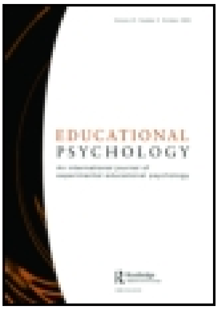

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Juxtaposing math self-efficacy and self-concept as predictors of long-term achievement outcomes

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In this study, we tested the hypothesis that self-efficacy and self-concept reflect different underlying processes and both are critical to understanding long-term achievement outcomes. Although both types of self-belief are well established in educational psychology, research comparing and contrasting their relationship with achievement has been surprisingly sparse. This is particularly the case when considering critical developmental periods and high-stakes achievement outcomes. In the current research, we use the longitudinal study of Australian youth which uses the 2003 Australian Programme of International Student Assessment cohort ($N = 10{,}370$; M [age] = 15) as the first time wave and follows participants over eight years. Using latent path modelling and controlling for a wide range of background covariates, we found: (a) strong relations between achievement, self-efficacy and self-concept in mathematics at age 15; (b) both self-concept and self-efficacy were independent and similarly strong predictors of tertiary entrance ranks at the end of high school; (c) math self-efficacy was a significant predictor of university entry but math self-concept was not; and (d) math self-concept was a significant predictor of undertaking post-school studies in science, technology, engineering or math, but math self-efficacy was not.

Keywords: self-efficacy; self-concept; academic achievement; university entry; post-high school transitions

Introduction

Self-beliefs predict a range of important outcomes across a number of life domains (Bandura, 1986; Marsh, 2007). Although empirical research has noted their importance in sports and organisational settings, the effect of self-beliefs on achievement has been most widely studied in educational psychology, where the focus has primarily been on academic self-concepts and self-efficacy (Bong & Skaalvik, 2003). Indeed, these two self-belief constructs have been the focus of international assessment programmes aimed at identifying the factors that contribute to the academic achievement of students around the world including the Programme of International Student Assessment (PISA). Research on PISA and other databases has consistently shown the strong relationship between achievement and self-beliefs across nations

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(e.g. Lee, 2009; Marsh & Hau, 2003, 2004; Marsh et al., 2013). Although PISA and other large databases often contain both self-concept and self-efficacy, most research in this area has typically focused on one or the other. With notable exceptions (e.g. Marsh, Trautwein, Lüdtke, & Köller, 2008), little research has juxtaposed these self-belief constructs as predictors of academic achievement and achievement-related outcomes. The research that has compared and contrasted these constructs has typically been cross-sectional or, when longitudinal, measured achievement with low-stakes tests. That is achievement is typically measured by the researcher under conditions of anonymity and thus has no formal implications for the test taker. The current research uses math self-efficacy and self-concept from a representative longitudinal database of 15-year-old Australian youth to predict developmentally significant Tertiary Entrance Ranks (TER; i.e. final school year matriculation results), university entry, and science, technology, engineering and mathematics (STEM) university majors. We first explore research that links self-efficacy and achievement and self-concept and achievement before juxtaposing their relative roles.

Academic self-efficacy as a predictor of achievement

Although much of the academic self-efficacy research has focused on its effect on task choice, achievement goals and goal pursuit (see Bong & Skaalvik, 2003; Marsh, Walker, & Debus, 1991), there is now extensive evidence of the link between self-efficacy and academic achievement (e.g. Diseth, Danielson, Samdal, 2012; Phan, 2012; Stankov, Lee, Luo, & Hogan, 2012). Indeed, the meta-analysis by Richardson, Abraham, and Bond (2012) found that self-efficacy was the strongest psychological correlate of academic achievement among those studied (general self-esteem but not academic self-concept was included in this analysis). From a causal perspective, Schunk and colleagues (see also Bandura, 1993) have provided extensive evidence, from longitudinal studies and experimental and quasi-experimental manipulation, that student's self-efficacy effects achievement (see Pajares & Schunk, 2001 for a review). The finding that self-efficacy predicts actual achievement is consistent with Bandura's (1986, 2001) and Schunk and Zimmerman (2007) triadic reciprocal causation model. This model suggests that individuals' cognitions, behaviours and their environment are mutually related over time such that change in any one gives rise to changes in the others. From this perspective, it would be expected that the way individuals feel about their ability to complete a given task would cause and be caused by their academic achievement (see Bandura, 1993; Schunk, 1989). Research in this area suggests that this reciprocal relationship is due to individuals with high self-efficacy persisting longer when faced with difficulties and applying more sustained effort to a task generally. This predicts later achievement and, as a result, stronger subsequent self-efficacy (Marsh et al., 1991). Valentine, Debois, and Cooper (2004) meta-analysis shows strong support for these reciprocal relationships, but found that the strength of these reciprocal relations did not differ for self-efficacy and academic self-concept.

Academic self-concept as a predictor of achievement

There is now strong evidence that academic self-concept also effects achievement. Indeed, considerable self-concept research in recent years has been devoted to the reciprocal effects model (REM; see Marsh, 2007 for a review). Similar to Bandura's triadic reciprocal causation model, the REM indicates that higher academic achievement leads to more positive academic self-concept, and more positive self-concept results in higher achievement in a spiral of positive benefits (Marsh, 2007). Considerable empirical evidence supports the causal role of self-concept as a critical non-cognitive factor that influences later achievement (see Marsh, 2007; Marsh & Craven, 2006; Marsh & O'Mara, 2008; Valentine et al., 2004). Indeed, Marsh et al. (2008) found that academic self-concept was the strongest predictor of the 14 psychosocial variables in PISA2000 (including self-efficacy). Importantly, the causal effect of academic self-concept on achievement is present not only in low stakes, but is also supported for high-stakes achievement tests. For example, research involving a large and representative sample of young Australians found that after controlling for prior achievement and a range of demographic variables, self-concept was a significant predictor of high-stakes university entrance achievement tests (Marks, MacMillan, & Hillman, 2001). Furthermore, this research showed that academic self-concept was a stronger predictor than either parental or student aspirations, that have long been the focus of sociological, educational and psychological research and theory (e.g. Schoon & Parson, 2002; Schoon, Parsons, & Sacker, 2004; Sewell, Haller, & Portes, 1969). Given that similar causal ordering models have been identified for both self-efficacy and self-concept, it is thus important to consider the distinction between them.

