Personal bests (PBs): A proposed multidimensional model and empirical analysis

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Background. This study seeks to identify the cornerstones of personal bests (PBs) in the educational setting.

Aims. The study proposes a multidimensional PB model in which students are most likely to attain PBs on tasks/goals that are (1) specific, (2) challenging, (3) competitively self-referenced, and (4) self-improvement based.

Sample. The study draws upon data from 1,016 students from 5 Australian high schools.

Methods. The hypothesized 4-factor structure, its invariance across gender and year-level, and the predictive utility of PBs are tested using confirmatory factor analysis and structural equation models with particular focus on the contribution of a higher-order PB construct to measures of persistence, class participation, educational aspirations, and enjoyment of school. The fundamental dimensions of the model are further tested using multidimensional scaling.

Results. The 4-factor structure fit the data well and significantly predicted persistence, class participation, educational aspirations, and enjoyment of school. The multidimensional scaling indicates that the 4 component factors can be defined in terms of the dual extent to which they reflect a clear goal focus and a self-improvement focus.

Conclusion. Discussion centres on a proposed ‘Quadriploar PB Model’ emanating from the data analysis and strategies educators can use to facilitate PBs in the classroom.

Ian Thorpe may well be the greatest swimmer in Australia’s history. Analysis of his media interviews indicates that his approach to swimming revolves around personalized standards of excellence and the concept of personal bests (PBs). At the ninth FINA (Federation Internationale de Natation) World Swimming Championships in Japan, Thorpe avenged his 2000 Olympic Games defeat by Pieter van den Hoogenband in the 200m Freestyle. When asked about his victory in Japan, he replied, ‘The 200 m tonight was a great victory over myself more than anything’ (Sydney Morning Herald, July 2001). Thorpe’s approach to his swimming is not unique in the sporting world.

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Countless sportspeople harness the principle of personalized standards of excellence and PBs to their advantage. This article proposes that students can also benefit from a focus on PBs in their academic lives.

There is surprisingly little research into PBs in the education domain. Work by Elliot and colleagues (e.g. Elliot, 1999; Elliot & McGregor, 2001) is akin with its focus on mastery-approach goals encompassing intra-personal goals that are self-referential and self-improvement based. Similarly, Pintrich’s (2000) definition of mastery orientation takes into account self-improvement and the possibility of competition with one’s own personal standards. Taking these different perspectives together, it is evident that the PB concept and construct could well be multidimensional. Hence, the multidimensional perspective on PBs under focus in this study represents an extension on previous authors’ important work.

Where a PB is incorporated in research it is usually as an indicator or measure of a treatment condition or as an outcome measure in other fields of psychological inquiry. To date, for example, it has been used as a measure to distinguish between types of perfectionism (Schuler, 2000), as a measure to explore the impact of personality traits and self-efficacy among elite athletes (Wicks, 1997), as an independent variable in exploring the impact of a personal best strategy on convergent and divergent thinking (Morse & Morse, 1995), as an outcome explored as a critical consequence of anxiety in a sporting setting (Inlay, Carda, Stanbrough, & Dreiling, 1995), as a measure to estimate the ability of sport competitors (Hopkins & Green, 1995), as an outcome measure in research to explore the impact of competitiveness in a sporting setting (Martin, Eklund, & Smith, 1994), as a validational measure in studies of mental movement simulation amongst elite athletes (Oishi, Kimura, Yasukawa, & Yoneda, 1994), as an indicator of effective leaders (Kouzes & Posner, 1987; Posner & Kouzes, 1990), and as an indicator of one’s perceived ability (Marks, 1984). Within the educational domain, however, little attention is given to PBs as a means for student improvement or as a focus of educational research. This article conceptually and empirically explores PBs from an educational perspective.

As is discussed more fully below, PBs hold implications for motivation and achievement in terms of their facilitating effects for self-efficacy, persistence, educational participation, enjoyment of school, and task interest and engagement. There is not, however, a formal framework for understanding PBs beyond simply saying that they refer to a level of performance that matches or exceeds a previous best. It is suggested here that PBs reflect more than just this. In fact, they reflect the combined effects of different aspects of students’ orientations to their schoolwork. In particular, it is proposed that PBs are the result of students’ various levels of goal setting and that there exist particular goal-related profiles that are more likely to evoke PBs than others.

Goals and their relationship to PBs

Over the past three decades there has been increasing interest and emphasis on goals and goal setting. Goals and goal setting have been extensively explored in diverse domains including educational and personality psychology (e.g. Bandura, 1997), industrial and organizational psychology (e.g. Locke & Latham, 2002), social psychology (e.g. Fishbein & Ajzen, 1975), and sport and exercise psychology (e.g. Weinberg, 2002).

In the educational domain, four types of goal representations are outlined by Elliot and Sheldon (1997) that traverse achievement motivation. The first relates to task-specific goals that are specific guidelines for proximal performance (e.g. ‘complete
this assignment’). The second relates to situation-specific goals that reflect the purpose of and reasons for performing and achieving (e.g. ‘write clear and well thought out answers to the test questions’ or ‘perform better than others in the class on this test’). The third representation relates to personal goals that reflect more general and wide-ranging goals than those which relate to a specific situation (e.g. ‘improve on last year’s previous grade’ or ‘top the class at the end of the year’). The fourth relates to the images of self one has for the future, reflecting more distal goals (e.g. ‘immerse myself in a really satisfying career’ or ‘earn a lot of money after college’).

It is proposed that the first two goals – task-specific and situation-specific – jointly encompass the essence of PBs. The first goal provides students with clear information about what they are trying to achieve in the immediate future. The second goal provides students with the reason for why they want to achieve a particular outcome. As is discussed below, the joint operation of ‘what’ and ‘why’ goals provide the foundation for understanding and then attaining PBs.

