, 2005). In terms of performance in group-based learning tasks, some studies (e.g., Azmitia & Montgomery, 1993; Miell & McDonald, 2000) have found that friends generally outperform acquaintances, although, others have not (e.g.,

Berndt, Perry & Miller, 1988). Moreover, it appears that performance differences between friendship and acquaintance groups may vary according to task types (Chung, Lount, Park & Park, 2018). To illustrate, a recent meta-analysis (Chung et al., 2018) compared the performances of friendship and acquaintance groups, involving both school-based and workplace studies, and found that friends generally outperformed acquaintances on maximizing tasks (e.g., coming up with as many ideas as possible), although, friends did not outperform acquaintances for optimizing tasks (e.g., producing correct answers).

Efficacy beliefs

Many factors may be identified in the mixed findings concerning the performances of friends and acquaintances on group-based tasks. Indeed, there is still much to unpack concerning the motivational processes that underlie how students approach working with their friends and acquaintances. Hanham & McCormick (2008, 2009) have suggested that students' self-efficacy beliefs for working in groups may be related to students' attitudes to cooperating with friends and acquaintances, as well as group behaviours such as generating and critiquing ideas (Hanham & McCormick, 2018). Self-efficacy, which refers to individuals' beliefs about their capabilities of executing and organising courses of action to secure desired outcomes, is a key component of Bandura's (1997, 2001) Social Cognitive Theory (SCT). This study seeks to build on this line of research through exploring the possible roles of two other categories of efficacy beliefs: *collective efficacy* and *proxy efficacy*.

Collective Efficacy

A key tenet of SCT is that efficacy beliefs are fundamental to the exercise of human agency, which refers to actions carried out intentionally (Bandura, 1997). There are different modes by which humans can exercise agency, including direct

personal agency, which involves self-efficacy. Humans can also exercise agency in concert with others; this is known as collective agency. The effectiveness of collective agency is underpinned in large part by collective efficacy. Arguably the most common conceptualisation of collective efficacy is that it represents group members' shared beliefs in their perceived collective capabilities to achieve desired outcomes (Bandura, 1997). Although less common, collective efficacy can also be conceptualized as a group member's personal belief about the group's capability to attain desired outcomes (Alavi & McCormick, 2018).

Similar to self-efficacy, collective efficacy is domain/task specific and emerges over time in groups in response to inputs such as feedback and the perceived characteristics of group members (Goncalo, Polman & Maslach, 2010). Collective efficacy is assumed to be related to the choices made by groups, the amount of effort that groups exert on tasks, and persistence when groups encounter difficulties (Bandura, 2000). Several meta-analyses (Gully, Incalcaterra, Joshi & Beaubien, 2002; Stajkovic, Lee & Nyberg, 2009) found that collective efficacy predicted group performance. Collective efficacy has also been linked to group goals (Goddard, Hoy & Hoy, 2004) and group cohesion (Wang & Hwang, 2012). Although collective efficacy beliefs have been associated with a range of positive outcomes, some research (e.g., Goncalo et al., 2010), has suggested that high levels of collective efficacy in early phases of group assignments may have a negative impact on the eventual overall performance of groups. According to Concalo et al. (2010) high collective efficacy can act as a restraint on group processes such as group conflict, which are ultimately, important for successful group performance.

As an emergent group-level state, there are a number of sources of information, which may shape the collective efficacy beliefs of groups. Mastery

experiences are considered the most influential source of efficacy beliefs. Groups that have had previous successes are likely to have strong collective efficacy, whereas groups with a record of failures are likely to have weak collective efficacy (Bandura, 1997). Collective efficacy can also be influenced through vicarious experiences in which groups observe the successes and failures of other groups, which share similar characteristics (e.g., ability levels). Social persuasion can also be a source of collective efficacy, whereby groups are provided with appraisals of their capabilities from influential sources, for example, managers in workplace contexts and teachers in school settings. Positive evaluations from influential sources will likely boost collective efficacy; on the other hand, negative assessments will likely reduce collective efficacy. The affective states of groups can also impact collective efficacy. In striving to attain desired outcomes, many groups, from time to time, will be confronted with a range of stressors, which impact the mood of the group. Groups that respond positively to stressors are likely to have enhanced collective efficacy. Alternatively, groups which do not respond well to stressors are likely to have diminished collective efficacy.

Proxy efficacy

In addition to being able to exercise agency directly and collectively, individuals can also exercise agency indirectly, through the assistance of other entities, which can be categorised as proxies (Alavi & McCormick, 2016; Hanham, Ullman, Orlando & McCormick, 2014). There are a number of reasons for people to engage proxy agents. For instance, people may not possess the necessary knowledge and skills to act intentionally by themselves to obtain desired outcomes. This can be seen in legal matters, where people often employ a lawyer as a means to exercise their legal rights. Lawyers carry out various tasks on behalf of clients, such as representing

them in court proceedings in order to secure favourable judicial decisions. In financial matters, people often hire accountants to prepare and submit tax statements on their behalf.

The nature and structure of a particular environment may necessitate engagement with proxies. An example of this is a group assignment in which group members are designated specific roles to fulfil on behalf of the group. As stated by Hare (1994), a group role is a "position in a group (a status) with rights and duties toward one or more other group members" (p. 434). That is, fulfilling group roles involves an obligation to serve the needs of fellow group members and the group as a whole. For instance, a group member designated as the organizer of the group may be responsible for arranging milestones that need to be met, and ensuring that fellow group members are given timely reminders about these milestones. Carrying out such tasks on behalf of the group is important, as it should help other group members function more effectively in their roles as they are being made aware of when they need to complete specific tasks.

Sources of proxy efficacy are likely to be broadly similar to those of collective efficacy and self-efficacy, although the dynamics could be different. In the development of proxy efficacy in group work settings, members of groups are likely to form proxy efficacy judgments based on the successes and failures of their fellow group members carrying out specific roles. In the absence of direct experience with the fellow group members, proxy-efficacy may still be formed through previous observations of fellow group members carrying out tasks in classrooms, similar to those they were expected to perform during a particular group assignment. Proxy efficacy can also be shaped through social persuasion. For example, a reputable teacher or trusted friend may inform a group member about the capabilities of certain

other group members in carrying out their roles. Positive evaluations likely enhance proxy efficacy, whereas negative appraisals likely lower proxy efficacy. Observations of the affective states of fellow group members may also impact proxy efficacy beliefs. Proxy efficacy for fellow group members who are observed to be anxious during group work activities may diminish. In contrast, proxy efficacy for group members who are observed to be 'comfortable' may be increased.

Research questions

Several research questions guided this study. First, there are mixed findings concerning the performances of friendship and acquaintances in school settings. Moreover, it appears that there has not been empirical research exploring the performance differences of friendship and acquaintance groups in school settings in which project-based learning is the mode of instruction. Thus, the first research question is:

RQ1. Are there statistically significant differences in the performances of friendship and acquaintance groups working on group assignments in a school setting in which project-based learning is the principal mode of instruction?

Because project-based learning is the main mode of instruction for the participants in this study, students were likely to have spent considerable time working in groups with their classmates, and therefore to have developed shared beliefs about the capabilities of the project teams in which they worked (i.e., collective efficacy), and beliefs about the capabilities of individual classmates to carry out specific roles on behalf of their teams (i.e., proxy efficacy). As students worked in project groups for five weeks, the following research question is:

RQ2. How are collective efficacy and proxy efficacy beliefs related to the performances of the friendship and acquaintance groups in this study?

We were also interested in investigating possible interaction effects involving the key variables in the study. The final research question is:

RQ3. Are there statistically significant interaction effects involving collective efficacy, proxy efficacy, and group type (friends/acquaintances)?

Method

Sample

The sample comprised 21 friendship and 20 acquaintance groups completing group assignments in Religious Studies, Geography, and English at a Catholic Boys High School, in Sydney Australia. These subjects were chosen by the participating school; we considered it pragmatic, but also ethically important, to take account of the school's curriculum requirements. The total number of groups (n = 41) is above the minimum needed (i.e., 30) for running multilevel analysis with fixed parameters only (Stegmueller, 2013). Each group comprised 4 male students (N=164). Mean age = 13.54 years and SD = .55.

Measures

A questionnaire, titled "*Efficacy beliefs and Project-Based Learning*" was developed for this study. There were four versions of the questionnaire; with each version corresponding to a specific role for which group members were randomly allocated (i.e., coordinator, video producer, storyboard developer, project developer). Further discussion concerning the nature of roles is provided in the next section. Collective efficacy and proxy efficacy beliefs are domain/task-specific constructs and according to Bandura's (2006) guidelines, efficacy items *"must be tailored to the particular domain of functioning that is the object of interest"* (p. 308). In accordance with this advice, measures of collective efficacy and proxy efficacy were developed in

line with the parameters of the study. Ten items measured collective efficacy, with these items designed to capture group members' beliefs about their groups' capabilities for performing tasks such as "developing a plan for the group project" and "collaborating effectively". The collective efficacy items were measured on an 11-point percentage scale ranging from 0% not at all confident to 100% completely confident. Proxy efficacy items were based on the tasks for each specific group role. Ten items measured proxy efficacy for the coordinator, including, "coordinating other group members to perform their tasks" and "directing group discussion". Ten items measured proxy efficacy for the video producer, including, making sure "the video follows the storyboard" and "using different camera angles to improve the quality of the video". Nine items measured proxy efficacy for the storyboard developer, including, "developing the group's ideas into a storyboard" and "making changes to the storyboard based on feedback from the group". Seven items were used to measure proxy efficacy for the project developer including "reporting accurately on the group's progress to teachers" and "bringing together the group's research into a portfolio". For each role, group members were asked to rate their fellow group members' capabilities for successfully carrying out tasks for their specific roles. All of the proxy efficacy items were measured on an 11-point scale, ranging from 0% not at all confident to 100% completely confident".

Descriptions of the group roles

The names and descriptions of roles are identical to those employed by the school. The Coordinator was responsible for managing the group and acting as the group spokesperson, mediator, negotiator, and arbitrator to resolve interpersonal problems or conflicts as well as the main liaison with teachers. The Video Producer was responsible for the audio-visual elements of the project, including equipment,

recording, layout, and sound mixing through selected video editing platforms. The Storyboard Developer was responsible for the construction, development, and maintenance of the video storyboard, and editing the script. Lastly, the Project Developer was responsible for the planning, sequencing and allocation of tasks as well as the day-to-day running of the group including the maintenance of the group's online calendar, adherence to the group's contract, and meeting deadlines.

Procedures

Protocols for the study were approved by the Human Research Ethics Committee at Western Sydney University, and the Diocese in which the school was located. An information package was given to students in grade 8, which included an invitation and description of the study, an outline of what involvement would entail, and statements explaining that participation in the study was voluntary and they were free to withdraw anytime, without penalty. Those students, and their parents, who decided to participate gave written informed consent.

Sociometric Mapping

Sociometric mapping (Finegold & Eilam, 1995; Henrich, Kuperminc, Sack, Blatt & Leadbeater, 2000) was employed to identify friendship and acquaintance clusters. Each student was asked to nominate, in order, up to five students he regarded as close friends, and to nominate fellow students, in no particular order, whom they did not regard as close friends. The researchers deliberately chose not to require ranking to avoid possible priming of antagonistic thoughts about fellow students. In line with Henrich et al.'s (2000) approach, first, 21 friendship groups, comprising reciprocated friendships, were identified. Then, remaining students were sorted into 20 acquaintance (not-close friends) groups. Students were not made aware that they were being allocated to friendship and acquaintance groups.

Projects

In line with the curriculum requirements of the school, the study focused on project-based learning in three subjects. Data were collected whilst students undertook three stand-alone (non-integrated) five-week projects in three different disciplines: Geography, English and Religious Studies. All groups, with the same composition completed all three projects in the same roles. Students were initially randomly assigned their roles within the groups which they then carried out through all of the three projects. All three projects were run concurrently in timetabled lessons throughout the 5-week period - the duration of each project. As a project-based learning school, this is routine. In that period, students had a total of 13.5 periods (100 minutes per period) for each course equating to 22.5 contact hours over the life of the project. These lessons were mostly distributed over a fortnightly cycle (2.5 hours one week and 2 hours the following week) but not necessarily in the same period during the three-period school day.