Mathematics self-efficacy and self-concept: similarities and differences

Bong and Skaalvik (2003; see also Pajares & Schunk, 2001; Pietsch, Walker, & Chapman, 2003) provide a comprehensive overview of the similarities and differences between self-efficacy and self-concept. Both self-beliefs share a common core in that they are concerned with individual's self-perceptions of competence (Lee, 2009). In addition both constructs are hierarchical and can be measured at either general levels (i.e. self-esteem or generalised self-efficacy) or can be measured at increasingly domain specific levels (Bandura, 1986; Marsh, 2007). Importantly, research strongly suggests that domain specific measures of self-efficacy and self-concept are more strongly correlated with criterion variables than domain general versions of the same measure (Pajares & Schunk, 2001). Indeed, the link between general self-beliefs and achievement had been shown to be weak (e.g. Marsh & O'Mara, 2008). Theory also points to the important developmental role that social contexts and relationships play in the development of both self-beliefs (Bong & Skaalvik, 2003; Pajares & Schunk, 2001). Although there are clear similarities between these two constructs, theoretically and empirically they are distinct.

A critical difference is the focus of the constructs on either *descriptions* of competence or *evaluations* of competence. This is best seen in the differential use of explicit criteria for assessments of competence (Marsh et al., 2008). Self-efficacy measures self-perceptions of capabilities (i.e. description) and use clear explicit, or at least implicit, criteria in the wording of the self-efficacy items (see Appendix). Thus items measuring self-efficacy relate to individual's perceptions of their capabilities to successfully undertake the actions required to complete a specific task (e.g. 'I would be able to calculate the area of a room in square metres'; Ferla, Valcke, & Cai, 2009). Self-concept, on the other hand, is evaluative, relating to judgements about whether one's behaviour matches self-set standards of worth and competence (e.g. 'I am good at mathematics'; see Marsh et al., 1991). This differential focus on description vs. evaluation is seen as a critical factor in understanding how individuals respond to measures of both and thus their underlying theoretical distinction (Marsh et al., 1991, 2008). For self-concept, students use normative judgements about their ability and social comparison processes with reference to their peers, but also internal comparisons of their performance in one academic domain relative to other academic domains (see Marsh, 2007; Parker, Marsh, Lüdtke, & Trautwein, 2013). This suggests that achievement in one domain will be positively related to self-concept in the same domain (external frame of reference) but negatively related to self-concept in other domains (internal frame of reference) after controlling for achievement in both domains. These effects are summarised by the internal/external frame of reference (IE) model (see Marsh, 2007 for a review). Research with self-concept suggests that these internal comparison processes are not only in operation when self-concept is predicted by achievement, but also when self-concept predicts later achievement and achievement-related outcomes (see Parker, Schoon et al., 2012).

Because self-efficacy is descriptive, with the exception of novel or ambiguous activities, students use their experience with similar tasks as a guide to assessing their likelihood of success (Bong & Skaalvik, 2003; Marsh et al., 1991). Thus, for students with experience in solving mathematics problems, self-efficacy items (e.g. 'I would be able to calculate the area of a room in square metres') do not require them to make either normative or internal comparisons (Marsh et al., 2008). As such, the negative relationship between achievement in one academic domain and self-beliefs in another academic domain has been hypothesised to be stronger for self-concept than self-efficacy where frames of reference are less relevant (Marsh et al., 1991). This has important implications not just for the role of achievement predicting self-belief constructs, but also when considering the role of self-belief constructs predicting outcomes like course choice (see below).

Juxtaposing mathematics self-efficacy and self-concept as predictors of achievement

Differences between self-concept and self-efficacy (as detailed above) likely explain why these self-beliefs have independent effects on achievement (Pajares & Schunk, 2001). Valentine et al. (2004) provided a large scale meta-analysis of the effect of self-efficacy and self-concept on academic achievement. Their research strongly confirmed the causal effect of both self-beliefs on achievement with an average effect-size of .08. Importantly, this study compared self-efficacy and self-concept as predictors of achievement and found no statistically significant difference between them. This suggests that both constructs are equally important predictors of achievement. However, there were some limitations in this meta-analysis. Most pertinent to the current research, with only one exception, the studies used in the Valentine et al. study used a measure of either self-efficacy or self-concept rather than both measures simultaneously. As such, it is not clear whether these self-beliefs are independent predictors of achievement.