Task-specific goals (‘what’ students are trying to achieve)
There are two dimensions on which task-specific goals vary: specificity and difficulty/challenge. PBs are, for the most part, specific goals or outcomes. The goal-setting literature shows that goals that are specific lead to higher levels of performance (Locke & Latham, 1990). Specific goals seem to have their positive impact by reducing the ambiguity about what is to be achieved (Locke, Chah, Harrison, & Lustgarten, 1989). One reason PBs are adaptive, then, is because they are a clear standard to aim for. Whereas the mark or score needed to outperform a competitor is often unknown, the mark or score needed to attain a PB is always known. Goals also vary in terms of the level of challenge and it is on this dimension of challenge that PBs are also relevant. By definition, the level of challenge or difficulty prescribed by a PB must be at least higher than that of a previous best level of performance. In fact, it appears that the specificity and difficulty of the goal interact such that specific and difficult goals yield higher levels of performance. Indeed, Locke and Latham (1990) found effect sizes for the positive impact of specific and difficult goals in meta-analyses ranging from .42 to .80. Taken together, task-specific and challenging goals are proposed as two cornerstones of PBs.

Situation-specific goals (‘why’ students are trying to achieve)
There is more to PBs than simply the attainment of a standard. It is also the attainment of a personalized standard – one that is set in relation to one’s own previous level of performance – that is fundamental to PBs. It is the personalized element of PBs that distinguishes them from other goals and that renders them a particularly powerful means of motivation. This brings into consideration two factors: competitive self-reference and self-improvement. The former relates to a competitive orientation that is aligned more to competing with one’s own previous performance than with others. The latter relates to a motivation to extend or build on previous levels of performance or attainment. Hence, competitively self-referenced and self-improvement goals are proposed as the other two cornerstones of PBs.

Taken together, the evidence and arguments reviewed above suggest a multi-dimensional model of PBs that encompasses goals that are specific, challenging, competitively self-referenced, and self-improvement-based. It is argued that this model provides a useful framework for not only understanding the core components of PBs, but also for considering how to maximize opportunities for students to reach PBs.
As yet, however, this model has not been empirically tested and it is the purpose of this study to do so.

**Personal bests and other educational concepts**

**Success and self-efficacy**

For a number of reasons, PBs have the potential to facilitate or enhance key educational factors. First, they make success more accessible to students. Theoretically, any student can perform as well as or better than before. When students believe that success is accessible to them, there is less need to manoeuvre in failure-avoidant ways and more reason to be optimistic and hopeful when facing future challenges and tasks (Covington, 1992; Martin & Marsh, 2003; Martin, Marsh, & Debus, 2001a, 2001b, 2003; Martin, Marsh, Williamson, & Debus, 2003). PBs also have the capacity to enhance self-efficacy and self-esteem. Martin (2001, 2002; see also Bandura, 1997; Marsh, 1990) described how the experience of success is one of the most powerful sources of self-efficacy and self-esteem. It therefore follows that if PBs provide greater opportunities for success they also enhance opportunities for students to gain a sense of self-efficacy and self-esteem in what they do. Moreover, not only does success enhance self-esteem, it also energizes students to persist at challenging tasks (Bandura, 1997).

**Intrinsic motivation**

PBs also bring into consideration the issue of intrinsic motivation. Self-determination theory (Ryan & Deci, 2000), for example, distinguishes motivation in terms of its intrinsic elements (motivation based on inherent interest in or satisfaction with an activity) and extrinsic elements (motivation based on external attributes of a task such as reward, approval, or grades). Of particular relevance here, intrinsic motivation is linked with desire for challenge among students and this notion of challenge is centrally related to the concept of PBs (La Guardia & Ryan, 2002; see also Deci, Schwartz, Sheinman, & Ryan, 1998). For example, activities that are optimally discrepant from people’s skill levels (i.e. aligned with PBs) are usually more intrinsically motivating (Danner & Lonky, 1981). Moreover, given this link to intrinsic motivation it is feasible to consider PBs as critical to related factors such as educational participation and enjoyment of school. PBs, then, can be linked to important educational factors and it is a further purpose of this study to determine the extent to which this is the case.

**Achievement goals**

As indicated earlier in the article, PBs are also relevant to achievement goal research. The focus of achievement goal research has predominantly been on mastery and performance orientations (Nicholls, 1984). Performance-oriented students tend to be concerned about ability or competence relative to others. Mastery-oriented students tend to focus on developing (rather than demonstrating) competence, improving, making progress, and attaining mastery – indeed, what would appear to be the essence of PBs (Dweck, 1986; Dweck & Leggett, 1988; Elliott & Dweck, 1988; Nicholls, 1989). Given the relevance of mastery orientation to PBs as a personalized and self-improvement-based goal orientation (see Pintrich, 2003) and the elements of performance orientation that may be adaptive to student engagement and performance (Epstein & Harackiewicz, 1992; Harackiewicz, Barron, & Elliot, 1998; Harackiewicz & Elliot, 1993), it is suggested that PBs may represent a construct that is an
adaptive blend of both mastery and performance orientations (see Pintrich, 2003 for further discussion on coordinating multiple goals).

Flow

Finally, the issue of PBs also brings into consideration the concept of ‘flow’. Over the last decade there has been increasing interest in the concept of flow (Csikszentmihalyi, 1990; Jackson & Csikszentmihalyi, 1999). Flow occurs when a person is totally absorbed in a task, is mainly motivated by the enjoyment and satisfaction the task provides, and is primed for optimal performance (Csikszentmihalyi, 1990). Researchers see the balance between challenge and skill as perhaps the most important aspect of flow. Flow is best achieved when the level of challenge presented to students slightly exceeds their level of skill (see also Vygotsky, 1978). Indeed, this is the zone in which we would hypothesize that PBs are the individual’s focus.

A PB orientation

Taken together, theorizing and research into goal setting, self-efficacy, intrinsic motivation, achievement goals, and flow suggest that the concept of PBs has relevance to the educational lives of students. Moreover, previous research suggests that PBs may well be multidimensional encompassing important complementary constructs that together reflect a student’s PB orientation. It is this notion of a PB orientation that is also of interest in this study.