Whilst undertaking different projects derived from varying content and syllabus outcomes, the summative task (or 'end-product') for each of the three projects required groups to produce a short video whilst fulfilling four different predetermined roles and thereby utilizing similar skills (e.g., video producing, storyboarding) to complete the project. Two teachers, subject matter experts, from respective disciplines (Geography, Religious education and English) marked all group videos in their respective areas of expertise. As is practice at the school, when discrepant marks allocated by teachers were in different performance bands (i.e., basic, competent, and advanced), these differences were resolved by discussion between the markers or via moderation by the head of faculty. A rubric was designed for each of the three projects. However, whilst each one addressed specific content

from each knowledge domain, criteria dealing with the video production were consistent across all three rubrics (see Appendix A). A short description of each project and the associated problem-solving tasks are presented below.

Globalization Project (Geography)

Students explored how the process of globalization had transformed global communities and created significant opportunities as well as great challenges and disparity socially, technologically, and economically. In addition, students investigated the various strategies that had been implemented by government and non-government organizations to minimize or reduce the impacts of globalization on both global communities and the environment. The summative task was a short video of a panel discussion (with group members as panelists) concerning the origins, benefits and burdens of globalization, and its impact on relationships between developed and developing countries in terms of access to education, food, health, shelter, natural resources, and quality of life.

People of the Covenant Project (Religious Studies)

Students investigated the concept of the covenant that Judaeo-Christian peoples made with their god. The summative task for this project was a short video of a contemporary story depicting how the people of the covenant live their lives and highlighting its importance to them. More specifically, students were required to make a video that uses illustrations, words, images and other media to convey the message. Over the course of this project, students were challenged in terms of their filmmaking ability and conceptual understanding of the nature of religion and the notion of the covenant.

English Cultural Poetry

Students explored how different poets from different cultures had utilized poetry to convey meaning and understanding of their traditions and customs, and how they expressed their individual cultural identities. Moreover, an important outcome of this project was the fostering of intercultural understanding. Understandably, the first step for students was to explore poetical techniques used to convey messages, how to deconstruct and analyse poetry through critical poetic analysis, and how to effectively and imaginatively use various poetic techniques and structures when composing their own poems including haikus and slam poems. The summative task of this project was a video promoting cultural awareness and diversity through poetry. This involved the creation of a group poem about a chosen culture(s) that is not their own, expressed through video.

Video production in projects

For all projects, a number of non-compulsory tutorials and scaffolded activities were available for each student in relation to his specified role within the group. Other specialized tutorials such as whiteboard videos were also available.

Administration of surveys

Efficacy beliefs are malleable and can change over time (Bandura, 1997). Because the projects were to run for a period of 5 weeks, it was considered important to measure efficacy beliefs over several intervals. Survey data were collected just after the commencement (end of week 1), mid-point (end of week 3), and completion (end of week 5) of the projects.

Analyses and results

Exploratory factor analyses

Exploratory factor analysis (EFA) was employed because of the sample size. Principal axis factoring with Oblimin rotation was separately applied to the items measuring collective efficacy and proxy efficacy for each of the roles. The criteria for extraction were eigenvalues greater than one, scree plot, and most importantly, theoretical considerations.

EFA of the collective efficacy items at times 1 and 3 identified single factors. However, EFA of the collective efficacy data collected at time 2, found that item 10, *the group can resolve conflict constructively*, loaded as a separate, single factor. To ensure comparability between measurement points, EFAs for the collective efficacy items at each measurement point were run again with item 10 removed from the analyses. Three collective efficacy factors (identical items), one for each measurement point were identified. In Table 1 below, the scale means, standard deviations and the ranges of the factor loadings are reported. In addition, as an estimate of reliability, we report McDonald's Omega (ω) (McDonald, 1999).

Table 1

EFA with the collective efficacy variables at times 1, 2, and 3.

Time and variable name	Scale Means	SD	Range of the factor loadings	ω
Time 1 Collective efficacy	82.6	11.3	.63 to .83	.92
Time 2 Collective efficacy	84.7	10.4	.73 to .87	.93
Time 3 Collective efficacy	83.9	11.6	.61 to .82	.94

Proxy-efficacy was operationalised as a characteristic of the group, that is, group members estimating other group members' capabilities in fulfilling their specific

roles. Thus, in a group of four, there were three proxy efficacy scores for each role. The mean of the scores provided the proxy efficacy measure for each role.

EFAs of the proxy-efficacy items identified single factors for each of the four roles that were identical across the three measurement points. The ranges of the factor loading and Omega estimates are reported in Table 2 below.

Table 2

EFA with the proxy efficacy variables for each of the roles at times 1, 2, and 3.

Time and variable name	Scale Means	SD	Range of factor loadings	ω
Time 1 Proxy efficacy for the coordinator	77.3	22.5	.74 to .90	.97
Time 2 Proxy efficacy for the coordinator	79.2	22.5	.84 to .93	.98
Time 3 Proxy efficacy for the coordinator	78.0	23.5	.82 to .91	.98
Time 1 Proxy efficacy for the video producer	83.0	16.1	.62 to .82	.95
Time 2 Proxy efficacy for the video producer	84.0	16.2	.46 to .93	.96
Time 3 Proxy efficacy for the video producer	83.4	17.9	.61 to .89	.97
Time 1 Proxy efficacy for the storyboard developer	80.6	20.1	.78 to .85	.97
Time 2 Proxy efficacy for the storyboard developer	81.7	19.7	.83 to .91	.98
Time 3 Proxy efficacy for the storyboard developer	82.4	18.4	.82 to .91	.97
Time 1 Proxy efficacy for the project developer	79.3	20.5	.69 to .90	.96
Time 2 Proxy efficacy for the project developer	80.1	20.3	.78 to .93	.97
Time 3 Proxy efficacy for the project developer	82.1	19.1	.76 to .91	.97

Multilevel Modeling

As an initial step, fully unconditional variance decomposition models were estimated (see Table 3). All variables had statistically significant variance at the individual level. There was statistically significant variance at the group level for collective efficacy at all three time points. There was also statistically significant

Table 3

Variance decomposition models

	Individual Level			Group Level			
Variable	Variance	SE	p-values	Variance	SE	p-values	Intraclass Correlations
T1CE	106.42*	22.13	.00	25.47*	10.69	*	.19
T2CE	72.42*	11.57	.00	38.41*	2.52	**	.35
T3CE	104.98*	18.57	.00	30.79*	13.21	*	.23
T1PEC	330.35*	78.29	.00	132.00*	65.72	*	.28
T2PEC	336.74*	67.27	.00	156.06*	72.91	*	.31
T3PEC	370.20*	70.95	.00	168.04*	158.04	***	.31
T1PEVP	151.05*	36.36	.00	72.49	38.16		.32
T2PEVP	190.57*	37.11	.00	54.47*	24.16	*	.22
T3PEVP	241.81*	70.50	.00	73.78	44.13		.23
T1PESB	312.80*	66.39	.00	76.45	39.76	.	.19
T2PESB	209.66*	45.54	.00	174.13*	77.01	**	.45
T3PESB	163.14*	29.34	.00	163.32*	71.14	*	.50
T1PEPD	346.41*	74.62	.00	35.43	43.61		.10
T2PEPD	251.96*	48.14	.00	137.07*	46.76	***	.35
T3PEPD	262.26*	58.30	.00	103.78*	35.48	***	.28

Note: * = $p \leq .05$, ** = $p \leq .01$, *** = $p \leq .001$
t - statistic

T1CE = Time 1 collective efficacy; T2CE = Time 2 collective efficacy; T3CE = Time 3 collective efficacy; T1PEC = Time 1 proxy efficacy for the coordinator; T2PEC = Time 2 proxy efficacy for the coordinator; T3PEC = Time 3 proxy efficacy for the coordinator; T1PEVP = Time 1 proxy efficacy for the video producer; T2PEVP = Time 2 proxy efficacy for the video producer; T3PEVP = Time 3 proxy efficacy for the video producer; T1PESB = Time 1 proxy efficacy for the storyboard developer; T2PESB = Time 2 proxy efficacy for the storyboard developer; T3PESB = Time 3 proxy efficacy for the storyboard developer; T1PEPD = Time 1 proxy efficacy for the project developer; T2PEPD = Time 2 proxy efficacy for the project developer; T3PEPD = Time 3 proxy efficacy for the project developer.

variance at the group level at all three time points for proxy efficacy for the coordinator. Proxy efficacy for the storyboard developer and proxy efficacy for the project developer had statistically significance variance at the group level for times 2 and 3, though not at time 1. Proxy efficacy for the video producer only had statistically significant variance at the group level at time 2. Variation in statistically significant group variance at different time points for proxy efficacy for the different roles may be explained by the level of activity required for each role at each time point. The coordinator was required to be active at the outset, whereas other roles probably required greater activity at different points in the process.

Table 4

Pearson correlations of the level-two variables

	1	2	3	4	5	6	7	8
1. GP Geography								
2. GP Religious Studies	.27*							
3. GP English	.38*	.31						
4. T1PE	.01	-.03	.15					
5. T2PE	.15	-.03	.23*	.90*				
6. T3PE	.19*	-.01	.22*	.75*	.87*			
7. T1CE	.25*	.22*	.32*	.84*	.69*	.55*		
8. T2CE	.42*	.36*	.26*	.70*	.69*	.58*	.79*	
9. T3CE	.45*	.30*	.32*	.58*	.70*	.80*	.59*	.81*

GP = Group performance; T1PE = Time 1 Proxy Efficacy; T2PE = Time 2 Proxy Efficacy; T3PE = Time 3 Proxy Efficacy; T1CE = Time 1 Collective Efficacy; T2CE = Time 2 Collective Efficacy; T3CE = Time 3 Collective Efficacy

* $p < .05$

The next step was generating level 2 variables: Means of individual level collective scores of each group member in each group were calculated. The means were then assigned to all members of the same group. Means of proxy efficacy at each time point, for each role, were calculated and assigned to all members of the same group. Pearson correlations of the level 2 variables are presented in Table 4. Separate multilevel models were developed to assess the relationships between the group performance as dependent variable in Geography, Religious Studies, and English. However, all variables were at level 2. We adopted a hierarchical approach for model testing (Pedhazur, 1982). As group type, that is, whether groups comprised friends or acquaintances, was fundamental to the study, this variable was entered first as a dummy variable (acquaintances = 0, friends = 1). As an emergent property of groups, collective efficacy was entered next, followed by the group characteristic, proxy efficacy. Product terms (e.g., group type X collective efficacy at time 3) were entered last. The final models for each subject are presented in Tables 4 to 6.

Predictors of group performance in Geography

In Table 5 multilevel models with group performance as the dependent variable in Geography are presented. Model 4 is the final model. Group type emerged

as a statistically significant predictor of group performance in the final model, with friendship groups outperforming acquaintance groups. There were several statistically significant interaction terms. These are depicted as regression lines in Figures 1 and 2. Figure 1 shows that for Geography when collective efficacy at time 3 was low, acquaintance groups generally scored higher in the summative tasks, but when collective efficacy was high, the friendship groups generally performed better on the summative task than acquaintance groups.

There was also a statistically significant interaction between group type and proxy efficacy at time 3. Figure 2 shows that when proxy efficacy was low, acquaintance groups generally scored higher than friendship groups on the summative task, but when proxy efficacy was high, friendship groups generally scored higher task. In Geography, the results suggest that collective and proxy efficacy beliefs were important for the performances of friendship groups.