Given that research on self-efficacy and self-concept typically comes from different theoretical perspectives and focuses on different outcomes, it is not surprising that the Valentine et al. (2004) meta-analysis contained few studies which directly compared both constructs. Furthermore, the limited use of self-efficacy and self-concept in the same study is not only due to different research groups favouring one measure over the other, but also due to concerns about multicollinearity. Indeed, this issue is exemplified in the study by Pietsch et al. (2003), which found that self-efficacy was a much stronger predictor of achievement than self-concept. However, a later re-analysis by Marsh, Dowson, Pietsch, and Walker (2004) suggested that this difference was likely attributed to the extremely high correlation between the measures of self-efficacy and self-concept. Hence, the authors showed that a model which constrained the effect of self-concept and self-efficacy on achievement to be equal, more appropriately represented the data. This finding is consistent with other studies which have more adequately compared and contrasted self-efficacy and self-concept as predictors of achievement (e.g. Ferla et al., 2009; Marsh et al., 2008; Skaalvik & Rankin, 1996). Such results suggest that self-efficacy might be a slightly stronger predictor, but that this difference is typically very small, is at least partially dependent on what other factors are controlled for and is sometimes inflated when researchers use actual items from the achievement test to assess self-efficacy (Marsh, Roche, Pajares, & Miller, 1997). Taken together, the conclusion from such research is that both self-efficacy and self-concept are related but independent predictors of achievement that are of similar importance (Pajares & Schunk, 2001).

Although these findings are important, the vast majority of these studies used low-stakes achievement tests and/or covered a short time period. Hence, much of the available research may not provide sufficient insight into the role of self-beliefs in predicting developmentally significant achievement tests and other academic outcomes that have implications for the long-term educational and occupational attainment of students (e.g. tests which determine university entry). As such juxtaposing these two constructs for critical outcomes is likely to be important in guiding not just research but also effective intervention efforts.

High-stakes achievement and achievement-related choices

TER, consisting of school-based assessments and standardised testing, are one of the most important achievement measures used in education in Australia and other countries. TER scores are the primary measure of achievement used in Australia to allocate university places competitively, and places in particular university major programmes, to graduating high-school students. Even for individuals who do not enter university, TER scores have major implications for labour force participation. Surprisingly little research has examined the non-achievement factors which predict TER (Marks et al., 2001). This is problematic as TER is seen as a critical in terms of long-term occupational attainment. Put simply, high achievement in TER and similar tests are seen as important gateways to occupational and status attainment as students leave school and enter adulthood.

Although TER is clearly an important outcome, research suggests that achievement alone is not sufficient for an understanding of the long-term occupational and socio-economic attainment of young people. Research suggests that educational attainment (i.e. number of years of schooling) mediates almost all of the effects of intelligence on long-term outcomes (Hauser, 2010). That is, for individuals with equal levels of educational attainment, intelligence has a relatively small direct effect on later occupational and socio-economic attainment. As such, there is a need to focus not only on predictors of achievement but also achievement-related outcomes, such as whether young people continue in their educational careers after compulsory schooling. Indeed, school achievement is one of the strongest predictors of university entry, yet it is clear that many students who have the requisite ability do not attend university (Bowen, Chingos, & McPherson, 2009). Although there are now many formal education pathways that lead to successful life outcomes, there is a need for more research on what factors predict students' entry into university. With low-skilled jobs increasingly moving out of OECD and other developed countries, there is now a greater need for institutions to focus on training young people for high-skilled professions. This is both a government focus in order to remain internationally competitive and a welfare issue as the increasing attainment gap between university and non-university educated individuals has come at the cost of those without a university education (Côté, 2006; OECD, 2010, 2011). Thus, there is an urgency to understand the factors beyond schooling achievement that predict university entry (see Bowen et al. 2009 for an example). Limited research has considered the role of academic self-efficacy in predicting university enrolment, but some research does indicate that self-efficacy is linked with higher academic aspirations (Bandura, Barbaranelli, Caprara, & Pastorelli, 1996). In contrast, empirical research has shown that self-concept is a significant predictor of university enrolment, controlling for prior achievement (Marsh, 1991; Parker, Schoon, et al., 2012).

Although there is a need to increase university participation, a growing concern is to ensure that young people are studying in fields that are critical to the needs of a modern society. Of most concern is the worldwide decline in enrolments in STEM over the last two decades (Nagengast & Marsh, 2012; OECD, 2011), resulting in young people who may not have the skills needed to compete in a modern technology-based society and worldwide shortages of students pursuing university qualifications in STEM (Lubinski & Benbow, 2006; National Academy of Sciences, 2005). Internal comparison processes have been shown in a number of longitudinal studies to play an important role in predicting course selection. For example, Parker, Schoon, et al. (2012; see also Marsh, 1991), in a large representative study of German and English youth, showed that math and verbal self-concepts (measured two and four years earlier respectively) predict field of study at university after controlling for prior academic achievement, gender and socio-economic status. Interestingly, the findings from this study indicate in both Germany and England that self-concept was a stronger predictor of field of study than prior academic achievement and that high math self-concept positively predicted studying in a math intensive field (e.g. science or engineering) but negatively predicted studying in a verbal intensive field (and vice versa for verbal self-concept). Similar findings have been found for within school selection of advanced courses (Nagy, Trautwein, Baumert, Köller, & Garrett, 2006; Nagy et al., 2008). Indeed, illustrating the importance of self-concept as a predictor of course choice, Marsh and Yeung (1997) showed that domain specific academic self-concept consistently predicted course aspirations and actual selection in line with the IE model whereas school grades did not contribute to the prediction of these outcomes after controlling for academic self-concepts.

Given the importance of frames of reference processes for course selection, it would be expected that self-efficacy would play a relatively less important role in course selection than self-concept. Thus, although some research has shown math self-efficacy to predict major selection at college (Betz & Hackett, 1983), the IE model would predict that self-concept would be a more important predictor.