Drawing on a research tradition examining hierarchical models of human cognition and behaviour (e.g. Elliot & Church, 1997; Marsh & Shavelson, 1985; Shavelson, Hubner, & Stanton, 1976), it is proposed that the specific PB dimensions can be subsumed under a more global characterization of the individual. In the present study, this global characterization is referred to as a PB orientation. From a theoretical perspective a PB orientation concept serves as a useful means to integrate different goal dimensions. From an empirical perspective, when modelling the ‘effects’ of PBs on particular educational constructs a PB orientation enhances parsimony and also resolves statistical problems such as suppression effects encountered with highly correlated first order factors (see Bollen, 1989). From an applied perspective, the global PB concept appears to be a more readily utilized concept than the specific dimensions underpinning it. For example, when looking ahead to upcoming performances or reflecting on previous performances, it is evident that PBs are referred to in the more global sense and not so much the specific dimensions underpinning it.

The role of gender and year-level in PBs

Recently there has been a marked increase in interest in boys’ education. Such research has pointed to declining levels of achievement and motivation among boys in recent years (see MacDonald, Saunders, & Benfield, 1999; Martin, 2004; Organisation for Economic Co-operation and Development, 2001; Rowe & Rowe, 1999; Weaver-Hightower, 2003). If, as is hypothesized in this paper, PBs have particular relevance to motivation and achievement, the issue of gender and PBs is also of relevance. Assessment of gender differences provides an opportunity to explore the generality of the PB concept across males and females, the gender-related consistency of the psychometric properties of the multidimensional PB framework, and specific ways in which males and females diverge and converge at mean levels.
Of similar importance to the gender effects in motivation are the year level differences that are commonly reported in motivational research. For example, a decline in student motivation and engagement is typically found to emerge after the middle school transition (e.g. see Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002; Martin, 2001; Wigfield et al., 1997). Again, inferring from the hypothesized link between PBs and motivation, it is deemed important to also explore the role of age in the context of PBs. Further aims of the study, then, are to: first, examine the invariance in factor structure across gender and across school year levels, and second, examine mean gender and year-level differences in PBs.

**Aims of the present study**

It is hypothesized that four dimensions of specific, challenging, competitively self-referenced, and self-improvement goals reflect a PB orientation. This four-factor model is tested for its psychometric properties as well as for invariance across gender and year level. Given that these four factors are considered to jointly reflect a PB orientation, a higher-order factor analytic model is also examined in which the four factors are modelled as the lower order of a higher-order PB orientation. Moreover, given the link between PBs and a variety of educational factors discussed above, it is also hypothesized that this PB orientation will predict a set of key educational factors (class participation, enjoyment of school, educational aspirations, and persistence) that conceptually follow from a focus on working towards one’s personal best. Having explored the predictive utility of a framework along these lines, the underlying dimensions of these four constructs will then be examined with a view to developing a parsimonious framework for further conceptualizing PBs and for developing intervention aimed at assisting students to work to their academic potential.

**Method**

**Sample and procedure**

Respondents were 1,016 students from five Australian government high schools in Years 7 and 8 (61%), Years 9 and 10 (34%), and Years 11 and 12 (5%). All schools were located in urban areas of Sydney. Schools primarily drew on middle- to upper-middle-class areas. In total, 55% of students were females and 45% males. The mean age of students was 14.2 years ($SD = 1.4$). Teachers administered the instrument to students during class. The rating scale was first explained and a sample item presented. Students were then asked to complete the instrument on their own and to return it once completed to the teacher at the end of class.

**Materials**

The instrument assessed numerous dimensions of students’ academic engagement, including dimensions hypothesized to be relevant to the study of PBs. These dimensions were (1) the four hypothesized components of PBs: specific goals (e.g. ‘I aim for specific results in my schoolwork’), challenging goals (e.g. ‘I aim for goals in my schoolwork that challenge me’), competitively self-referenced goals (e.g. ‘I compete with myself more than with other students’), and self-improvement goals (e.g. ‘When I do my schoolwork I try to do better than I’ve done before’); and (2) four educational correlate measures: persistence (e.g. ‘If I can’t understand my schoolwork at first, I keep going over it until I do’), enjoyment of school (e.g. ‘I enjoy being a student’), class participation (e.g. ‘I get involved in things we do in class’), and educational aspirations (e.g. ‘I intend to
complete school'). The PB-related items are presented in the Appendix. Four items comprised each scale. To each item, students rated themselves on a scale of 1 (strongly disagree) to 7 (strongly agree).

**Confirmatory factor analysis and structural equation modelling**

Confirmatory factor analysis (CFA), performed with LISREL version 8.54 (Joreskog & Sorbom, 2003), was used to test the psychometric properties of the instrument. In CFA, the researcher posits an *a priori* structure and tests the ability of a solution based on this structure to fit the data by demonstrating that (a) the solution is well defined, (b) parameter estimates are consistent with theory and *a priori* predictions, and (c) the chi-squared and subjective indices of fit are reasonable (Marsh, Balla, & McDonald, 1988; McDonald & Marsh, 1990). Maximum likelihood was the method of estimation used for the models. In evaluating goodness of fit of alternative models, the root mean square error of approximation (RMSEA) is emphasized. Although the RMSEA is apparently the most widely endorsed criterion of fit, also presented are the non-normed fit index (NNFI), the comparative fit index (CFI), the chi-squared test statistic, and an evaluation of parameter estimates.

For RMSEAs, values at or less than .05 and .08 are taken to reflect a close and reasonable fit, respectively (see Joreskog & Sorbom, 1993; Marsh, Balla, & Hau, 1996; Schumacker & Lomax, 1996). The NNFI and CFI vary along a 0 to 1 continuum in which values at or greater than .90 and .95 are typically taken to reflect acceptable and excellent fits to the data, respectively (McDonald & Marsh, 1990). The CFI contains no penalty for a lack of parsimony so that improved fit due to the introduction of additional parameters may reflect capitalization on chance, whereas the NNFI and RMSEA contain penalties for a lack of parsimony.