Table 5

Multilevel models with group performance in Geography as the dependent variable

	Model 1			Model 2			Model 3			Model 4		
Fixed Effects	*b*	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
Intercept	10.050	. 527	***	.223	. 3.961		-6.850	3.288	*	-8.529	24.101	
GT	.712	.759		.440	.759		-0.215	.628		-22.401	10.365	*
T3CE				.140	.067	*	.055	.093		-.662	.365	
T2CE				.054	.116		.094	.091		.832	.567	
T1CE				-.076	.063		.335	.098	***	.299	.389	
T3PE							3.552	7.732		-19.670	39.483	
T2PE							15.756	10.027		81.930	63.750	
T1PE							-50.517	12.632	***	-81.094	42.817	
GT*T3CE										.365	.169	*
GT*T2CE										.034	.190	
GT*T1CE										-.069	.199	
GT*T3PE										-40.130	15.854	*
GT*T2PE										15.058	20.918	
GT*T1PE										17.355	23.236	
T3PE*T3CE										.588	.457	
T2PE*T2PE										-.883	.780	
T1PE*T1CE										.189	.526	
Residuals	5.921	1.084	***	4.723	.886	***	3.223	.584	***	.858	.190	***
Log likelihood		-1962.959			-1958.325			-1950.489			-1945.414	
R^2		.02			.22*			.47***			.58***	

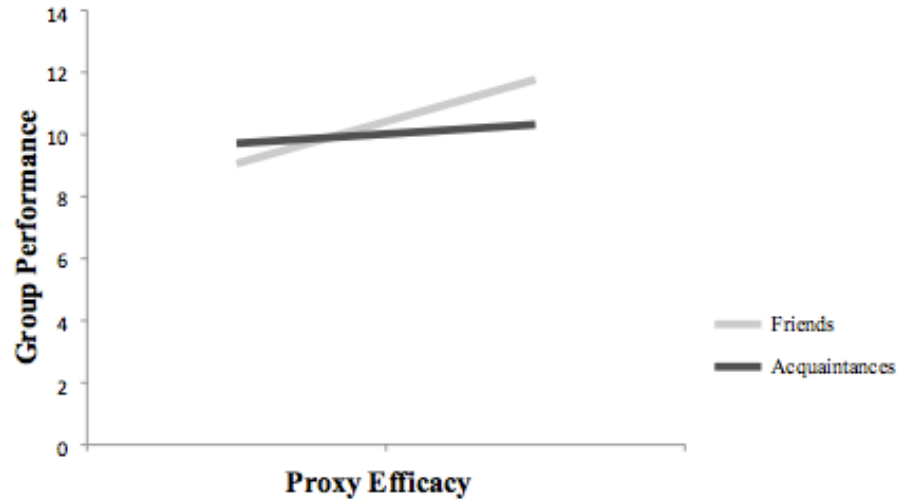
Note. GT = Group Type; T3CE = Time 3 Collective Efficacy; T3PE = Time 3 Proxy Efficacy T2CE = Time 2 Collective Efficacy; T1CE = Time 1 Collective Efficacy; T1PE = Time 1 Proxy Efficacy; GT*T3CE = Interaction between Group Type and Time 3 Collective Efficacy; GT*T2CE = Interaction between Group Type and Time 2 Collective Efficacy; GT*T1CE = Interaction between Group Type and Time 1 Collective Efficacy; GT*T3PE = Interaction between Group Type and Time 3 Proxy Efficacy; GT*T2PE = Interaction between Group Type and Time 2 Proxy Efficacy; GT*T1PE = Interaction between Group Type and Time 1 Proxy Efficacy; T3PE*T3CE = Interaction between Time 3 Proxy Efficacy and Time 3 Collective Efficacy; T2PE*T2CE = Interaction between Time 2 Proxy Efficacy and Time 2 Collective Efficacy; T1PE*T1CE = Interaction between Time 1 Proxy Efficacy and Time 1 Collective Efficacy.
* = $p \leq .05$, ** = $p \leq .01$, *** = $p \leq .001$.

Figure 1

Interaction of group membership by collective efficacy at time 3 in Geography.

Figure 2

Interaction of group membership by proxy efficacy at time 3 in Geography.



Predictors of group performance in Religious Studies

Multilevel models with group performance in religious studies as the dependent variable are presented in Table 6. In the final model, collective efficacy

measures at times 1, 2, and 3 were statistically significant predictors of group performance. For the final model, proxy efficacy measures at times 2 and 3 were statistically significant negative predictors of group performance; correlations in Table 3 show that the proxy efficacy measures were negatively correlated with group performance in Religious Studies. These results indicate that although groups' shared beliefs in their collective abilities to successfully carry out tasks (i.e., collective efficacy) are positively associated with performance scores for summative task in religious studies, positive beliefs about the capabilities of group members to fulfil their roles as part of the group (i.e., proxy efficacy), do not translate to higher scores on the summative task– in fact they are negatively associated with group performance.

Table 6

Multilevel models with group performance in Religious Studies as the dependent variable

	Model 1			Model 2			Model 3			Model 4		
Fixed Effects	*b*	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
Intercept	6.850	.420	***	1.188	5.033		-4.038	4.543		10.658	18.837	
GT	.293	.531		-.040	.522		-.283	.420		-5.512	7.873	
T3CE				.010	.058		.017	.068		.715	.344	*
T2CE				.096	.060		.109	.061		-.979	.496	*
T1CE				-.038	.036		.207	.066	**	.475	.196	*
T3PE							1.293	4.744		95.382	30.688	**
T2PE							.049	7.932		-150.042	57.097	**
T1PE							-23.732	10.097	*	9.627	25.368	
GT*T3CE										.298	.116	**
GT*T2CE										-.320	.115	**
GT*T1CE										.132	.131	
GT*T3PE										-11.064	10.115	
GT*T2PE										.599	10.788	
GT*T1PE										6.290	15.221	
T3PE*T3CE										-1.095	.350	**
T2PE*T2PE										1.718	.656	**
T1PE*T1CE										-0.428	.266	
Residuals	2.857	.624	***	2.530	.578	***	1.757	.477	***	.858	.190	***
Log likelihood			-1948.018			-1945.527			-1938.054			-1923.370
R^2			.01			.12			.39**			.70***

Note. GT = Group Type; T3CE = Time 3 Collective Efficacy; T3PE = Time 3 Proxy Efficacy T2CE = Time 2 Collective Efficacy; T1CE = Time 1 Collective Efficacy; T1PE = Time 1 Proxy Efficacy; GT*T3CE = Interaction between Group Type and Time 3 Collective Efficacy; GT*T2CE = Interaction between Group Type and Time 2 Collective Efficacy; GT*T1CE = Interaction between Group Type and Time 1 Collective Efficacy; GT*T3PE = Interaction between Group Type and Time 3 Proxy Efficacy; GT*T2PE = Interaction between Group Type and Time 2 Proxy Efficacy; GT*T1PE = Interaction between Group Type and Time 1 Proxy Efficacy; T3PE*T3CE = Interaction between Time 3 Proxy Efficacy and Time 3 Collective Efficacy; T2PE*T2CE = Interaction between Time 2 Proxy Efficacy and Time 2 Collective Efficacy; T1PE*T1CE = Interaction between Time 1 Proxy Efficacy and Time 1 Collective Efficacy.
* = $p \leq .05$, ** = $p \leq .01$, *** = $p \leq .001$.

There was a statistically significant interaction between group type and collective efficacy at time 3. Figure 3 shows that when collective efficacy was relatively low at time 3, acquaintance groups outperformed friendship groups. However, when collective efficacy was relatively high at time 3, friendship groups outperformed acquaintance groups. This result is similar to that found for the summative task in Geography. There was a statistically significant interaction between group type and collective efficacy at time 2. Figure 4 shows that when collective efficacy was relatively low at time 2, acquaintance groups outperformed friendship groups. However, when collective efficacy was relatively high at time 2, friendship groups outperformed acquaintance groups. Again, this appears to be a recurring pattern of in the interactions involving collective efficacy and group type.

Figure 3

Interaction of group membership by collective efficacy at time 3 in Religious Studies.

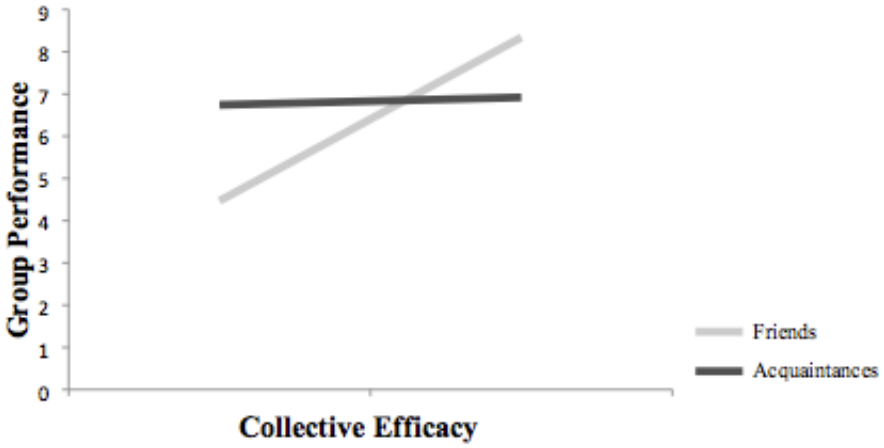
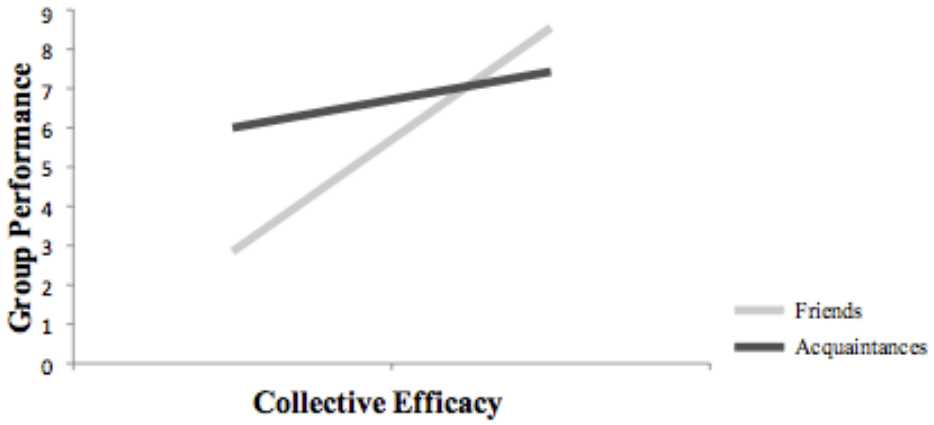


Figure 4

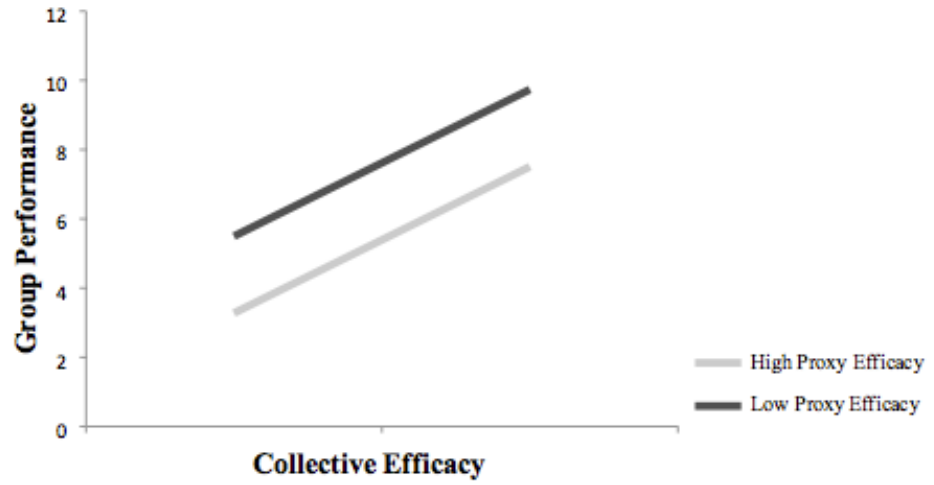
Interaction of group membership by collective efficacy at time 2 in Religious Studies.



There was a statistically significant interaction between proxy efficacy and collective efficacy at time 3 (see Figure 5). When collective efficacy was low, low proxy efficacy groups generally outperformed high proxy efficacy groups. Similarly, when

Figure 5

Interaction of proxy efficacy with collective efficacy at time 2 in Religious Studies.



collective efficacy was high, low proxy efficacy groups generally outperformed high proxy efficacy groups. There was a statistically significant interaction between proxy

efficacy and collective efficacy at time 2 (see Figure 6). When collective efficacy was low, low proxy efficacy groups generally outperformed high proxy efficacy groups. When collective efficacy was high, there was little difference in the performances of low and high proxy efficacy groups.

Predictors of group performance in English

Multilevel models with group performance in English as the dependent variable are presented in Table 7. In the final model, there were neither statistically significant direct effects nor statistically significant interactions.

Figure 6

Interaction of proxy efficacy with collective efficacy at time 3 in Religious Studies.