The present investigation

In the current research, we utilised the 2003 longitudinal study of Australian young people (LSAY) which followed a representative sample from the ages of 15–22 years old. The initial time wave of this database is the 2003 PISA sample where science, math and reading achievement tests, mathematics self-concept and mathematics self-efficacy were collected. This cross-sectional data will be used to explore the effect of achievement on math self-efficacy and self-concept. It is expected that all the achievement scores would be significantly associated with math self-beliefs. Based on the IE model, however, we anticipated that math and science achievement would be positively associated but English achievement would be a negatively associated. Further, we expected that this negative relationship would be stronger for self-concept, given the clear explicit criteria used to evaluate self-efficacy (Marsh et al., 1991).

Although the cross-sectional associations between achievement and self-beliefs are important, a more critical concern is the long-term effect of self-beliefs on developmentally significant high-stakes achievement and achievement-related outcomes, controlling for prior achievement. The age range of the LSAY sample provides an important opportunity to compare and contrast the effect of self-efficacy and self-concept as predictors of TER, university entrance and coursework selection. It is hypothesised that both self-concept and self-efficacy will be independent predictors of TER. Although both self-beliefs have been found to have a link with post-school achievement outcomes, very little research to our knowledge has compared and contrasted the role of academic self-efficacy and self-concept in predicting university entry or STEM coursework selection. It is thus difficult to develop hypotheses. Based on the IE model, we provide a tentative hypothesis that self-concept will be a more important predictor than self-efficacy in outcomes that require a significant choice component such as university coursework selection. This is because if someone has a positive self-concept in one choice domain, they are likely to have a relatively more negative self-concept in other domains, due to internal frame of reference processes. In contrast, because self-efficacy is so much less domain specific than self-concept (i.e. self-efficacies in different domains are more highly correlated than the corresponding self-concept measures), self-efficacy scores might be more highly correlated with domain-general academic outcomes (e.g. university entry). Finally, given that the comparison between self-efficacy and self-concept as predictor of achievement has in past research been somewhat dependent on what other variables are controlled for, this research tested all hypotheses and research questions both with and without a large set of covariates. The covariates included parental education and socio-economic status, year in school (hereafter grade), gender, and immigrant and indigenous status.

Methodology

Participants

The LSAY extension of PISA 2003 used in this research consisted of 10,370 15-year-old Australians surveyed over seven years (in the most recently available wave [2010] participants were aged 22). All time waves were used to identify whether participants had gone to university at any time from ages 15 to 22. The most critical time waves for the other variables, however, were Wave 1 (age 15) where achievement, and math self-efficacy and math self-concept were measured and Wave 5 (age 19) where TER (final school achievement ranks) and post-school

STEM course selection variables were collected. The database has a number of advantages which make it particularly well suited for the proposed research. First, the PISA data provides access to a large and representative sample of young Australians. Second, these young people are followed through major educational transition points allowing us to assess how math self-beliefs at age 15 predicted final school year achievement and post-school achievement outcomes.

The LSAY project includes several cohorts covering PISA data collection periods from 2003 to 2006. In the current research, we used the 2003 cohort as it was the most recent cohort which also covers a sufficient number of years after formal schooling to adequately capture those who went to university, including those who entered directly after schooling and those that took a 'gap-year' or deferment period before entering university. Given the target age of the PISA sample, the majority of the sample was in the second last year of lower high school in Australia (year 9). However, a small percentage (8%) of students were in a year lower and 20% were in a year higher. The sample had approximately equal numbers of females (N = 5149, 49.7%) and males (N = 5221) and consisted largely of children born to native born Australians (78%), with smaller populations of first (11%) and second (9%) generation Australian immigrants. Six percent of the sample identified as being of Aboriginal or Torres Islander decent. Using international classifications, 40% of the participants had at least one parent with a university level of education, 43% had at least one parent with either short cycle or post-secondary non-tertiary level of education. The remaining participants had at least one parent with some high-school (13%) or lower level of education. The average socio-economic index of the participants parents on the International Socio-economic Index was 52.84 (SD = 15.93) which is considerably higher than the OECD average (OECD, 2011). Gender, grade, immigrant and indigenous status, parental education and parental socio-economic status were used as covariates in the current study.

Measures

Self-efficacy

Math self-efficacy was measured on an eight-item scale from the PISA database (see OECD, 2004). The scale was based closely on the work of Bandura (1993) and aimed to measure real world rather than curriculum-based mathematical tasks (e.g. 'how confident do you feel about…calculating how much cheaper a TV would be after a 30% discount'; see Appendix for items). Reliability of this scale was good (α = .86, glb = .90; given recent controversy about the usefulness of alpha [see Sijtsma, 2009], we also report greatest lower bound (glb) as a measure of reliability). Items were measures on a four-point Likert scale with poles of *very confident* and *not at all confident*.

Self-concept

The self-concept items (e.g. 'I learn mathematics quickly'; see Appendix for items) were modelled on the SDQII (Byrne, 1996; also see Marsh, 1990, 1993; Marsh & Craven, 1997). Because of limitations on the length of the PISA questionnaire battery, only five items were used to represent math self-concept. Reliability of the scale was good (α = .89, glb = .89). Items were measured on a four-point Likert scale with poles of *strongly agree* and *strongly disagree.*

Achievement

As part of the PISA 2003 study, participants sat a two hour test that examined their 'functional ability' in reading, mathematics and science. Since the PISA major domain in 2003 was math achievement, the majority of test questions focused on children's skill in mathematics with a smaller number of items testing their ability in reading and science. Answers were summarised into a single score for each of the three domains using an item-response model (see OECD, 2004). Five plausible values were generated for each participant. As such, five separate data-sets were used in this research each of which contained one plausible value score for math, reading and science achievement. All statistical analyses involving achievement were conducted on each of these data-sets separately. Parameter estimates were drawn from the average estimates from the five data-sets with standard errors corrected for the between plausible value variance using the formula by Rubin (1987).