A growing body of research has emphasized potential problems with traditional pairwise, listwise, and mean substitution approaches to missing data (e.g. Brown, 1994; Graham & Hoffer, 2000; Little & Rubin, 1987), leading to the implementation of the expectation maximization algorithm, the most widely recommended approach to imputation for missing data, as operationalized using missing value analysis in LISREL.

**Multidimensional scaling**

Multidimensional scaling (MDS) was used to explore dimensions underpinning the four goals. MDS assists the researcher in determining the perceived relative position of a set of objects or items (Hair, Anderson, Tatham, & Black, 1995). MDS is typically used to determine similarities amongst a set of objects (rather than self-report questionnaire items). It is, however, considered appropriate for use in the present study not only in terms of its heuristic value, but also in terms of its focus on mapping constructs in multidimensional space as is relevant here. If two items are similarly rated by respondents, they will be located in multidimensional space in a way that the distance between them is smaller than the distance between other pairs of items. The resulting perceptual map indicates the relative positioning of all items. The researcher then interprets the underlying dimensions in a way that best explains the positioning of items in the map, particularly as it relates to an underlying theoretical rationale. The present analysis used the multidimensional scaling procedure in SPSS, which created the similarity matrix from the raw data using the Euclidean distance measure (Young & Harris, 1994).
Results

First order CFA

The first model tested was a first-order factor analysis comprising all eight factors relevant to the study. This CFA yielded a good fit to the data, $\chi^2(436) = 2055.64$, NNFI = .98, CFI = .98, RMSEA = .060. Factor loadings are presented in Table 1. Taken together, the loadings are acceptable. Reliabilities (Cronbach's alpha) presented in Table 1 are also acceptable. Correlations are presented in Table 2. Of particular interest is the correlation amongst the four goal constructs (specific, challenging, competitively self-referenced, and self-improvement). Results show that specific goals and challenging goals are most highly correlated with each other as is self-improvement goals with these to a more modest extent. Competitively self-referenced goals, although highly correlated with specific, challenging, and self-improvement goals, is not as high as the correlations amongst the other three goal constructs.

The high correlations between the four PB factors might be better represented in a unidimensional model. To test this possibility, a one-factor congeneric model was tested in which the 16 PB items loaded on the one factor. This model was compared with one in which the 16 PB items loaded on the hypothesized four factors. Data showed that the one-factor model, $\chi^2(104) = 2780.93$, NNFI = .92, CFI = .93, RMSEA = .160, did not fit the data as well as well as the four-factor model, $\chi^2(98) = 966.83$, NNFI = .97, CFI = .98, RMSEA = .093, as indicated by the significant difference in chi-squared values and goodness-of-fit indices (Cheung & Rensvold, 2002). Hence, the four-factor model is the best fitting one.

Higher-order CFA

It has been hypothesized that jointly the four-goal constructs reflect a PB orientation. This brings into consideration representing a higher-order factor that is derived through the contribution of these four goals. In higher-order models, correlations between first order factors are constrained to be zero and relations among these first-order factors are explained in terms of higher-order factors. Because the number of higher-order factor loadings is typically smaller than the number of correlations among first-order factors, the higher-order models are more parsimonious. Here, for example, the six correlations among the four motivation and engagement factors were explained in terms of four higher-order factor loadings relating the four first-order factors to the one higher-order factor. Although the relative ability of first-order and higher-order factor models to fit the data is a critical feature in the evaluation of higher-order models, Marsh (1987) noted several other features that were also important. In particular, if correlations among first-order factors were small, then the hierarchy must necessarily be weak and most of the reliable variance in the first-order factors could not be explained in terms of higher-order factors.

Accordingly, higher-order factor analysis was carried out in which the four goals load on a higher-order factor, termed PB orientation. This model fit the data well, $\chi^2(450) = 2115.32$, NNFI = .98, CFI = .98, RMSEA = .060, with higher-order factor loadings of .97 (specific goals), .95 (challenging goals), .60 (self-referenced goals), and .88 (self-improvement goals). Correlations between the higher-order PB orientation and the key correlates were: .72 (educational aspirations), .67 (enjoyment of school), .57 (class participation), and .77 (persistence). Although the first-order model fit the model significantly better than the higher-order model (indicating that the first-order level is critical to the conceptualization and measurement of PBs), the higher order is an
### Table 1. Factor loadings for the instrument

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Cronbach’s α: .82, .90, .86, .88, .77, .88, .90, .78

### Table 2. Inter-scale correlations emerging from CFA

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<td>CG</td>
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<tr>
<td>CSRG</td>
<td>.55</td>
<td>.58</td>
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<td>SIG</td>
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<tr>
<td>EA</td>
<td>.73</td>
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<td>.44</td>
<td>.63</td>
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<tr>
<td>ES</td>
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<td>CP</td>
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<td>.32</td>
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<td>–</td>
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<tr>
<td>P</td>
<td>.73</td>
<td>.72</td>
<td>.45</td>
<td>.75</td>
<td>.62</td>
<td>.56</td>
<td>.49</td>
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excellent fitting one as well and a useful means of modelling PBs in a way that can examine the individual effect of PBs, yet retain the multidimensional framework underpinning it.

**Multigroup confirmatory factor analysis and tests of invariance**

Analyses thus far have assumed that the factor structure is consistent across key groups in the sample. To date, inadequate attention has been given to critical differences in factor structure of many motivation-related constructs and the question, for example, of whether a given instrument measures the same components with equal validity for particular groups such as for males and females or for students of different ages. At a pragmatic level, the implications of this issue are substantial. For example, unless there is reasonable support for the invariance of the PB structure across gender, it may not be justified to compare PB responses across males and females. Such concerns about factor structure invariance are most appropriately evaluated by using CFA to determine whether - and how - the structure of PBs varies according to gender and age (see Byrne & Shavelson, 1987; Hattie, 1992; Marsh, 1993).