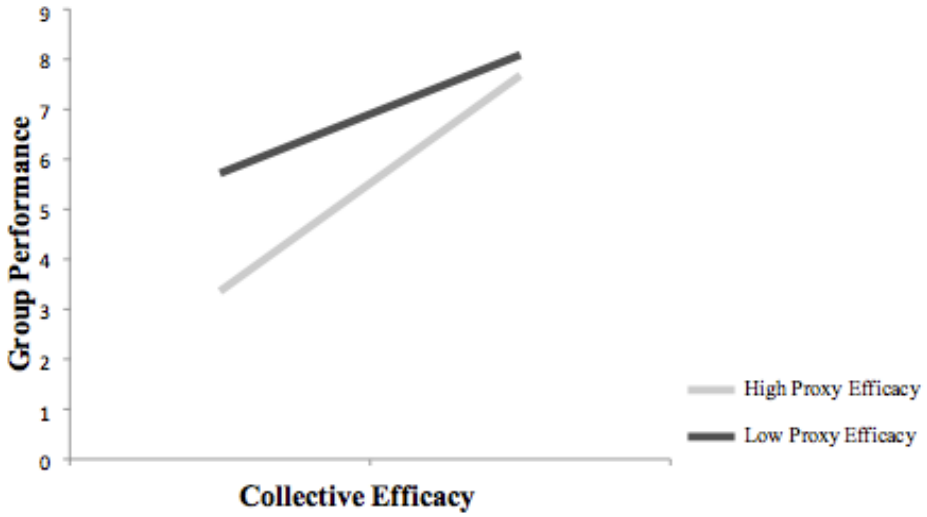


Table 7

Multilevel of models with group performance in English as the dependent variable

	Model 1			Model 2			Model 3			Model 4		
Fixed Effects	*b*	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
Intercept	9.750	.463	***	1.269	3.171		-2.833	3.914		2.828	21.240	
GT	.774	.690		.540	.775		.032	.759		-14.545	10.776	
T3CE				.122	.059	*	.073	.124		-.184	.453	
T2CE				-.104	.084		-.094	.097		.392	.758	
T1CE				.087	.058		.350	.111	**	.081	.408	
T3PE							-1.267	10.101		-18.705	45.209	
T2PE							-16.807	9.210		66.138	87.469	
T1PE							-34.971	14.152	*	-65.031	42.026	
GT*T3CE										-.218	.217	
GT*T2CE										.096	.232	
GT*T1CE										.182	.233	
GT*T3PE										13.802	19.080	
GT*T2PE										30.151	20.551	
GT*T1PE										-31.767	26.187	
T3PE*T3CE										.584	.502	
T2PE*T2PE										-.745	1.048	
T1PE*T1CE										.101	.554	
Residuals	4.902	1.164	***	4.282	1.001	***	3.623	.814	***	3.066	.687	***
Log likelihood	-1959.088			-1956.318			-1952.892			-1949.471		
R^2	.03			.15*			.28**			.39***		

Note. GT = Group Type; T3CE = Time 3 Collective Efficacy; T3PE = Time 3 Proxy Efficacy T2CE = Time 2 Collective Efficacy; T1CE = Time 1 Collective Efficacy; T1PE = Time 1 Proxy Efficacy; GT*T3CE = Interaction between Group Type and Time 3 Collective Efficacy; GT*T2CE = Interaction between Group Type and Time 2 Collective Efficacy; GT*T1CE = Interaction between Group Type and Time 1 Collective Efficacy; GT*T3PE = Interaction between Group Type and Time 3 Proxy Efficacy; GT*T2PE = Interaction between Group Type and Time 2 Proxy Efficacy; GT*T1PE = Interaction between Group Type and Time 1 Proxy Efficacy; T3PE*T3CE = Interaction between Time 3 Proxy Efficacy and Time 3 Collective Efficacy; T2PE*T2CE = Interaction between Time 2 Proxy Efficacy and Time 2 Collective Efficacy; T1PE*T1CE = Interaction between Time 1 Proxy Efficacy and Time 1 Collective Efficacy.
* = $p \leq .05$, ** = $p \leq .01$, *** = $p \leq .001$.

Discussion and Conclusions

This study explored several aspects of project-based learning of groups that comprised either friends or acquaintances. Three research questions guided the study. RQ1 was concerned with whether there were statistically significant differences in the group performances of friendship and acquaintance groups. In answer to the first research question, there was a significant difference in the performances of friendship and acquaintances, but only in geography. One explanation for this result concerns the nature of the summative task used for the geography project, which was a filmed panel discussion. Arguably, a panel discussion could afford greater opportunity for interaction between group members regardless of their nominated role. Friendship may be a more salient factor for the summative task because it requires greater discourse between group members to prepare, deliver, and present a filmed panel discussion. Implicit in the task, group members were required to offer opinions,

discuss, exchange ideas and build upon each other's contributions in order to prepare a script and to fulfil a role as a panellist with a particular perspective, and, like an actor in a play, each group member would also be aware of each other's lines. This, in turn, may favour friendship over acquaintance groups as research suggests that the generation and building of ideas occurs more readily among friends than among acquaintances (Azmitia & Montgomery, 1993; Hartup, 1998). Although a recent meta-analysis (see Wentzel et al. 2018) found friendship groups in general performed better on academic achievement tasks than acquaintance groups, this was not a uniform finding across the three subjects in this study. This result mirrors previous mixed findings in some past studies (e.g., Berndt et al., 1988), which found no statistically significant differences in performances of friendship versus acquaintance groups.

RQ2 was concerned with how collective efficacy and proxy efficacy beliefs were related to the overall performances of the friendship and acquaintance groups. In terms of direct effects, collective efficacy measured at the beginning, mid-point and end-point of the Religious Studies project was positively associated with performance on the summative task for this subject. This positive association between collective efficacy and group performance is consistent with findings from studies on collective efficacy in organizational settings (Gully, et al., 2009; Stajkovic et al., 2009). This finding also aligns with emerging research in school-based settings, which have shown that collective efficacy can predict task performance for group activities (Khong, Liem & Klassen, 2017). It is important to note that collective efficacy did not predict group performance for the final multilevel models in English and Geography. This result may suggest the importance of context when examining efficacy beliefs (McCormick, Alavi & Hanham, 2015). Future research on efficacy beliefs in project-

based learning settings may probe contextual factors (e.g., group allocated roles vs. teacher allocated roles) more deeply, for example, through interviews and/or observational analysis.

Whilst collective efficacy was positively associated with group performance in Religious Studies, proxy efficacy measured at the mid and end points of the project was negatively associated with group performance on the summative task in Religious Studies. As a possible explanation, it is likely that the higher the individual's proxy beliefs, the greater the agency individuals ceded to the proxies, which could result in a diminution of their personal performances. Simply put, overconfidence in fellow group members' abilities likely leads to a lessening of their own efforts. The nature of the summative task and the subject itself may have also contributed to this result. Arguably, elements of religious studies are more abstract in nature (e.g., who or what is god?) which could have impacted the assessment of other group member's capabilities and depth of knowledge in the subject matter which is bound up in one's conceptions of one's and others' faith beliefs.

To further understand the role of collective efficacy and proxy beliefs in the performance of friendship and acquaintances it also important to consider the findings concerning the statistically significant interactions identified in this study and which provide an affirmative answer to the final research question (RQ3 i.e., Are there statistically significant interaction effects involving collective efficacy, proxy efficacy, and group type?). For the subjects of Geography and Religious Studies there appears to be a consistent pattern concerning the nature of the interactions involving collective efficacy and group type. In general, when collective efficacy was low, acquaintance groups scored higher on the summative tasks, and when collective efficacy was high, friendship groups scored higher on the summative tasks. Thus, in

the context of this study, collective efficacy likely was a salient factor in the performance of friendship groups in Geography and Religious Studies. One explanation is that there may have been differences in the degree of connectedness amongst friends. Although friends tend to have stronger interpersonal affiliations and bonds than acquaintances (Zajac & Hartup, 1997), it is important to acknowledge that the nature and quality of friendships vary (Berndt, 2002). It is possible that in this study, when connection was low, friendship groups were more likely to have lower collective efficacy, and subsequently, lower performance. On the other hand, when connection was high, friendship groups were likely to have higher collective efficacy, and subsequently, higher performance. The sociometric measure used in this study to identify friendship clusters, focused on reciprocated friendship nominations. Future research may consider sociometric measures that capture not only reciprocated friendship relations but also variability in the degree of connectedness between students in different friendship clusters.

In Religious Studies lower proxy efficacy was associated with higher scores on the group performance tasks, especially when collective efficacy was low. It is important to distinguish between a group characteristic i.e., in this case, proxy efficacy and an emergent group phenomenon (collective efficacy) (Kozlowksi & Klein, 2000). Although proxy efficacy was measured using means of all proxy efficacy beliefs for each role, the frames of reference were the individual roles, whereas the frame of reference for collective efficacy was the group (i.e., the group perceived capabilities for successfully performing tasks as a group). One may speculate that proxy efficacy and collective efficacy have a complementary relationship. That is, when one is low, the other likely is a stronger predictor of performance.

This study has limitations that need to be acknowledged. First, the sample comprised participants from a single, all male, Catholic High school. Consequently, the findings of the research have limited generalizability. It would be unwise to assume the results would necessarily apply in a different context. The participating school was chosen as it is one of very few schools in Australia to adopt project-based learning as the main mode of instruction for students in the junior high school years. Future research should explore the role of efficacy beliefs in project-based learning settings with a larger, preferably, random, sample of schools, including non-denominational and co-educational schools. Second, participant constraints mean the study focused on three school subjects with participants from Grade 8. Future research should include a wider range of subjects including science and math-based subjects, with participants from different grade cohorts in high school. Third, the length of the projects for this study ran for a total of five weeks. Projects can run for longer periods (e.g., 10 weeks). As efficacy beliefs are fluid and changeable, the nature of the relationships involving collective efficacy and proxy efficacy with group performance may be significantly different depending on the length of the project; with projects of varying lengths, it may be worthwhile to model time as a variable. Future research should explore the role of efficacy for projects of longer durations. Fourth, only a limited number of theoretical constructs were used to predict group performance on the summative tasks. It is possible that other constructs, such as self-efficacy, could also predict the performance of friendship and acquaintance groups on project-based assignments. Self-efficacy beliefs may also be important to consider when taking into account the nature of group tasks. For example, proxy and collective efficacy did not predict group performance for the poetry task. Given the unique nature of this art form, it is reasonable to expect students to vary in their perceived

capabilities (i.e., self-efficacy) for effectively contributing to a group poem. Future studies should incorporate the self-efficacy construct alongside the other efficacy constructs, proxy efficacy, and collective efficacy.

Despite limitations, this study is one of the first to explore the roles of collective efficacy and proxy efficacy with project-based learning. To date, few studies have included collective efficacy in studies of group work in high school settings, and it is unclear if any studies have included this construct in research on project-based learning or studies on friendship and acquaintance groups. The inclusion of proxy efficacy appears to be new in terms of studies of groups in not only school settings, but also studies of groups more generally. In efficacy-based research studies, higher efficacy beliefs are often assumed to be associated with higher performance outcomes. Although only a single study, the findings from this research suggest that there are likely to be differences in different contexts.

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Chapter 7: Appendix A

Table A1

Excerpts from Rubrics Showing Criteria for Summative Tasks (video) for Projects used in this Study.

CRITERIA ***Marks****	**BASIC** ***1-2-3-4***	**COMPETENT** ***5-6-7***	**ADVANCED** ***8-9-10***
Religious Studies Covenant Animated (whiteboard) Video Production (Group task)	- Uses a surface other than a whiteboard for the video - Creates a literal story about covenant - Makes limited reference to covenant in the video - Uses uneven transitions between scenes - The video fails to meet the required length - The video is not uploaded to the dropbox - Students demonstrate lack of team work and collaboration as is evident in the quality of the summative task presented	- Uses a whiteboard for the video - Creates a contemporary story about covenant - Story reflects covenant in the characters' lives - Uses transitions between scenes - The video meets the minimum required length (2 minutes) - The video is uploaded to the dropbox - Students demonstrate sound team work and collaboration as is evident in the quality of the summative task presented	- Finds creative ways to use a whiteboard for the video - Creates a contemporary, interesting story about covenant - Story reflects clearly covenant in the characters' lives - Uses smooth or innovative transitions between scenes - The video meets the minimum (2 mins.) required length but does not exceed the maximum (4 mins.) - The video is uploaded to the dropbox as Quicktime, MP4 or AVI file.
Geography Globalisation Panel Discussion Video Production (Group task)	- Students provide basic and limited information in their filmed panel discussion about the globalisation process and its impact on global communities - Students provide simplistic solutions to minimise impacts of globalisation process with little evidence of critical	- Students provide sound information in their filmed panel discussion about the globalisation process and its impact on global communities - Students provide reasonably developed solutions to minimise impacts of globalisation process with sound	- Students provide highly developed and sophisticated information in their filmed panel discussion about the globalisation process and its impact on global communities - Students provide highly developed and well thought solutions to minimise impacts of globalisation

	thinking in their video presentation - Students demonstrate lack of team work and collaboration as is evident in the quality of the summative task presented	evidence of critical thinking in their video presentation - Students demonstrate sound team work and collaboration as is evident in the quality of the summative task presented	process with clear and well developed evidence of critical thinking in their video presentation - Students demonstrate a high level of team work and collaboration as is evident in the quality of the summative task presented
English Poetry Video Production (Group task)	- Group constructed poem demonstrates basic understanding and insight into chosen culture(s) - Students may incorporate basic poetic techniques and devices - Students demonstrate lack of team work and collaboration as is evident in the quality of the summative task	- Group constructed poem demonstrates sound understanding and insight into chosen culture(s) - Students incorporate some poetic techniques and devices - Students demonstrate sound team work and collaboration as is evident in the quality of the summative task presented	- Group constructed poem demonstrates highly developed and sophoisticated understanding and insight into chosen culture(s) - Students incorporate highly developed and sophisticated poetic techniques and devices - Students demonstrate a high level of team work and collaboration as is evident in the quality of the summative task presented