Tertiary entrance rank

In Australia, final school-year achievement is given by a single TER. This rank is important not only as a measure of achievement but it is also used by universities to assign student places in major programmes. These ranks were awarded to year 12 students on a state specific basis when the first wave of data was collected. Although the makeup of this score differs by state, the final rank typically consists of a combination of school-based achievement and state-wide standardised testing. All states, except Queensland, provide TER scores on a 100-point scale which are state-based percentiles and are generally considered to be equivalent (Marks et al., 2001). Scores in Queensland range from 1 to 25 with 1 being the highest possible TER rank (Marks et al., 2001). In order to provide a consistent metric across states, we first reverse scored the Queensland TER scores and then *z-standardised* TER scores within each state. The distributions across all states were very similar.

University entry

For each year of the LSAY 2003 testing programme, participants were asked about whether they were currently, or had ever entered university education. Responses over the eight waves were then combined such that a participant was coded with a one if they had entered university at any stage from 2003 to 2010. Only those who indicated they had never entered university in the 2010 wave of the study were coded as zero, indicating they had not entered university at any point. The rest was coded as missing and their status was estimated from the statistical model applied to the data (see analyses section below).

STEM course selection

During Wave 5, participants were asked if they were currently studying in a STEM field at a tertiary level. Those that were studying in a math or science field at a tertiary level were coded as one; those that had not were coded as zero.

Missing data

There was little missing data at Time 1 when achievement and self-beliefs were collected. However, as with most longitudinal data, particularly data which cover both a long time period and includes the transition from high school (see Parker, Martin, Martinez, Marsh, & Jackson, 2010; Parker, Schoon et al., 2012; Parker, Lüdtke, Trautwein, & Roberts, 2012), attrition over the eight years of the sample was large. In particular, at Wave 5 when TER, university entry, and studying in STEM field data were collected, the sample attrition rate was 34.8% (Wave 5 total $N = 6658$). Selectivity analysis indicated that this attrition across the period of the LSAY was not missing at random. Indeed, people who dropped out of the study were much more likely to be indigenous (OR = 4.59) and more likely to be males (OR = 1.31). Participants who dropped out of the study also had lower self-efficacy, self-concept, came from more disadvantaged socio-economic environments and had lower achievement with Cohen's D ranging from .46 to .62. It is for this reason that we implemented full information maximum likelihood estimation (FIML; Enders, 2010).

It is now well recognised in the social sciences that traditional approaches to missing data (e.g. listwise or pairwise deletion) are inappropriate and can lead to considerable bias in parameter estimates when data are not missing completely at random. Modern methods like FIML provide a principled approach to dealing with missing data which use all available information for parameters and provide a superior approach to missingness when the data are missing at random. Indeed, even when data are missing not at random FIML provides a superior approach to traditional listwise approaches (Enders, 2010). The efficacy of FIML can be increased by the use of auxiliary variables which are not part of the estimated model but which are likely to be associated with missingness (Enders, 2010). In the current research, we analyse data with and without an extensive set of covariates which were likely to be associated with the outcome variables but may also be related to missingness. In cases where these covariates were not modelled, the covariates were used as auxiliary variables such that the missing data model was similar for both adjusted (models including covariates) and unadjusted (models excluding covariates) models.

Analysis

Measurement error is a key concern in almost all applications of correlation and regression analysis. Whenever measurement error is not taken into account, results are likely to be attenuated (see Cohen, Cohen, West, & Aiken, 2003). To control for this, in the current research, math self-efficacy and self-concept were estimated by latent variables using multiple indicators (i.e. multiple items). Latent variable modelling allows for the direct estimation of measurement error (variance in indicator items not associated with the underlying latent variable), which can then be controlled for in hypothesis testing. The measurement structure of these latent variables was first tested in a confirmatory factor analysis (CFA) before the latent variables were incorporated into a series of latent variable structural equation models. Where latent self-concept, self-efficacy or university entrance exam marks were outcome variables, maximum likelihood regression was used to estimate parameters. For the university entry and studying in STEM fields outcomes, parameters were estimated using probit regression. All models were implemented in Mplus 6.1 (Muthén & Muthén, 2010).

All variables, except the dichotomous variables, were *z-standardised*. The LSAY database has a nested data structure in which students were nested within schools. If this complex data structure is not accounted for, standard errors, chi-square and log-likelihood values may be biassed (see Cohen et al., 2003). To control for this, we utilised the TYPE = COMPLEX option in Mplus, which adjusts standard errors for the effects of clustered data and thus gives appropriate statistical significance tests.

Preliminary results

Confirmatory factor analysis

Given that multicollinearity can be a problem when comparing self-efficacy and self-concept, we first explored the measurement properties and relationships between the two self-beliefs. CFA gave a satisfactory fit: χ^2 (64) = 3998, RMSEA = .08, CFI = .92 indicating that the hypothesised model, which proposes two distinct factors in which cross-loadings of items onto non-target latent factors was constrained to zero, provided a good account of the data. Further supporting the hypothesised factor structure, inspection of the modification indices indicated that freeing cross-loadings would not result in a noticeably better fitting model. Rather, exploration of the modification indices did suggest a substantial correlation between the residuals of two self-efficacy items as a major source of model misfit. Exploration of these items revealed that both items required participants to estimate their ability to solve an algebraic expression (see Appendix for self-efficacy items 5 and 6). Thus, we re-estimated the model correlating the residual of these two algebra self-efficacy items. The correlated residual between the two algebra self-efficacy items was retained for all subsequent models. This model revealed a substantial improvement in fit over the model without the correlated residual: $\chi^2(63) = 2013$, RMSEA = .06, CFI = .96. Exploration of the latent correlation between self-efficacy and self-concept revealed that while strong ($r = .65$), was considerable smaller and thus less likely to be influential than that observed in Pietsch et al. (2003) study.