Hence, it was of interest to determine factor invariance across boys and girls and across year levels (early vs. later high school). Testing for factor invariance essentially involves comparing a number of models in which aspects of the factor structure are systematically held invariant across groups and assessing fit indices when elements of these structures are constrained. Relatively invariant fit indices are indicative of invariant factor structure. The present analyses examined the comparative fit indices for a number of models that held successive elements of the four-factor PB structure invariant across boys and girls and then across early (Years 7, 8, and 9) and later (Years 10, 11, and 12) high school.

**Invariance across boys and girls**

The first multigroup CFA examined the factor structure for boys and girls and allowed all factor loadings, uniquenesses, and correlations to be freely estimated. This model yielded an excellent fit to the data, $\chi^2(196) = 1098.89$, CFI = .97, NNFI = .97, RMSEA = .095. Although this model is a good fit to the data, it is important to formally test for invariance between boys and girls.

The present study examined the comparative fit indices for five models across boys and girls. The first model holds no parameters invariant and freely estimates all loadings, factors, uniquenesses and correlations (this yielded an acceptable fit – see above). The second model holds the factor loadings invariant across boys and girls; the third holds both factor loadings and uniquenesses invariant; the fourth holds the factor loadings and correlations invariant; and the fifth holds the factor loadings, the uniquenesses, and the correlations invariant.

Results in Table 3 indicate that when successive elements of the factor structure are held invariant across gender, the fit indices are comparable (e.g. all CFI = .97). This suggests that the factor structure, factor loadings, uniquenesses, and factor correlations are parallel for boys as they are for girls. Indeed, the application of recommended criteria for evidence of lack of invariance (i.e. a change of .01 in fit indices - see Cheung & Rensvold, 2002) indicates that there is relative invariance across all models. Taken together, these data suggest that in terms of underlying PB constructs and the composition of and relationships amongst these constructs, boys and girls are not substantially different.
The second multigroup CFA examined the factor structure for younger and older high school students (early high school = Years 7, 8, and 9 and later high school = Years 10, 11, and 12), and allowed all factor loadings, uniquenesses, and correlations to be freely estimated. This model yielded an excellent fit to the data, $\chi^2(196) = 1023.53$, $CFI = .97$, $NNFI = .97$, $RMSEA = .096$. Again, although this model is a good fit to the data, it is important to formally test for invariance between the two year groupings. As above, this involved examining the comparative fit indices for the same five models across early and late high school year groupings.

Results in Table 4 indicate that when successive elements of the factor structure are held invariant across year groupings, the fit indices are comparable (e.g. all CFIs = .97). Again, the application of recommended criteria for evidence of lack of invariance (i.e. a change of 0.01 in fit indices – see Cheung & Rensvold, 2002) indicates that there is relative invariance across all models. Taken together, these data suggest that in terms of underlying PB constructs and the composition of and relationships amongst these constructs, early and later high school students are not substantially different.

### Table 3. Invariance tests across boys and girls

<table>
<thead>
<tr>
<th>Model</th>
<th>$\chi^2$</th>
<th>DF</th>
<th>CFI</th>
<th>NNFI</th>
<th>RMSEA</th>
</tr>
</thead>
<tbody>
<tr>
<td>All parameters are free (no invariance)</td>
<td>1098.89</td>
<td>196</td>
<td>.97</td>
<td>.97</td>
<td>.095</td>
</tr>
<tr>
<td>Loadings are invariant</td>
<td>1131.46</td>
<td>208</td>
<td>.97</td>
<td>.97</td>
<td>.094</td>
</tr>
<tr>
<td>Loadings and uniquenesses are invariant</td>
<td>1183.86</td>
<td>224</td>
<td>.97</td>
<td>.97</td>
<td>.092</td>
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<td>Loadings and correlations are invariant</td>
<td>1167.98</td>
<td>218</td>
<td>.97</td>
<td>.97</td>
<td>.093</td>
</tr>
<tr>
<td>Loadings, correlations, and uniquenesses are invariant</td>
<td>1117.86</td>
<td>234</td>
<td>.97</td>
<td>.97</td>
<td>.090</td>
</tr>
</tbody>
</table>

### Invariance across younger and older students

The second multigroup CFA examined the factor structure for younger and older high school students (early high school = Years 7, 8, and 9 and later high school = Years 10, 11, and 12), and allowed all factor loadings, uniquenesses, and correlations to be freely estimated. This model yielded an excellent fit to the data, $\chi^2(196) = 1023.53$, $CFI = .97$, $NNFI = .97$, $RMSEA = .096$. Again, although this model is a good fit to the data, it is important to formally test for invariance between the two year groupings. As above, this involved examining the comparative fit indices for the same five models across early and late high school year groupings.

Results in Table 4 indicate that when successive elements of the factor structure are held invariant across year groupings, the fit indices are comparable (e.g. all CFIs = .97). Again, the application of recommended criteria for evidence of lack of invariance (i.e. a change of 0.01 in fit indices – see Cheung & Rensvold, 2002) indicates that there is relative invariance across all models. Taken together, these data suggest that in terms of underlying PB constructs and the composition of and relationships amongst these constructs, early and later high school students are not substantially different.