Table A2

Rubric for video production across all projects

CRITERIA	BASIC	COMPETENT	ADVANCED
Video Production (Generic rubric. Elements of which incorporated into project rubrics) *Teacher to select what is appropriate for their project*	Students demonstrate basic skills in creating a video production - Basic development of concept or brainstorming - Limited editing of final product with no transitions or audio support - Lack of coherence or clarity in script/theme/story - Little evidence of storyboard or script underpinning production - Lack of coordination between members of production crew - Deadlines or benchmarks routinely missed impacting on quality of final product	Students demonstrate sound skills in creating a video production - Sound development of concept or brainstorming - Some editing of final product with use of transitions or audio support - Reasonably coherent and clarity evident in script/theme/story - Some evidence of storyboard or script underpinning production - Clear collaboration and coordination between members of production crew - Deadlines or benchmarks routinely met ensuring reasonable quality of final product	Students demonstrate highly developed skills in creating a video production - Detailed development of concept or brainstorming - Advanced editing of final product with creative use of transitions and audio support - Coherence and clarity evident in script/theme/story - Clear evidence of storyboard or script underpinning production - Extensive collaboration and coordination between members of production crew - Deadlines or benchmarks always met ensuring high quality of final product

Chapter 8

Summaries, Conclusions and Limitations

Introduction

This chapter concludes the studies into self-efficacy and academic performance in a project-based learning classroom. The primary aim of this thesis was to investigate to what extent the motivational construct of self-efficacy developed and changed in relation to the instructional environment *over time* and how these beliefs were related to subsequent student performance. For this thesis, two longitudinal data sets were collected (in 2015 and 2018) and used for four studies contained within. One data set was used for studies into instruction and achievement (Chapters 3 and 6) and the other data set, for the studies investigating the impact of critical learning events on the development of self-efficacy as well as exploring the difference between general and situational self-efficacy (Chapters 4 and 5). Another data set was collected in 2015 in conjunction with researchers from Western Sydney University and University of Wollongong. This data forms the study described in Chapter 7. In this chapter, the key research questions and findings from each of these four studies will be reviewed and discussed as well as the limitations of each and the potential directions for future research.

The Educational Context of the Studies: An Active-Learning Environment

The studies in this thesis were undertaken in a high school that deploys project-based learning across the school years 7 to 10 (ages 12 to 16), problem-based learning in Year 11 (age 17) and the flipped classroom in Year 12 (age 18). All these approaches to learning are considered ‘active-learning’ pedagogical approaches. To avoid disruption to senior school classes and to understand the development of self-efficacy over time and in relation to achievement/performance, the studies in this thesis were administered in junior classes (years 7 and 8) where project-based learning is the mode of instruction. In this context, project-based learning is

considered an approach where the curriculum is presented to the learner in the guise of an ‘authentic’ project. During a project, students work in groups and are required to activate prior knowledge as well as engage with new and increasingly complex concepts to present a solution or ‘end-product’ that could have real-world implications or even implementation (Thomas, 2000). This idea of contextualising learning and leveraging student interest through ‘teaching by projects’ has been around for over a century (Dewey, 1897). However, it was in the latter part of the twentieth century that a consensus about what constitutes project-based learning was reached; namely, projects are the main mode of instruction with each having a ‘driving question’ that ties together the key underlying conceptual (often multidisciplinary) knowledge and activities that drive student learning. The goals and central activities of projects require students to investigate, transform and construct knowledge (beyond their current skills and knowledge) with the teachers taking more of a facilitative role in the learning process (Savery, 2006; Thomas, 2000). In this thesis, Chapter 2 (Hendry et al., 2017) describes the innovative educational environment in which the studies were carried out, an all-boys high school near Parramatta, Western Sydney, Australia. It ‘sets the stage’ for the subsequent chapters.

Summary of Findings

The focus of this thesis is self-efficacy and the role these beliefs play in relation to learning, achievement and performance. Self-efficacy involves a self-judgement as to how successful one will be in completing a particular task with the skills one presently possesses (Bandura, 1986). For more than forty years, self-efficacy has shown itself to be an important motivational construct to learning and one that possesses significant predictive powers in relation to performance particularly in the academic domain (Bandura, 2012; Honicke & Broadbent, 2016). It

has also revealed itself to be a powerful mediating influence on other constructs (see, for example, Onoda, 2014; Sue-Chan & Ong, 2002; Niemivirta & Tapola, 2007; Zimmerman & Kitsantas, 2014). Given its importance to learning, understanding to what extent self-efficacy develops and changes over time and those factors that contribute to its growth within an authentic learning environment became the prime focus of this thesis. Below you will find our main findings organized around the six research questions outlined in Chapter 1.

1. To what extent does self-efficacy develop over time? and 2. Is development of self-efficacy over time the result of the influence of instruction?

These questions were considered important because an analysis of current studies seeking to demonstrate the influence of instructional practices on student self-efficacy suffers, seemingly, from one of two problems. Firstly, they are either insufficiently authentic, that is, they use contrived experimental designs in a non-classroom setting lasting a few hours (e.g., Hushman & Marley, 2015). It is unlikely that self-efficacy, a purportedly slow process developing in parallel to someone's knowledge of a domain really grows on such limited time scale. What was needed therefore was research that studies the development of self-efficacy over a longer stretch of time in an authentic classroom context. And secondly, they measure changes in self-efficacy in a single group of students without sufficient controls (e.g., Alt, 2015). These studies tend to use a pretest-post-test design, leaving open the possibility that observed changes have causes unrelated to the instructional treatment.

The first study in this thesis (Chapter 3) addressed these questions by charting the development of self-efficacy in relation to instruction. The study was conducted over a five-week science Chemistry project. The self-efficacy measure used in this study was an 8-item scale taken from the larger *Motivated Strategies for Learning*

Questionnaire (MSLQ) developed by Pintrich, Smith, Garcia and McKeachie (1993). The measure turned out to have high internal consistency. The measures used in this study were administered online through student-owned devices using Qualtrics surveying software (Qualtrics, Provo, UT). A microanalytical measurement approach was used to collect data through student devices (in this instance, all students had iPads or laptops). This method of measurement is discrete and can be administered in close temporal proximity to the outcomes being measured with responses collected almost immediately. The study was conducted over a 12-week period with eight measures taken in total. A pre-test was administered three weeks prior to commencement of a five-week Year 8 Science project on 'physical and chemical changes'. Students were surveyed once weekly for the duration of the project. This was followed by an immediate post-test one week after the conclusion of the project; and then a delayed post-test was administered three weeks after the immediate post-test.

In analysing the data, an innovative approach combining latent-growth modelling with time-series design was adopted to investigate if students' feelings of self-efficacy grew as a result of the exposure to the five-week science course. The assumption of the latent growth-curve model was that, if instruction would have a causal effect on self-efficacy, then a larger growth of self-efficacy during the course than in the pre- and post-instructional periods would be observed. The data fitted this model well. It showed that significant growth of self-efficacy was observed during the course of instruction, absent during the phases where no instruction was provided leading to the conclusion that the project-based chemistry course indeed caused self-efficacy in students to grow (and which cannot be ascribed to other factors). One of the key questions to emerge from this study was why did instruction in *this* learning

environment lead to a significant (albeit small) growth in the self-efficacy of the participants over the course of the study?

3. Do 'critical learning events' in particular cause self-efficacy to increase?

A subsequent research question was therefore whether learning events at certain junctures during the project-based learning process (named 'critical learning events') cause self-efficacy to develop and/or increase. Critical learning events were defined as exercises, activities, assignments, and experiments (in science) that can be distinguished from more routine classroom tasks in three ways. They were designed to focus on gaps in the learner's knowledge base with regard to critical subject-matter; they help exploring new ways of applying knowledge acquired during the project; and they are deliberately collaborative in nature. Following Bandura's (1977, 1986, 1997) suggestions that self-efficacy is particularly fostered if the learning tasks allow for comparison with the performance of others and being encouraged or convinced by others regarding one's level of ability, we assumed that the growth of self-efficacy would be particularly influenced by these critical learning events. Our assumption was that successfully completing a new learning event would increase *situational* self-efficacy. In addition, we hypothesized that the amount of change produced by the confrontation with these events would be predictive of the change in *general* self-efficacy.

To test these hypotheses, we measured the construct of self-efficacy repeatedly with 186 male Year-7 high school students during a five-week, project-based, secondary school biology course and observed the ensuing changes. A microanalytical measurement approach to learning in a real classroom environment was adopted with measures taken before and after four critical learning events. In this study, reported in Chapter 4, we distinguished between *general* and *situational* self-

efficacy. The general self-efficacy measure was composed of an 8-item scale taken from the larger *Motivated Strategies for Learning Questionnaire* (MSLQ) developed by Pintrich, et al., (1993). It was supposed to measure student's self-efficacy judgements with regard to the course as a whole. The situational self-efficacy measure was adapted from the same 8-item scale but adapted specifically for situationality. It required students to respond to the learning task right in front of them. A confirmatory factor analysis (CFA) provided evidence of the construct validity of this new measure. During the study, general self-efficacy was measured on four occasions, including pre- and post-tests taken two weeks either side of the project. Situational self-efficacy was measured eight times either side of four critical learning events (four pairs of measures).

Results showed that there was a significant main effect for general self-efficacy. Post-hoc pairwise comparisons suggested that, during the course, general self-efficacy increased significantly, a replication of the previous study (Chapter 3; Hendry,Rotgans & Van der Molen, 2020, submitted). For the situational construct, although differences were always in the direction of higher self-efficacy after the critical learning event, they were not always significant. These changes in situational self-efficacy between post-and pre-critical learning events were however nevertheless positively related to change in general self-efficacy over the course, suggesting that critical learning events, affording students to assess their level of mastery situationally, contribute to increases in general self-efficacy.

A serious issue limiting conclusion was that we ended up with complete protocols of only 67 out of 186 students (36%). All other students' data had to be discarded because of illness, participation in extra-curricular school activities, and flooding (!). In a rather noisy classroom setting, the quality of data collected may be

subject to such unexpected extraneous influences difficult to control by the investigator. It made our study preliminary and exploratory.

4. How different are general and situational self-efficacy? and 5. Is academic achievement better predicted by situational than by general self-efficacy*?*

The third study (Chapter 5) in this thesis scrutinised the extent to which the general (dispositional) and situation-specific versions of self-efficacy should be considered manifestations of the same underlying construct and how well these general and situation-specific self-efficacy measures predicted achievement. In the extant literature on self-efficacy there arise a number of issues regarding the nature and the desired specificity of measurement of this construct. In short, Bandura (1986) proposed that self-efficacy seems to be tied to specific tasks rather than being a general dispositional attribute of students (and studies measuring it are operationalised accordingly). Along with Bandura, self-efficacy researchers stress that self-efficacy is related to a *specific task* at hand and it is not to be conceived as a general dispositional quality of a person that applies to many different contexts (Bandura, 1977; Bandura, 1986; Bandura, 1989, 2012; Duncan & McKeachie, 2005; Gist & Mitchell, 1992; Mathieu et al., 1993; Wolf, 1997; Zimmerman, 2000). Conversely, other self-efficacy researchers have viewed self-efficacy more as a trait or a characteristic of a person that is more or less invariant over situations (Chen et al., 2001; Schwarzer & Jerusalem 1995; Wolf 1997; Zhao et al., 2005) and have subsequently studied and measured the construct in this way. Furthermore, both sets of researchers have attempted to use either situational or general self-efficacy measures to predict subsequent achievement. To address these issues in the literature the following research questions were posed: How different are general and

situational self-efficacy? Is academic achievement better predicted by situational than by general self-efficacy?