Associations between achievement and self-beliefs

After confirming the factor structure of self-efficacy and self-concept, we then explored the relationship between concurrent achievement and self-beliefs. In this case, math self-efficacy and self-concept were regressed on math, science and reading achievement. The fit of this model was acceptable: $\chi^2(96) = 3067$, RMSEA = .06, CFI = .95. The results are presented in Table 1 and suggest that all three achievement scores were significantly related to both math self-efficacy and self-concept. In addition, the results were consistent with the IE model as science and math achievements were positively associated with both math self-concept and math self-efficacy. In contrast, reading achievement was negatively associated with both math self-belief factors after controlling for the other achievement scores. As hypothesised, the negative relationship between reading achievement and math self-efficacy was weaker (in comparison to its standard errors) than the negative relationship between reading achievement and math self-concept. This is consistent with the

Table 1. Self-efficacy and self-concept predicting key achievement outcomes: adjusted and unadjusted for covariates.

	Unadjusted					Adjusted				
	Self-efficacy	Self-concept	TER	University entry	STEM course	Self-efficacy	Self-concept	TER	University entry	STEM course
Self-efficacy	–	–	.14(.03)***	.04(.03)	.06(.05)	–	–	.16(.02)***	.06(.03)*	.05(.05)
Self-concept	–	–	.09(.03)***	.00(.07)	.16(.04)***	–	–	.09(.02)***	.01(.02)	.17(.04)***
TER	–	–	–	1.25 (.08)***	−.01(.06)	–	–	–	1.21(.08)***	−.02(.07)
Achievement										
Math	.47 (.02)***	.58 (.03)***	.23(.03)***	.16(.10)	.05(.11)	.42(.02)***	.58(.03)***	.26(.03)***	.20(.10)***	.01(.10)
Reading	−.31 (.02)***	−.36(.03)***	.27(.03)***	.61(.11)***	−.15(.13)	−.22(.03)***	−.32(.04)***	.16(.03)***	.31(.10)***	−.04(.13)
Science	.42 (.02)***	.17(.03)***	.01(.04)	−.11(.10)	.15(11)	.37(.02)***	.17(.03)***	.05(.04)	.09(.10)	.10(.12)
Covariates										
Parent income	–	–	–	–	–	.00(.01)	−.03(.01)**	.09(.01)***	.11(.05)*	−.01(.06)
Parent education	–	–	–	–	–	.06(.01)***	.01(.01)	.07(.02)***	.27(.05)***	.07(.06)
Grade	–	–	–	–	–	.02(.01)*	−.08(.01)***	−.10(.02)***	.17(.09)*	−.02(.09)
Gender	–	–	–	–	–	−.25(.03)***	−.09(.03)***	.15(.02)***	.84(.10)***	−.32(.11)**
Immigrant	–	–	–	–	–	.15(.02)***	.16(.02)***	.07(.02)***	.53(.08)***	.08(.07)
Indigenous	–	–	–	–	–	.08(.04)	.22(.03)***	−.04(.02)*	.04(.24)	−.30(.37)
R^2	.38	.23	.37	.51	.06	.41	.25	.43	.57	.06

Notes: $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$. Standard errors in parentheses.

prediction of Marsh et al. (1991). Math achievement was slightly more strongly related to math self-concept than math self-efficacy, but science achievement was more strongly related to self-efficacy than self-concept. However, also consistent with the I/E model, science achievement (.42) was almost as strongly related to math self-efficacy as math achievement (.47), whereas math achievement (.58) was much more strongly associated with math self-concept than science achievement (.17). This can be explained by the fact that self-concept is much more domain specific than self-efficacy.

Importantly, although the addition of key covariates attenuated the size of the parameter estimates, the results were still highly consistent and did not change the interpretation of the findings. Interestingly, paths relating to self-efficacy were slightly more affected by the inclusion of covariates than those for self-concept. Likewise, the IE negative paths from reading achievement to math self-efficacy and self-concept were strongly attenuated, though still statistically significant, by the inclusion of the covariates. Both the unadjusted and adjusted models explained large percentages of the variance in self-efficacy and self-concept.

Self-beliefs as predictors of achievement and achievement outcomes

The next step in the analysis was to explore the predictive effect of math self-efficacy and self-beliefs on TER, university entry and whether participants pursued studies in STEM fields (fit statistics are not available for models which have categorical outcomes). Results (Table 1) indicated that self-efficacy was a slightly stronger predictor than self-concept of TER after controlling for Time 1 achievement. However, this difference was small in comparison to the standard errors. Importantly, both self-concept and self-efficacy were significant independent predictors over and above prior achievement. Furthermore, the achievement and self-belief variables measured at age 15 explained a considerable amount of the variance in TER achievement measured four years later. The only exception to this was science achievement which was not a significant predictor of TER, after reading and math achievement were accounted for. Unsurprisingly, much of the variance in university entry was explained by TER which is used to award university places. Over and above TER, however, reading, and to a lesser extent math achievement at age 15 were significant predictors. Neither self-belief predicted university entry after controlling for achievement and TER. Math self-concept was the only significant predictor of studying in a STEM field.