### Table 4. Invariance tests across early and later high school

<table>
<thead>
<tr>
<th>Model</th>
<th>$\chi^2$</th>
<th>DF</th>
<th>CFI</th>
<th>NNFI</th>
<th>RMSEA</th>
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<tr>
<td>All parameters are free (no invariance)</td>
<td>1023.53</td>
<td>196</td>
<td>.97</td>
<td>.97</td>
<td>.096</td>
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<tr>
<td>Loadings are invariant</td>
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<td>.094</td>
</tr>
<tr>
<td>Loadings and uniquenesses are invariant</td>
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<td>.97</td>
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<td>.093</td>
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<td>Loadings and correlations are invariant</td>
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<td>234</td>
<td>.97</td>
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### Structural equation modelling examining predictive utility of a PB orientation

It was of interest to examine a model in which the four goals comprise the hypothesized higher-order PB orientation, and which in turn predicts the four key correlate measures enjoyment of school, educational aspirations, class participation, and persistence. Accordingly, structural equation modelling was carried out which included the CFA measurement model as well as beta paths between the latent factors. Also in this model are beta paths between each of gender and age and the higher order PB orientation. This model fit the data well, $\chi^2(512) = 2252.02$, $NNFI = .98$, $CFI = .98$, $RMSEA = .058$, and is presented in Figure 1. Results show that females are more inclined than males to adopt a PB orientation and that a PB orientation is a significant and positive predictor of educational aspirations, enjoyment of school, class participation, and persistence.
Interestingly, of these significant parameters, PBs most strongly predicted future orientations and engagement longevity, educational aspirations and persistence.

**Further exploring dimensions underpinning the four-factor model**

Representing the PB model in terms of a higher-order factor is one way to capture a PB orientation through accommodating a set of hypothesized factors. Another way to understand the dimensions underpinning PBs is to map the four hypothesized factors in multidimensional space with a view to identifying a set of parsimonious and key dimensions to explain its component factors. With this in mind, multidimensional scaling was conducted using all items from each of the four goal factors. Four models were explored to test for dimensions parallel to the four component factors. The two- (RSQ = .92), three- (RSQ = .96), and four-dimensional (RSQ = .98) models fit the data markedly better than the one-dimensional (RSQ = .77) model. The two-dimensional model was selected as the most defensible because it reflected greater parsimony whilst also explaining the bulk of common variance. Stimulus coordinates are mapped in Figure 2.

The location of items in this figure suggests that these two dimensions can be interpreted as a clear goal focus and a self-competition focus. Self-competition focus (SCF) refers to competition with oneself and clear goal focus (CGF) refers to a focus on specific and challenging goals. Competitively self-referenced items are primarily high on SCF and low on CGF; performance related but in reference to one’s own performance and also more focused on the competition with self than with specific goals. Challenging goals are primarily high on CGF and lower on SCF: focused less on competition with self and more on the challenge/goal at hand. Specific goals are highest on CGF and lower on SCF: more goal related and less self- and performance related. Perhaps most importantly, self-improvement goals are predominantly located in the quadrant reflecting high self-competition focus and high clear goal focus.

**Discussion**

This study sought to examine a multidimensional model of PBs in the academic setting. A four-factor model of PBs – comprising specific goals, challenging goals, competitively

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Figure 1. Hypothesized PB process, $\chi^2$(512) = 2252.02, NNFI = .98, CFI = .98, RMSEA = .058, – all parameters statistically significant ($p < .05$) unless otherwise indicated.
self-referenced goals, and self-improvement goals – was tested and found to evince an excellent fit to the data. The higher-order PB orientation deriving from this was also a good fit and was found to significantly predict a set of constructs that were hypothesized to sensibly relate to PBs. Further analysis using multidimensional scaling was undertaken to shed light on the dimensionality of PBs. This analysis suggested that goals can be located in two-dimensional space reflecting clear goal focus and self-competition focus.

Figure 2. Stimulus configuration derived from MDS.

Note. sref = Competitively self-referenced goals; ch = Challenging goals; spec = Specific goals; imp = Self-improvement goals.

Coordinating mastery and performance goals
PBs may shed light on recent debate focused on mastery and performance goals in achievement contexts. Since the late 1970s there has been considerable interest in the reasons and purposes for learning (Kaplan & Maehr, 2002). Achievement goal theory has been a dominant approach to better understanding the reasons and purposes of student learning and engagement. According to Dweck and Leggett (1988), students’ achievement goal orientations influence the way they think, feel, and behave in academic contexts (see also, Ames, 1992; Elliott & Dweck, 1988). The focus of achievement goal research has predominantly been on mastery and performance orientations (Nicholls, 1984). Although the evidence clearly demonstrates the adaptive properties of mastery goals, there is evidence showing that performance-related...
dimensions are not necessarily inimical to successful functioning in school (see for example, Elliot & Church, 1997; Epstein & Harackiewicz, 1992; Harackiewicz, Barron, Carter, Lehto, & Elliot, 1997; Harackiewicz et al., 1998; Harackiewicz & Elliot, 1993; Martin & Debus, 1998). Indeed, the debate as to the relative advantages and drawbacks of performance orientation in the context of a mastery orientation is ongoing (see Harackiewicz, Barron, Pintrich, Elliott, & Thrash, 2002; Kaplan & Middleton, 2002). Interestingly, the correlational data showed that competitively self-referenced goals was the specific PB dimension yielding the lowest average correlation with the educational outcomes and this may reflect the oft-reported differential impact of mastery and competitive goals on educational outcomes.

Given the relevance of mastery orientation to PBs as a personalized and self-improvement-based goal orientation and the elements of performance orientation that may be adaptive to student engagement and performance, it is suggested that PBs may represent a construct that is an adaptive blend of both mastery and performance orientations. Specifically, it is a construct that primarily reflects a mastery orientation because it is self-referenced and self-improvement-based and yet holds a slice of performance orientation because the student competes with his or her own previous performance. PBs, then, are consistent with a personalized journey of improvement and proactivity, yet retain the energizing properties that a performance orientation may offer. Indeed, PBs may be a means by which students are able to coordinate multiple goals in the classroom. It has been suggested that students can hold both mastery and performance goals (Heyman & Dweck, 1992; Wentzel, 1992), however, there are some indications that students do not always do this successfully, which can put strain on them and make achievement of secondary importance (Urdan & Maehr, 1995). PBs may be a way to facilitate students’ coordination of mastery and performance goals.