To that end, data from three general and five situation-specific versions of the self-efficacy scale of the MSLQ (Pintrich, et al., 1993) administered over a period of a five-week course on cell biology were analysed. The data points used in this study for situational measures was related to student responses before, during and after number of relevant specific tasks ('critical learning events') for which their situational self-efficacy was assessed. Subsequent to the course, a measure of achievement was administered.

All measures of self-efficacy showed sufficient construct validity, as exemplified by good model fit following structural equation modelling. Results indicated that one latent factor was underlying each of the self-efficacy measures. Subsequently, one general self-efficacy and three related situational measures were submitted to a confirmatory factor analysis, which indicated that they were invariant over time. Indeed, the structure of the all measures was identical providing evidence that they all measured self-efficacy and not something else. However, attempts to load items from the general self-efficacy and related situational measures onto one latent factor failed with a two-factor model providing a more parsimonious fit (than a one-factor model), suggesting that the general and the situation-specific versions of the self-efficacy measures must measure different aspects of the construct. Additionally, through the use of path analysis, three general and five situation-specific measures taken over the course of the cell-biology lessons were related to each other and to an academic achievement measure. Results of this path analysis indicated that general self-efficacy was a medium-strong predictor of academic achievement. The situational self-efficacy measures, however, turned out to be dependent upon the

closest preceding general self-efficacy measure, and entertained no direct relationship with academic achievement as measured at the end of the course. It was concluded that general and situational self-efficacy are indeed measuring different aspects of the learning situation, and, it appears, contrary to current opinion, that a general measure of self-efficacy is a more robust predictor of academic achievement than its situational variant.

6. How are self-efficacy and academic achievement causally related?

In Chapter 6, we addressed another discussion point found in the literature examining how academic self-efficacy and knowledge acquisition are causally related. This study attempted to address another question arising from the literature, which is: How are self-efficacy and academic achievement causally related?

Data used in this study were collected from students during a five-week science (biology) project-based learning event on both self-efficacy and knowledge using a measure known as the Concept Retrieval Test (CRT; see Rotgans & Schmidt, 2014, and Hays, 2019). Establishing the causal direction between these two variables is important not only for gaining a better understanding of the nature of academic self-efficacy but also because of its instructional implications. The objective of this study, therefore, was to clarify this issue of causal directionality between academic self-efficacy and knowledge by testing three hypotheses. The first is the "standard hypothesis of academic self-efficacy" found in the literature, which predicts that academic self-efficacy determines academic performance. The second hypothesis is the "by-product hypothesis of academic self-efficacy," which predicts that one's level of academic self-efficacy is determined by one's knowledge level. The third hypothesis is the "reciprocal hypothesis of academic self-efficacy" and predicts that academic self-efficacy determines academic performance, which in turn determines

academic self-efficacy etc. To test all three hypotheses simultaneously, a cross-lagged panel analysis was conducted. This analysis entailed a measurement of students' academic self-efficacy and academic performance simultaneously at four points in time with the cross-effects of the measures examined to determine causality. Following the cross-lagged panel analysis, the standard hypothesis that academic higher levels of self-efficacy lead to higher levels of achievement was supported. However, the two subsequent hypotheses, one which assumed that higher levels of academic self-efficacy are a consequence of increasing knowledge and the other that academic self-efficacy and knowledge are influence each other reciprocally were not supported. The clarification of the direction of causality in this study, that is, confirming that academic self-efficacy is the cause of academic performance, has implications for instructional theory, practice and reforms given, as Talsma, Schüz, Schwarzer and Norris (2018) point out in their meta-analytic review, that the *"direct manipulation of self-efficacy has long been recommended as an intervention strategy in learning settings"* and it is therefore *"important to be confident that the relationship between self-efficacy and academic performance is being interpreted accurately"* (p. 137).

The final study included in this thesis is described in Chapter 7. It presents a different take on the self-efficacy construct by exploring the role of *collective efficacy* and *proxy efficacy* beliefs in the performances of project-based learning teams comprising friends and acquaintances groups are explored. In this study the role of collective and proxy efficacy beliefs in the performances of project-based learning teams comprising friends and acquaintances was explored. In the study, 162 students were organized into 20 acquaintance groups and 21 friendship groups with each group comprising 4 students undertaking separate five-week projects in three different

knowledge domains - Geography, Religious Studies, and English. Self-report surveys were administered three times over the five-week period and teacher-assessed group performance scores were collected. Multilevel modeling was used to examine relationships between variables in the study. Results of the study reveal that there were statistically significant interactions involving group type, collective efficacy, and proxy efficacy were identified in Geography and Religious Studies (not English). The potential implications for teachers is that it may be advantageous to assign students to friendship groups, provided they nurture collective efficacy, and that proxy efficacy may negatively affect group performance, depending on the context.

Limitations

Studies into motivational constructs within any learning environment can suffer from a number of limitations. An overview of the predominant shortcomings pertaining to this thesis, in which studies were conducted with different classes, at different times and within same learning environment are discussed below (for a more detailed discussion the limitations of each study, please see the relevant chapter). Firstly, the studies contained within this thesis relied on the use of *self-report measures*. Whilst all measures used in this thesis were validated, there remains the possibility that students have varying degrees of introspection, adding to bias in the data and that social desirability (i.e. wishing 'to look good') may play a larger role than often assumed, in particular when self-presentation contributes to teacher judgements of student competence (Fisher & Katz, 2000). There is always the chance too, with self-report measures in a longitudinal study, that a growing *familiarity* or *experience* with the instruments leads to a change in student responses in later surveys. A second limitation are the results of the studies undertaken, which, when significant, showed only small effect sizes, the potential causes of which being varied and theorised in depth in the context of each study. A third broad limitation in the

thesis relates to the instructional environment in which these studies were operationalised – a school where student-centred approaches to learning are the main (only) mode of instruction – with all research being undertaken in project-based learning science courses for young males in early high school (ages 12-14). This situation raises questions about the generalizability of the findings of these studies or the extrapolation of their results to different (or even similar) instructional environments and other questions like whether Science is a knowledge domain which may or may not lend itself more to project-based learning and therefore impact the development of self-efficacy and affect the results either way.

Directions for Further Research

The findings of this thesis (as well as the perceived limitations above) provide starting points for further and broader research into the development of self-efficacy, a motivational construct considered important for learning. In particular, further research into the interaction between self-efficacy and instructional environments is required, especially in learning environments that are utilising active-learning pedagogies like project- and problem-based learning (given their reported and purported benefits to student learning). And although we believe to have shown that project-based instruction adds to self-efficacy, we have not demonstrated which specific instructional practices are particularly helpful in fostering self-efficacy and how the sources of information used to form these beliefs may be amplified in such a learning environment. Furthermore, these studies have brought into sharper focus the relationship between the situational and general (dispositional) aspects of the construct of self-efficacy and how they relate to performance. The findings that the general and the situation-specific versions of the self-efficacy measures must measure different aspects of the construct certainly requires further research as does the

finding, contrary to the commonly held view, that the general measure was a more robust predictor of performance than the situational measure. Lastly, whilst our study confirmed the standard hypothesis, that academic self-efficacy results in knowledge gains (and not higher as a consequence of increasing knowledge or reciprocally influential) in this context, further exploration into the direction of causality of academic self-efficacy and performance is required given the manipulation of student self-efficacy has been proposed as a way of improving performance. These questions need to be addressed by means of further research.

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Samenvatting

(Summary in Dutch)

Inleiding

Dit hoofdstuk vormt de afsluiting van het onderzoek naar zelfvertrouwen (self-efficacy) en academische prestaties in een project-gebaseerde leeromgeving. Het primaire doel van dit proefschrift was te onderzoeken in hoeverre het motivationele construct self-efficacy zich in de loop van de tijd ontwikkelde en veranderde in relatie tot de leeromgeving en hoe dit construct samenhing met de studieprestaties van leerlingen. Voor dit proefschrift werden twee longitudinale datasets verzameld (in 2015 en 2018) en gebruikt voor de vier daarin opgenomen studies. Eén dataset werd gebruikt voor studies naar instructie en prestatie (hoofdstukken 3 en 6) en de andere dataset voor de studies die de invloed van kritische leerervaringen op de ontwikkeling van self-efficacy en daarnaast het verschil tussen algemene en situationele self-efficacy onderzochten (hoofdstukken 4 en 5). Weer een andere dataset werd in 2015 verzameld in samenwerking met onderzoekers van de Western Sydney University en de University of Wollongong. Deze data staan aan de basis van het onderzoek dat in hoofdstuk 7 wordt beschreven. In dit afsluitende hoofdstuk worden de belangrijkste onderzoeksvragen en bevindingen van elk van deze studies besproken, evenals de beperkingen van elk onderzoek en de mogelijke richtingen voor toekomstig onderzoek.

De onderwijscontext van de studies: Een activerende leeromgeving

De studies in dit proefschrift werden uitgevoerd in een middelbare school die project-gebaseerd onderwijs toepast in de schooljaren 7 tot 10 (leeftijd 12 tot 16),

probleemgestuurd onderwijs in leerjaar 11 (leeftijd 17) en de flipped classroom in leerjaar 12 (leeftijd 18). Al deze benaderingen worden beschouwd als pedagogische benaderingen die ’actief leren’ bevorderen. Om verstoring van het onderwijs in de klassen in de bovenbouw te voorkomen en om de ontwikkeling van self-efficacy in de loop van de tijd en in relatie tot prestaties te begrijpen, werden de onderzoeken in dit proefschrift uitgevoerd in de onderbouwklassen (leerjaar 7 en 8), waar project-gebaseerd leren de instructiewijze is. In deze context wordt project-gebaseerd leren beschouwd als een aanpak waarbij het curriculum aan de leerling wordt gepresenteerd in de gedaante van een 'authentiek' project. Tijdens een project werken de leerlingen in groepen en moeten zij hun voorkennis activeren en zich bezighouden met nieuwe en steeds complexere concepten om een oplossing of "eindproduct" te presenteren dat implicaties kan hebben voor de echte wereld of daarin zelfs geïmplementeerd kan worden (Thomas, 2000). Dit idee van leren in context en de belangstelling van leerlingen te wekken door ’doceren aan de hand van projecten’ bestaat al meer dan een eeuw (Dewey, 1897). Het was echter in het laatste deel van de twintigste eeuw dat zekere consensus werd bereikt over wat project-gebaseerd leren inhoudt, namelijk dat projecten de belangrijkste wijze van instructie zijn. Daarbij heeft elk project een 'stuwende vraag' heeft die de belangrijkste onderliggende conceptuele (vaak multidisciplinaire) kennis en activiteiten samenbrengt die het leren van studenten sturen. De doelen en centrale activiteiten van projecten vereisen dat studenten bestaande informatie onderzoeken, transformeren en construeren (voorbij hun huidige vaardigheden en kennis). Daarbij neemt de docent vooral een faciliterende rol in het leerproces op zich (Savery, 2006; Thomas, 2000). In dit proefschrift wordt in hoofdstuk 2 (Hendry et al., 2017) de innovatieve onderwijsomgeving beschreven waarbinnen de studies zijn uitgevoerd, een ‘all-boys high school’ in de buurt van

Parramatta, West-Sydney, Australië. Het vormt het toneel voor de daaropvolgende hoofdstukken.

Samenvatting van de Bevindingen

De focus van dit proefschrift is self-efficacy en de rol die dit construct speelt in relatie tot leren en studieprestaties. Self-efficacy houdt een zelfoordeel in over hoe succesvol men zal zijn in het uitvoeren van een bepaalde taak met de vaardigheden die men op dat moment bezit (Bandura, 1986). Al meer dan veertig jaar blijkt self-efficacy een belangrijk motivationeel construct te zijn voor leren dat een belangrijke voorspellende waarde heeft voor prestaties, met name in het academische domein (Bandura, 2012; Honicke & Broadbent, 2016). Ook is gebleken dat self-efficacy een sterke mediërende invloed heeft op andere constructen (zie bijvoorbeeld Onoda, 2014; Sue-Chan & Ong, 2002; Niemivirta & Tapola, 2007; Zimmerman & Kitsantas, 2014). Gezien het belang ervan voor leren, werd het begrijpen van de mate waarin self-efficacy zich ontwikkelt en verandert in de loop van de tijd en de factoren die bijdragen aan de groei ervan binnen een authentieke leeromgeving de belangrijkste focus van deze thesis. Hieronder worden onze belangrijkste bevindingen gepresenteerd, geordend rond de zes onderzoeksvragen die in hoofdstuk 1 zijn geschetst.