We re-estimated the model with a set of covariates thought to be associated with both the outcome variables and math self-beliefs. Like the previous cross-sectional model, the introduction of the results did not considerably alter the interpretation of the results. The major change was that controlling for background covariates resulted in self-efficacy at age 15 being a marginally significant but small predictor of university entry. Consistent with the previous models, the inclusion of covariates tended to affect parameter estimates predicting and predicted by self-efficacy more so than self-concept. In both adjusted and unadjusted models, the predictors explained over half the variance in university entry but only a small percentage of the variance in STEM course selection. Figure 1 provides a representation of the significant paths adjusted for the covariates.

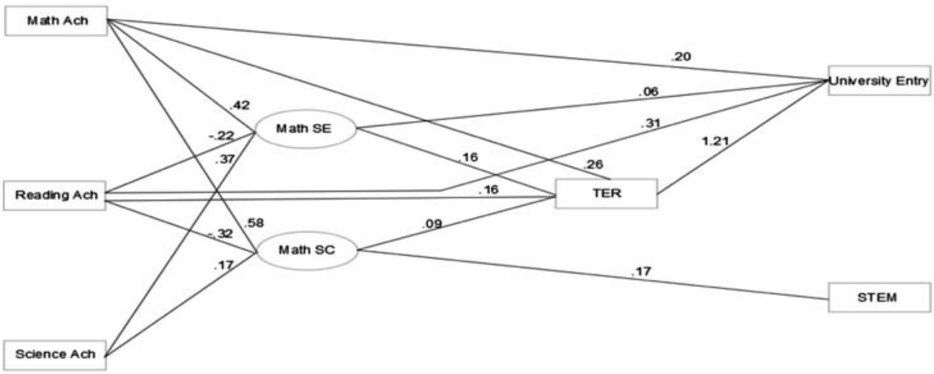

Figure 1. Conceptual model of critical paths from adjusted model. Only significant paths for the central hypothesised relationships shown. All non-significant estimates and effects of covariates can be found in Table 1.

Discussion

The current research explored the role of academic self-concept and self-efficacy as an outcome of standardised achievement and as a predictor of high-stakes TER, university entry and STEM course selection. Results suggested that achievement was strongly related to both self-beliefs and that controlling for prior achievement and a host of covariates, self-concept and self-efficacy were significant predictors of TER. Further, self-efficacy was found to be a significant predictor of university entry, and self-concept was a significant predictor of STEM course selection. The results provide longitudinal support for the distinct value of self-efficacy and self-concept in predicting high-stakes outcomes. This is important as there continues to be confusion over both the theoretical and practical distinction between the two constructs (Bong & Skaalvik, 2003).

Juxtaposing self-concept and self-efficacy as outcomes of achievement

For the concurrent relationships, math achievement was strongly positively associated with both math self-concept and math self-efficacy while reading achievement was significantly negatively related to both self-belief constructs. These findings are interesting as they suggest that IE processes are in operation for both self-beliefs. Importantly, however, and consistent with Marsh et al. (1991), the negative relationship between reading achievement and self-concept was stronger than that between reading achievement and self-efficacy. This is to be expected if, as Marsh et al. (2008) suggest, individuals use internal and external frames-of-reference in order to evaluate their competence, but have much less need to utilise such processes when evaluating whether they can or cannot do a particular task.

While the negative relationship between reading achievement and self-efficacy was smaller than that for self-concept, the effect size was still relatively large. This may have been due to the PISA focus on self-efficacy questions relating to applied problems (e.g. finding distances on maps, calculating savings from a discount). Students may not have had clear experience with applying the mathematics skills they developed in the classroom to these real world problems and thus were required to use frames of reference more heavily in order to give responses to these self-efficacy items.

Juxtaposing self-concept and self-efficacy as predictors

Self-concept was not simply an outcome variable in the current model but also a predictor of later achievement related outcomes. In this regard, the results suggest that both self-concept and self-efficacy were statistically significant and independent predictors of TER. Importantly, these effects remained significant after controlling for prior achievement, indicating that the way individuals describe their competence (i.e. self-efficacy) and the way they evaluate their ability (i.e. self-concept) predicted TER independently of achievement. This is consistent with the REM of self-concept which suggests that the self-beliefs that individuals hold about their competence in a particular domain have very real implications for their later achievement (see Marsh, 2007). Importantly, it also supports the findings of Marks et al. (2001) that psychological constructs (including self-concept) have implications for TER, beyond that which can be explained by prior achievement. The stakes are high for TER marks which have important implications for whether students will be able to enter tertiary education, as well as the choice of universities and courses available to them. It may be that positive self-beliefs provide a resource from which students can draw from to cope with the TER testing period. Indeed, positive self-beliefs are associated with greater effort, persistence and confidence, and lower anxiety (Marsh, 2007; Stankov et al., 2012). Thus, an intuitive hypothesis would suggest that higher self-beliefs may facilitate higher quality of TER exam preparation, or facilitate better study habits over the course of the participants' educational careers.

Of developmental interest in this study was the role of self-beliefs at age 15 in predicting later TER, university entry and STEM course selection. It is well established that self-beliefs and achievement are reciprocally related over high school (Valentine et al., 2004). The current study extends this past research by demonstrating the influence of self beliefs on achievement, after controlling for prior achievement in high-stakes achievement tests. Thus, the importance of providing schooling environments in which children develop appropriately positive assessments of their competence is critical for in-school outcomes but, given the implications of TER scores, may also influence long-term educational and occupational attainment (Covington, 2000). This result is further emphasised by the finding that self-beliefs at age 15 predicted university entry and STEM course selection after controlling for prior achievement and TER. Thus, intervention efforts focused on the role of self-beliefs in forming educational aspirations are likely to be pertinent even from early high school (Parker, Lüdtke et al., 2012).