A quadripolar PB model
The multidimensional scaling framework suggests something of a ‘Quadrupled PB Model’. In terms of PBs, ineffective goals would be those that have neither clarity, challenge, nor self-competition as their focus. Specific goals and challenging goals do have clear focus but are not necessarily high on self-competition, whereas competitively self-referenced goals are not necessarily clear but high on reference to self. It seems that self-improvement is the goal that reflects high levels of clarity and self-competition – indeed, this is feasible from a very face valid perspective, which holds that PBs are necessarily about improving on a previous specific standard of one’s own performance. This Quadripolar PB Model is presented in Figure 3. Indeed, this model holds implications for pedagogical practice and intervention and these implications are discussed below.

The personal best index (PBI)
A concerted emphasis on PBs in school might involve a more formalized assessment of PBs. One way of doing this is to make use of a PB Index (PBI) when reporting to students (and their parents). Typically, the primary quantification of students’ performance at school in a given term or year is through their relative grading and/or ranking. That is, their grade in History, for example, is often determined relative to other students’ performance in that subject. A relative grading system immediately confines ‘success’ to a handful and relegates relatively lower performances or ‘failure’ to many (see Covington, 1992, 1998). The PBI would be a personalized measure, and because of this, it is possible for a student who had never scored highly in relative terms to receive a high
PBI if he or she performed better, was more engaged in the subject, or more skilful than previously. Indeed, extending this concept to its logical conclusion, there may be two valedictorians at the school: one who tops the school in relative grading and one who tops on aggregate PBI.

The PBI would be calculated on the basis of a student matching or exceeding a previous level of performance. This is particularly important for students scoring highly on relative grading because there is less room for improvement for them - that is, students should not be penalized because their previous levels of high performance yield ceiling effects for them. Nor should the PBI be onerously punishing of a student who slips lower than a previous level of performance. It is designed to be an encouragement-based and success-oriented measure of performance not a punitive indicator. The PBI is conceptually compelling; however, there is a need to rigorously examine the effects of its implementation over time in terms of appraisals of self and also in terms of objective measures of performance and achievement and measures of class and school climate.

Critical research issues for further consideration
The present study provides detailed analysis of the multidimensionality of PBs. There are, however, a number of critical issues important to consider when interpreting findings and which provide some direction for further research.

The data presented in this study are all self-reported. Although this is a logical and defensible methodology in its own right given the substantive focus, it is important to conduct research that examines the same constructs using data derived from additional sources such as, for example, that from teachers and parents. It is also important to recognize that the measures relate to school generally and not to specific school subjects. It may be that the more focused the measures are on specific school subjects, the more useful they are from an intervention perspective. Furthermore, the data were collected at the one time point and so future longitudinal work is needed to explore the stability of constructs over time and perhaps some analysis of possible causal ordering that also incorporates student achievement. Taken together, these points suggest that future research should collect subjective and objective data and conduct such data collection in a longitudinal design.

The focus of this study has been on individual-level PBs. There may also be scope to also explore class and school climates - that is, aiming for aggregate-level PBs. Although, the present study adopted an individual-differences approach to PBs, it is recognized that class- and school-level factors are also potentially relevant. Work that has assessed...
class-level goals has found that they are associated with patterns of behaviour, affect, and
cognition (Roeser, Midgley, & Urdan, 1996; see also Midgley & Urdan, 1995; Urdan,
Midgley, & Anderman, 1998). Indeed, advances in statistical software enable researchers
to more accurately assess the relative influence of individual-, class-, and school-level
factors using multi-level modelling (see Bryk & Raudenbush, 1992; Goldstein, 1995),
and so future research can readily explore the influence of class- and school-level
climates relative to individual-level variation in PBs.

Although the four-factor model’s components are conceptually defensible, hold
opportunities for educational practise, and are valid from a factor structure perspective, the
high correlations between the first-order facets may present some statistical challenges.
With such high correlations there exists the possibility of collinearity in predictive and/or
structural equation models that only examine the first-order level and the analytic problems
that follow from this such as suppression effects (e.g. see Bollen, 1989). This brings into
focus the interface between models that are appropriate to research and models that are
appropriate to practise and how related challenges can be resolved.

Some qualification of the multidimensional framework is also required. It will be
recalled that this framework is essentially based on the interpretation of the axes as clear
goal focus and self-competition focus and so it should be stated that it can only be
inferred that these axes represent the quadripolar model as hypothesized.
Notwithstanding this, it is pointed out that latent constructs are never measured
directly, but rather are the representation of a set of observed measures. Thus, while the
predicted empirical positioning of the factors in the framework validates the present
interpretation of these axes, it is suggested that further work is required that more
directly establishes this interpretation. Future work might also extend what has been
initiated in the MDS in terms of developing scales that directly assess the overlap among
dimensions (e.g. specific self-improvement goals vs. challenging self-improvement
goals). This work would further clarify the precise ways in which multidimensional PBs
impact on critical educational outcomes.

Critical pedagogical issues for further consideration

Although PBs hold promise from motivation and achievement perspectives, there are
some qualifications and critical issues that must be considered to ensure that they are
used most profitably in the academic setting. First, PBs still set a standard against which
one is judged. Falling below this standard is likely to be disappointing, and so PBs do not
protect students from negative affect. It is therefore important to develop PB strategies
that do not discourage students if they fall below their PB goal. It is suggested that PBs be
expansive so that they encompass process goals (e.g. put in more time studying; try a
new way of introducing an essay) as well as outcome goals (see Schunk & Miller, 2002).
Process goals are – in theory – achievable by everyone and so an equal or greater focus
on these may protect students if they fall below their PB outcome goal. Indeed,
attending to process goals and reaching outcome goals are not mutually exclusive.