1. In welke mate ontwikkelt self-efficacy zich in de loop van de tijd? en 2. Is de ontwikkeling van self-efficacy in de tijd het resultaat van de invloed van instructie?

Deze vragen werden belangrijk geacht omdat een analyse van de bestaande studies naar de invloed van instructiepraktijken op de self-efficacy van leerlingen erop duidt dat die studies tekort schieten in verband met twee problemen. Ten eerste zijn ze onvoldoende authentiek, dat wil zeggen dat ze gebruik maken van gekunstelde

experimentele ontwerpen in een niet-klassikale setting die een paar uur duren (bijv. Hushman & Marley, 2015). Het is onwaarschijnlijk dat ontwikkeling van self-efficacy, in feite een traag proces dat zich parallel ontwikkelt met de geleidelijke ontwikkeling van iemands kennis van en vaardigheden binnen een bepaald domein, plaatsvindt binnen zo'n beperkte tijd.. Daarom achtten we onderzoek nodig dat de ontwikkeling van self-efficacy over een langere tijdspanne bestudeert in een authentieke onderwijscontext. Het tweede probleem is dat de studies meestal veranderingen in self-efficacy meten in een enkele groep leerlingen zonder voldoende controles (bv. Alt, 2015). Deze studies maken meestal gebruik van een pretest-posttest design, waardoor de mogelijkheid bestaat dat waargenomen veranderingen oorzaken hebben die niet gerelateerd zijn aan de wijze van instructie.

De eerste studie in dit proefschrift (Hoofdstuk 3) richtte zich op deze vragen door de ontwikkeling van self-efficacy in relatie tot instructie in kaart te brengen. De studie werd uitgevoerd gedurende een vijf weken durend project Natuur- en Scheikunde. De self-efficacy-maat die in deze studie werd gebruikt was een 8-item schaal afkomstig van de meer uitgebreide Motivated Strategies for Learning Questionnaire (MSLQ), ontwikkeld door Pintrich, Smith, Garcia en McKeachie (1993). De 8-item schaal bleek een hoge interne consistentie te hebben. De in deze studie gebruikte vragenlijsten werden online afgenomen via devices van studenten met behulp van Qualtrics enquêtesoftware (Qualtrics, Provo, UT). Een microanalytische meetbenadering werd gebruikt om gegevens te verzamelen via student devices (in dit geval hadden alle studenten iPads of laptops). Deze meetmethode is discreet en kan onmiddellijk worden toegepast nadat de studenten het project-gebaseerd onderwijs hebben gevolgd. Het onderzoek werd uitgevoerd over een periode van 12 weken, met in totaal acht metingen. Drie weken voor het begin

van een vijf weken durend project in groep 8 over 'fysische en chemische veranderingen' werd een pre-test afgenomen. De leerlingen werden gedurende het project eenmaal per week ondervraagd. Dit werd gevolgd door een onmiddellijke post-test een week na de afsluiting van het project; en vervolgens werd een uitgestelde post-test afgenomen drie weken na de eerste post-test.

Bij de analyse van de gegevens werd gekozen voor een innovatieve aanpak die latente-groeimodellering combineert met een tijdreeksontwerp om te onderzoeken of de self-efficacy van de leerlingen groeide als gevolg van het volgen van het vijf weken durende project. De veronderstelling van het latente groei-curve model was dat, indien de instructie een causaal effect zou hebben op self-efficacy, een sterkere groei van self-efficacy tijdens de cursus dan in de pre- en post-instructie periodes zou worden waargenomen. De gegevens bleken goed in dit model te passen. Het model toonde aan dat een significante, zij het kleine groei van self-efficacy werd waargenomen tijdens de instructieperiode, en afwezig was tijdens de fasen waarin geen instructie werd gegeven. De conclusie was daarom dat de project-gebaseerde natuur- en scheikundecursus inderdaad een groei van self-efficacy bij leerlingen teweegbracht. Een van de belangrijkste vragen die uit deze studie naar voren kwam was *waarom* instructie in deze leeromgeving leidde tot een significante groei in de self-efficacy van de deelnemers in de loop van de studie.

3. Leiden vooral 'kritische leermomenten' tot een toename van self-efficacy?

Een volgende onderzoeksvraag was derhalve of leerervaringen op bepaalde momenten tijdens het projectmatig leerproces (aangeduid als 'kritische leermomenten') bijdragen aan de ontwikkeling van self-efficacy. Kritische leermomenten werden gedefinieerd als oefeningen, activiteiten, opdrachten, en

experimenten die op drie manieren kunnen worden onderscheiden van meer routinematige taken in de klas. Ze werden ontworpen om zich te concentreren op hiaten in de kennisbasis van de leerling met betrekking tot belangrijke moeilijke leerstof; ze helpen bij het verkennen van nieuwe manieren om tijdens het project verworven kennis toe te passen; en ze zijn zo opgezet dat de leerlingen moeten samenwerken. In navolging van Bandura's (1977, 1986, 1997) suggesties dat self-efficacy in het bijzonder wordt bevorderd als de leertaken de mogelijkheid bieden tot vergelijking tussen de eigen prestaties met die van anderen en als men door anderen wordt overtuigd van het eigen bekwaamheidsniveau, veronderstelden wij dat de groei van self-efficacy in het bijzonder zou worden beïnvloed door deze kritische leermomenten. Onze veronderstelling was dat het succesvol afronden van een nieuw kritisch leermoment de *situationele* self-efficacy zou verhogen. Bovendien veronderstelden we dat de mate van verandering die de confrontatie met deze leermomenten teweegbracht, voorspellend zou zijn voor de verandering in *algemene* self-efficacy. Om deze hypothesen te testen, hebben we het construct self-efficacy herhaaldelijk gemeten bij 186 mannelijke middelbare scholieren uit jaar 7 tijdens een vijf weken durende, project-gebaseerde, biologiecursus in het secundair onderwijs en de veranderingen in self-efficacy bepaald. Een microanalytische meetbenadering van leren in een authentieke leeromgeving werd gebruikt met metingen voor en na vier kritische leermomenten. In deze studie, waarvan verslag wordt gedaan in Hoofdstuk 4, maakten we onderscheid tussen algemene en situationele self-efficacy. De algemene self-efficacy-meting bestond uit een 8-item schaal uit de grotere Motivated Strategies for Learning Questionnaire (MSLQ) ontwikkeld door Pintrich, et al., (1993). Deze schaal werd verondersteld de self-efficay van de studenten te meten met betrekking tot de cursus als geheel. De situationele self-efficacy maat werd gebaseerd

op dezelfde 8-item schaal, maar specifiek aangepast voor situationaliteit. Bij het invullen van deze lijst moesten de studenten hun self-efficacy inschatten met betrekking tot de leertaak die ze onmiddellijk daarna moesten uitvoeren. Een confirmatieve factoranalyse (CFA) leverde ondersteuning voor de constructvaliditeit van deze nieuwe maat. Tijdens de studie werd algemene self-efficacy op vier momenten gemeten, inclusief pre- en post-tests die twee weken voor en twee weken na het project werden afgenomen. Situationele self-efficacy werd acht keer gemeten aan weerszijden van de vier kritische leermomenten (vier meetparen).

De resultaten toonden aan dat er een significant hoofdeffect was voor algemene self-efficacy. Post-hoc paarsgewijze vergelijkingen suggereerden dat, gedurende de cursus, algemene self-efficacy significant toenam, een replicatie van het resultaat dat gevonden werd in de vorige studie (Hoofdstuk 3; Hendry, Rotgans & Van der Molen, 2020, ingediend). Voor het situationele construct waren de verschillen weliswaar altijd in de richting van hogere self-efficacy na de kritische leergebeurtenis, maar ze waren niet altijd significant. Deze veranderingen in situationele self-efficacy tussen post- en pre-kritische leermomenten waren niettemin positief gerelateerd aan verandering in algemene self-efficacy gedurende de cursus, wat suggereert dat kritische leermomenten, die studenten in staat stellen hun niveau van beheersing van de leerstof situationeel te beoordelen, bijdragen aan een toename in algemene self-efficacy.

Een belangrijk probleem dat de conclusie van de studie beperkte, was dat we uiteindelijk slechts van 67 van de 186 studenten (36%) volledige gegevens hadden. De gegevens van alle andere leerlingen moesten worden verwijderd wegens ziekte, deelname aan buitenschoolse schoolactiviteiten, en overstroming (!). Door deze vormen van ruis in de authentieke leeromgeving kan de kwaliteit van de verzamelde

gegevens onderhevig zijn aan onverwachte invloeden van buitenaf, die moeilijk door de onderzoeker te controleren zijn. Dit betekent dat deze studie vooral als voorlopig en verkennend moet worden beschouwd.

4. Hoe verschillend zijn algemene en situationele self-efficacy? en 5. Worden studieprestaties beter voorspeld door situationele dan door algemene self-efficacy?

De derde studie (Hoofdstuk 5) in dit proefschrift onderzocht in welke mate algemene (dispositionele) en situationele self-efficacy beschouwd moeten worden als manifestaties van hetzelfde onderliggende construct en hoe goed deze algemene en situationele self-efficacy studieprestaties voorspelden. In de bestaande literatuur over self-efficacy rijzen een aantal vragen over de aard en de gewenste specificiteit van de meting van dit construct. In het kort stelde Bandura (1986) dat self-efficacy eerder gebonden lijkt te zijn aan specifieke taken dan dat het een algemene dispositionele eigenschap van studenten is (en studies die het begrip meten zijn ook dienovereenkomstig geoperationaliseerd). Evenals Bandura benadrukken andere onderzoekers dat self-efficacy gerelateerd is aan een *specifieke* taak en niet moet worden opgevat als een algemene dispositionele eigenschap van een persoon die van toepassing is op veel verschillende contexten (Bandura, 1977; Bandura, 1986; Bandura, 1989, 2012; Duncan & McKeachie, 2005; Gist & Mitchell, 1992; Mathieu et al., 1993; Wolf, 1997; Zimmerman, 2000). Daarentegen hebben andere self-efficacy onderzoekers het begrip wel meer gezien als een karaktertrek of een eigenschap van een persoon die min of meer invariant is over situaties heen (Chen et al., 2001; Schwarzer & Jerusalem 1995; Wolf 1997; Zhao et al., 2005) Zij hebben het construct vervolgens op die manier bestudeerd en gemeten. Bovendien hebben beide groepen onderzoekers geprobeerd om ofwel situationele ofwel algemene self-efficacy

maten te gebruiken om latere studieprestaties te voorspellen. Om deze controverse in de literatuur aan te pakken werden de volgende onderzoeksvragen gesteld: Hoe verschillend zijn algemene en situationele self-efficacy? Worden studieprestaties beter voorspeld door situationele dan door algemene self-efficacy?

Daartoe werden gegevens geanalyseerd van acht metingen: drie algemene en vijf situatiespecifieke metingen van de self-efficacy schaal van de MSLQ (Pintrich, et al., 1993), die werden afgenomen in het kader van een vijf weken durende cursus over celbiologie. De metingen die in deze studie werden gebruikt voor situationele self-efficacy hadden betrekking op de antwoorden van de studenten voor, tijdens en na een aantal relevante specifieke taken ('kritische leermomenten'), na afloop van de cursus werd een studieprestatiemeting afgenomen.

Alle maten van self-efficacy toonden voldoende constructvaliditeit, zoals geïllustreerd door een goede modelfit na structural equation modelling. De resultaten toonden aan dat een latente factor ten grondslag lag aan elk van de metingen van self-efficacy. Vervolgens werden de algemene self-efficacy maat en drie gerelateerde situationele maten onderworpen aan een confirmatieve factoranalyse. Deze wees uit dat ze invariant waren in de tijd. De structuur van alle maten was inderdaad identiek, hetgeen de veronderstelling steunt dat ze allemaal self-efficacy maten en niet iets anders. Pogingen om items van de algemene self-efficacy maat en de gerelateerde situationele metingen op een latente factor te laden faalden echter, waarbij een twee-factoren model een spaarzamere fit gaf dan een een-factor model. Dit suggereert dat de algemene en situationele self-efficacy metingen verschillende aspecten van het construct meten. Bovendien werden met behulp van padanalyse de drie algemene en de vijf situationele maten, afgenomen in de loop van de lessen celbiologie, aan elkaar en aan een maat voor studieprestatie gerelateerd. De resultaten van deze padanalyse

toonden aan dat algemene self-efficacy een gemiddeld sterke voorspeller was van studieprestaties. De situationele self-efficacy resultaten bleken echter afhankelijk te zijn van de eerstvolgende algemene self-efficacy meting, en vertoonden geen directe relatie met studieprestaties zoals gemeten aan het eind van de cursus. Geconcludeerd werd dat algemene en situationele self-efficacy inderdaad verschillende aspecten van self-efficacy meten, en dat, in tegenstelling tot de vigerende opinie, blijkt dat algemene self-efficacy een robuustere voorspeller is van studieprestaties dan situationele self-efficacy.