University entry and course selection

The results for university entry and course selection provide a slightly more complex picture. For university entry, self-efficacy but not self-concept was a significant predictor, while for STEM course selection, self-concept but not self-efficacy was a significant predictor. Because self-concept and self-efficacy are substantially correlated ($r = .65$), it is important to note that there is much variance in the outcome variables that can be explained by either construct. Indeed, *post hoc* estimation of the models with either self-belief alone indicated that both did significantly predict university entrance and STEM-related university majors. However, results from hypothesised model with both variables indicated that the unique contributions of self-concept and self-efficacy, controlling for the effects of the other, indicated which achievement-related outcomes the two self-beliefs were most closely tied to.

When an academic outcome is heavily based on progression (i.e. decisions as to whether or not an individual will move to the next level of education), then descriptions of competence like those found in self-efficacy may be more important. Individual's decision-making as to whether they go on to university or not will be dependent on expectations of their success in obtaining the TER marks required and on perceptions of abilities to succeed within that arena. For outcomes which depend primarily on choice between academic domain options, however, self-concept may be more important. That is, where both self-concept and self-efficacy are related to assessments by the individual of their capacity to enter university and do well; self-concept may be instrumental in considering how individuals choose from different majors for which the individual qualifies. From an I/E frame-of-reference perspective, the relationship between self-concept and STEM course selection suggest that young people's external and internal comparison processes have a significant influence on STEM major selection. Utilising an internal frame of reference, young people evaluate their perceived ability in different academic domains against each other when making such choices. Thus individuals who are gifted in all academic areas are likely to qualify for university but their choice of whether to take a STEM major will likely be related to whether they consider their math or verbal abilities as stronger (Parker, Lüdtke et al., 2012).

A likely explanation for this pattern of outcomes might be the difference in domain specificity of the two constructs. Because math self-efficacy is more domain general than math self-concept, it is a better predictor of domain-general outcomes like university entrance. For similar reasons, the more domain-specific math self-concept is a better predictor of domain-specific outcomes like STEM coursework selection. This explanation is also consistent with the finding that controlling domain-general covariates tended to effect the predictive power of (the more domain-general) math self-efficacy than the (more domain-specific) math self-concept. These explanations cannot be tested easily in the present investigation, but could, perhaps, be differentiated in a study that included both domain general and multiple domain specific measures of these two academic self-belief constructs.

Strengths and limitations

The current research utilised a large and representative sample of Australian young people over a long and critical time period in their educational careers. Well-developed and validated measures of achievement and self-beliefs were utilised as well as real-world high-stakes outcomes. Despite these strengths there are several limitations which are important to consider in interpreting the results. First, as noted in the methodology, the attrition rates were relatively large. Attrition over such a long period which includes critical transition points is common in this type of research due to the difficulty of tracking participants over a long period and after they move out of formal education (see Parker, Schoon et al., 2012). To help address this issue, we used advanced approaches (FIML) to handling missing data in order to reduce the bias. Second, while large public databases have a number of advantages, secondary data analysis utilising them does have limitations. In particular, the researchers have no input into the constructs measured and the instruments used. As such we could not fully test the effect of the IE model on TER, university entry and STEM selection as we had no self-belief measures in verbal domains (e.g. verbal self-concept and self-efficacy). In addition, it would have been useful to have multiple measures of achievement and self-concept over more than one time wave to provide a clearer understanding of causal influences involved. Finally, post-school outcomes are influenced by a number of sources beyond those studied in the current research. For example, measures of parental aspirations, value and importance that participants held for different post-school destinations and goal commitment would have provided a more complete understanding of the processes in operation (see Dietrich, Parker, & Salmela-Aro, in press for a review). While secondary data has some limitations, the size and nature of the current sample as well as the long developmental time period in which participants were followed provided a rich and unique opportunity to explore the role of self-beliefs on critical long-term education outcomes.

Conclusion

The current research juxtaposed the roles of math self-concept and self-efficacy in their relationship with achievement, TER and achievement outcomes. Results supported the importance of both constructs which (a) had complex and domain specific relationships with concurrent achievement; (b) were significant predictors of later TER even after controlling for prior achievement. In addition, the more domain general measure of math self-efficacy was more closely related to the domain general measure of university entry than the more domain-specific measure of math self-concept, while math self-concept was the only significant variable apart from gender which predicted STEM course selection. The results suggest that both self-beliefs are important but that self-concept may be a better predictor when outcomes contain a significant choice component between different academic domains.

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Appendix

PISA self-concept items

(1) I am just not good at Mathematics. (R)
(2) I get good marks in Mathematics.
(3) I learn Mathematics quickly.
(4) I have always believed that Mathematics is one of my best subjects.
(5) In my Mathematics class, I understand even the most difficult work.

R = Reverse scored item

PISA self-efficacy items

Stem: How confident do you feel about having to do the following tasks?

(1) Using a train timetable to work out how long it would take to get from one place to another.
(2) Calculating how much cheaper a TV would be after a 30% discount.
(3) Calculating how many square meters of tiles you need to cover a floor.
(4) Understanding graphs presented in newspapers.
(5) Solving an equation like $3x + 5 = 17$.
(6) Finding the actual distance between two places on a map with a 1:10,000 scale.
(7) Solving an equation like $2(x + 3) = (x + 3)(x - 3)$.
(8) Calculating the petrol consumption rate of a car.