When aiming for PBs it is important that students do not set themselves up for
failure. Polivy and Herman (2002) identified the following reasons why individuals fail to
reach goals or change/improve their behaviour: setting unrealistically high goals and
then abandoning all effort when these goals are not met (rather than revise the goals to
more realistic levels of challenge), expecting change or success to come more easily
than is realistically possible, expecting change or success to come more quickly than is
realistically possible, and overestimating one’s ability to change or succeed. Polivy and
Herman conclude, ‘self-change efforts are frequently doomed to failure from the outset
by the unrealistic expectations brought to the enterprise. Impossible amounts, speed, ease, and rewards of change are anticipated; by definition, these cannot be achieved' (p. 680, 2002). Although challenging goals are the most effective goals, they must be grounded in reality and be achievable.

In contrast to students who lay the foundation for failure, others set excessively easy goals they are guaranteed to reach but which do not move them forward. Although goal-setting research is clear that the most effective goals are challenging (Locke & Latham, 2002), one might ask why anyone would want to set goals that are difficult or challenging to achieve. The answer is drawn from a wide array of research and theory showing that challenging or difficult goals offer the greatest potential for satisfaction or fulfillment at a number of levels. First, goal-setting research suggests that pride in performance is highest when one achieves challenging goals (Mento, Locke, & Klein, 1992). Second, self-efficacy research suggests that success on tasks that are difficult enhances one’s efficacy and control (Bandura, 1997). Research on self-efficacy also suggests that adoption of challenging goals enhances motivation because individuals create a discrepancy they subsequently aim to reduce (Bandura, 1989). Third, seminal educational theory (Vygotsky, 1978) and more recent psychological theory (Csikszentmihalyi, 1990; Jackson & Csikszentmihalyi, 1999) suggest that individuals are most engaged when levels of challenge match or realistically exceed their skill. Finally, research into task value suggests that students gain both attainment (satisfaction in performing well) and utility (perceived usefulness and relevance of the task) value in performing well on challenging and meaningful activities (Wigfield & Eccles, 1992). Taken together, students given appropriate conditions are inclined to set challenging but attainable goals, not avoid or shrink from them.

Although it is proposed that PBs reduce students’ tendency to engage in social comparisons, it is unrealistic to expect that they eliminate social comparisons. The nature of assessment in our competitive school system overtly assesses students in terms of their performance relative to others. ‘High stakes’ testing such as that conducted at critical times in students’ school life create a system-wide performance and comparative orientation (Ryan & La Guardia, 1999). Moreover, as students move from primary to high school, their tendency to compare themselves with others increases (Harter, 1996), and this is likely to continue even under a system of PBs. However, to the extent that PBs reduce the emphasis on comparisons and the extent to which these reduced comparisons enhance intrinsic motivation, PBs are deemed a fruitful pursuit.

It is important not to dismiss performance orientation as unhelpful to students’ motivation or achievement. As indicated earlier, in terms of cognitive engagement, learning strategies and self-regulation, performance-related goals can be adaptive in some settings and circumstances (Epstein & Harackiewicz, 1992; Harackiewicz et al., 1998; Harackiewicz & Elliot, 1993). Indeed, some research suggests that among college students, performance goals are related to higher performance, whereas learning goals are not (Harackiewicz, Barron, Tauer, Carter, & Elliott, 2000). It has also been argued that the competitive and comparative processes relevant to performance goals are not necessarily inimical to motivation and achievement. Rather, when competition and comparisons are couched in terms of personalized standards and benchmarks (as they are when dealing with PBs), they can be educationally adaptive. Indeed, it is the personalized competitive and comparative elements of PBs that distinguish them from learning goals.

It is also important to note that the concept of PBs is not a new one. It is a concept routinely invoked in the sporting context (though it has received little formal attention
in sport research). However, it receives surprisingly little attention in the education domain. Perhaps the excessively competitive school system does not provide sufficient scope for PBs. Perhaps it is the requirement for normative assessment that makes it unfeasible to develop a complementary personalized assessment system. Perhaps it is the perception that there is little overlap across human performance domains and so concepts successful in the sporting domain are not deemed particularly relevant in the educational domain. Perhaps it is because existing assessment requirements are onerous and adding to educators’ duties is undesirable. These and other issues should be addressed as educators seek to introduce PBs into their assessment system.

**Conclusion**

PBs are proposed as an important means to increase opportunities for students to achieve to their potential at school. PBs have the capacity to carry weight with many young people who routinely see PBs lauded by elite athletes they so often hold in high esteem. Schools incorporating PBs into their reporting regime can harness the intuitive appeal of PBs in a bid to provide their students with genuine experiences of success and give them a reason to dig deep on each new challenge. The Quadripolar PB Model holds that students are most likely to reach PBs on tasks/goals that are (1) specific, (2) challenging, (3) competitively self-referenced, and (4) focused on self-improvement. Such a model, it is proposed, provides clearer direction for educators as to the precise nature of PBs and the means to help students achieve them. Through consideration and application of the ideas presented in this article, it is envisaged that students can become more engaged in school and their schoolwork and more motivated to develop and improve themselves as students.

**Acknowledgements**

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**References**


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Appendix

Specific goals
- I set specific goals to aim for in my schoolwork
- I get a clear idea about specific things I'm trying to achieve in my schoolwork
- I aim for specific results in my schoolwork
- I get it clear in my head what specific goals I'm aiming for in my schoolwork

Challenging goals
- I set challenging goals for myself in my schoolwork
- I aim for goals in my schoolwork that challenge me
- I set challenges for myself in my schoolwork
- I like to work towards challenging goals in my schoolwork

Competitively self-referenced goals
- I am in competition with myself more than with other students
- I compete with myself more than with other students
- I compete with my own previous performances more than I compete with other students
- I compete with my own previous marks more than I compete with other students' marks

Self-improvement goals
- When I do my schoolwork I try to do it better than I've done before
- When I do my schoolwork I try to do the best that I've ever done
- When I do my schoolwork I try to do better than I've done before
- When I do my schoolwork I try to get a better result than I've got before