6. Hoe zijn self-efficacy en studieprestaties causaal gerelateerd?

In hoofdstuk 6 hebben we een ander discussiepunt uit de literatuur behandeld, namelijk hoe self-efficacy en kennisverwerving causaal gerelateerd zijn. De gegevens die in deze studie werden gebruikt, werden verzameld bij studenten tijdens een vijf weken durende project-gebaseerde biologiecursus. De data betroffen self-efficacy en kennis; voor deze laatste werd een maat gebruikt die bekend staat als de Concept Retrieval Test (CRT; zie Rotgans & Schmidt, 2014, en Hays, 2019). Het vaststellen van de causale richting tussen deze twee variabelen is niet alleen belangrijk voor het verkrijgen van een beter begrip van de oorsprong van self-efficacy bij leren, maar ook vanwege de implicaties ervan voor het onderwijs. Het doel van deze studie was daarom om deze kwestie van causale directionaliteit tussen self-efficacy en kennis te verduidelijken door drie hypothesen te testen. De eerste is de "standaardhypothese van self-efficacy bij leren" uit de literatuur, die voorspelt dat self-efficacy studieprestaties bepaalt. De tweede hypothese is de "bijproduct-hypothese van self-efficacy bij leren", die voorspelt dat iemands niveau van self-efficacy wordt bepaald door iemands kennisniveau. De derde hypothese is de "wederkerige hypothese van

self-efficacy bij leren"; deze voorspelt dat self-efficacy bij leren bepalend is voor studieprestaties, die op hun beurt weer bepalend zijn voor self-efficacy. Om alle drie hypothesen tegelijk te testen, werd een cross-lagged panelanalyse uitgevoerd. Deze analyse hield in dat self-efficacy bij leren en de studieprestaties van studenten op vier tijdstippen simultaan werden gemeten. Daarna werden kruiseffecten van de metingen onderzocht om de causaliteit vast te stellen. Na de cross-lagged panelanalyse werd de standaardhypothese dat hogere niveaus van self-efficacy bij leren tot hogere studieprestatieniveaus leiden, ondersteund. De twee daaropvolgende hypothesen, de ene die veronderstelde dat hogere niveaus van self-efficacy bij leren een gevolg zijn van toenemende kennis en de andere dat self-efficacy bij leren en het niveau van studieprestaties elkaar wederzijds beïnvloeden, werden echter niet ondersteund. De verduidelijking van de richting van causaliteit in deze studie, dat wil zeggen, de bevestiging dat self-efficacy bij leren een oorzakelijk verband heeft met studieprestaties, heeft implicaties voor de onderwijstheorie, de onderwijspraktijk en vooronderwijshervormingen. Talsma, Schüz, Schwarzer en Norris (2018) wijzen er in hun meta-analytische review op dat de "directe manipulatie van self-efficacy al lang wordt aanbevolen als een interventiestrategie in leeromgevingen" en dat het daarom "belangrijk is om er zeker van te zijn dat de relatie tussen self-efficacy bij leren en studieprestaties accuraat wordt geïnterpreteerd" (p. 137).

De laatste studie in dit proefschrift wordt beschreven in Hoofdstuk 7. Het presenteert een andere kijk op het self-efficacy construct doordat de rol van collectieve efficacy en zogenaamde proxy efficacy beliefs in de prestaties van project-gebaseerde leerteams bestaande uit vrienden en kennissen groepen wordt onderzocht. In de studie werden 162 studenten onderverdeeld in 20 kennissen- en 21 vriendengroepen. Elke groep bestond uit vier studenten die elk een vijf weken durend

project ondernamen in drie verschillende kennisdomeinen, te wetenaardrijkskunde, godsdienstwetenschappen, en Engels. Gedurende de vijf weken werden drie keer zelfrapportage-enquêtes afgenomen en door de leerkracht beoordeelde groepsscores werden verzameld. Multilevel modellering werd gebruikt om de relaties tussen variabelen in de studie te onderzoeken. De resultaten van de studie tonen aan dat er statistisch significante interacties bestonden tussen groepstype, collectieve effectiviteit en proxy self-efficacy bij aardrijkskunde en godsdienstwetenschappen, maar niet bij Engels. De mogelijke praktische implicatie voor leerkrachten is dat het voordelig kan zijn om leerlingen in vriendschapsgroepen in te delen.

Beperkingen van de studies

Onderzoek naar motivationele constructen binnen een leeromgeving kan lijden onder een aantal beperkingen. Een overzicht van de belangrijkste tekortkomingen met betrekking tot dit proefschrift, waarin studies werden uitgevoerd met verschillende klassen, op verschillende tijdstippen en binnen dezelfde leeromgeving worden hieronder besproken (voor een meer gedetailleerde bespreking van de beperkingen van elke studie wordt verwezen naar het betreffende hoofdstuk). Ten eerste waren de studies in dit proefschrift gebaseerd op het gebruik van zelfrapportage-metingen. Hoewel alle in dit proefschrift gebruikte maten gevalideerd waren, blijft de mogelijkheid bestaan dat studenten verschillen in introspectief vermogen, wat kan hebben bijgedragen aan vertekening in de gegevens en aan de kans dat sociale wenselijkheid (d.w.z. 'er goed uit willen zien') een grotere rol heeft gespeeld dan vaak wordt aangenomen, in het bijzonder wanneer zelfpresentatie bijdraagt aan het oordeel van de leraar over de competentie van studenten (Fisher & Katz, 2000). Bij zelfrapportage in een longitudinale studie bestaat ook altijd de kans dat een

toenemende vertrouwdheid of ervaring met de instrumenten leidt tot een verandering in de antwoorden van leerlingen in later afgenomen vragenlijsten. Een tweede beperking wordt gevormd door de resultaten van de uitgevoerde studies, die, als ze significant waren, slechts kleine effectgroottes lieten zien. De mogelijke oorzaken daarvan zijn in de verschillende studies besproken. Een derde algemene beperking in het proefschrift heeft te maken met de leeromgeving waarin deze studies werden uitgevoerd: één school waar gekozen is voor een leerlinggerichte onderwijsbenadering. Daarbij werden alle onderzoeken uitgevoerd in project-gebaseerde cursussen op het gebied van exacte vakken (natuurkunde, scheikunde, biologie) voor jongens in het begin van middelbare school (leeftijd 12-14). Dit roept de vraag op of de bevindingen van deze studies gegeneraliseerd kunnen worden en of de resultaten naar andere leeromgevingen geëxtrapoleerd kunnen worden.

Suggesties voor verder onderzoek

De bevindingen van dit proefschrift (en de hierboven beschreven beperkingen) bieden aanknopingspunten voor verder en breder onderzoek naar de ontwikkeling van self-efficacy, een motivationeel construct dat belangrijk wordt geacht voor leren. In het bijzonder is verder onderzoek nodig naar de interactie tussen self-efficacy en verschillende leeromgevingen, vooral leeromgevingen die gebruik maken van actief-leren, zoals project- en probleemgestuurd onderwijs (gezien de gerapporteerde voordelen voor het leren van studenten). En hoewel we menen te hebben aangetoond dat project-gebaseerd onderwijs bijdraagt aan de ontwikkeling van self-efficacy, hebben we niet aangetoond welke specifieke onderwijsbenaderingen in het bijzonder helpen bij het bevorderen van self-efficacy en hoe de informatiebronnen die worden gebruikt om self-efficacy te bevorderen, kunnen worden versterkt. Bovendien hebben

onze studies de relatie tussen de situationele en algemene (dispositionele) aspecten van het construct self-efficacy en hoe deze zich verhouden tot studieprestaties, scherper in beeld gebracht. De veronderstelling dat de algemene en de situatiespecifieke versies van het self-efficacy-instrument verschillende aspecten van het construct meten, vereist zeker verder onderzoek, evenals de bevinding dat, in tegenstelling tot de gangbare opvatting, algemene self-efficacy een robuustere voorspeller van studieprestaties is dan situationele self-efficay. Ten slotte, hoewel onze studie de standaardhypothese bevestigde dat algemene self-efficacy resulteert in een toename van kennis in deze context, is verder onderzoek nodig naar de richting van causaliteit van self-efficacy bij leren en studieprestaties, omdat de bevordering van de self-efficacy van studenten is voorgesteld als een manier om uiteindelijke prestaties te verbeteren. Deze vragen moeten worden beantwoord door middel van verder onderzoek.

Stellingen/Propositions

behorende bij het proefschrift

1. It is important to study the construct of self-efficacy in relation to instructional approaches like project-based learning given their increasing deployment in education. *(this thesis)*
2. Studying the development of self-efficacy *over time* using a discrete microanalytical (fine-grain) approach has revealed more nuanced aspects of the construct. *(this thesis)*
3. Contrary to current opinion, a general measure of self-efficacy is a more robust predictor of academic achievement than its situational variant. *(this thesis)*
4. Higher levels of general self-efficacy lead to higher levels of achievement and neither the other way around nor in a reciprocal manner. *(this thesis)*
5. Groups selected on the basis of friendship allows for the cultivation of collective efficacy leading to greater achievement than those formed with acquaintances. *(this thesis)*
6. Self-efficacy's importance extends beyond its relationship to achievement, it has shown itself to be a powerful mediating influence on other psychological constructs (see, for example, Niemivirta & Tapola, 2007; Zimmerman & Kitsantas, 2014)
7. There has been enduring interest in the qualities of learners that contribute to success beyond simply academic performance; however, attempts at

measuring these qualities are a more recent endeavour. (Duckworth & Yeagar, 2015)

8. The purpose of education is to support the development of knowledge and skills as well as attitudes and values that guide students towards ethical and responsible actions (OECD Report: Future of Skills and Education 2030).
9. Many educational researchers see the COVID-19 pandemic as an opportunity to rethink education and make much needed improvements and innovations worldwide. (Zhao & Watterston, 2021)
10. There has been significant investment in education across the world (particularly in the developing world) but 'being in school is not the same as learning'; delivered well, education benefits individuals and societies. (The World Bank: '*The Education Crisis: Being in School is Not the Same as Learning'*)
11. "*One cannot be all things, which would require mastery of every realm of human life"* (Albert Bandura).

Author Publications

Hendry, A., & Viney, C. (2012). Repackaging science, engineering, technical and other applied studies curricula into authentic projects and problems. *In: Mann, Llewellyn (Editor); Daniel, Scott (Editor). 23rd Annual Conference of the Australasian Association for Engineering Education 2012: Profession of Engineering Education: Advancing Teaching, Research and Careers, The. [Melbourne, Vic.]: Engineers Australia, 2012: 247-255.* Engineers Australia.

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Hendry, A., Rotgans, J. I., & Van der Molen, H.T. (2020). Fostering Self-efficacy: the Role of Instruction. (Submitted for publication, Australian Journal of Education).

Curriculum Vitae

Dr Adam Hendry holds the position of Assistant Principal (Learning) at Parramatta Marist High in Sydney, Australia, with responsibility for the teaching and learning and professional development of over 80 staff as well as oversight of educational and institutional research initiatives. He holds a Bachelor of Arts with Diploma of Education (1999) and a Masters in Ancient History (2005) - both degrees conferred by Macquarie University, Sydney. Since 2008, Adam has been involved in the implementation, practice and refinement of project- and problem-based learning at Parramatta Marist across all disciplines. Commencing his teaching career in 1998, he has worked in schools in Australia, the Netherlands and the United Kingdom. In 2015, Adam commenced doctoral studies under Professor Dr Henk Schmidt at Erasmus University co-supervised by Professor Dr Henk van Der Molen (also from Erasmus) and Assistant Professor Dr Jerome Rotgans from the Lee Kong Chian School of Medicine at Nanyang Technological University, Singapore. During his doctoral studies, he has presented his work at several international conferences including the PBL 2016 Congress, Zurich, Switzerland and American Educational Research Association (AERA) Annual Conference 2017, in San Antonio, USA. Additionally, from 2015 onwards, Adam has undertaken multiple studies into the effects of self, proxy and collective efficacy as well as group dynamics with Dr Jose Hanham from the School of Education at Western Sydney University. Current research interests are focused on the long term effects of PBL (especially on alumni), the impact of remote learning and self-efficacy engendered within a constructivist learning environment.

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