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1 Running Head: Verbal, Mathematics, and Physical Education Self-Concepts and
2 Achievements

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6 Verbal, Mathematics, and Physical Education Self-Concepts and Achievements: An

7 Extension and Test of the Internal/External Frame of Reference Model

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1 Abstract

2 *Objective:* The Internal/External Frame of Reference Model (I/E model; e.g., Marsh,
3 1986) posits that verbal achievement (Ach) produces a lower mathematics self-concept
4 (SC) and that, conversely, mathematics Ach fosters a lower verbal SC after controlling
5 for prior Ach in each domain. The present study extended this model by adding another
6 school subject that has not been previously investigated, namely physical education (PE).
7 The central goal was to verify whether Ach in PE positively or negatively predicts
8 academic SC in the mathematics and verbal domains.

9 *Design:* Prospective study over one school year.

10 *Methods:* Participants were 451 French high school students (mean age = 13.5). Ach
11 scores in mathematics, French and PE were gathered at the beginning of the school year.
12 At the end of this one, students completed a questionnaire to assess their SC in the three
13 school subjects.

14 *Results:* Structural Equation Modelling results revealed, according to the I/E model,
15 negative paths between mathematics Ach and verbal SC, and between verbal Ach and
16 mathematics SC. Results also revealed singular relationship patterns between the two
17 traditional school subjects and PE. A positive path between PE Ach and mathematics SC
18 was observed whereas the path with the verbal SC was non-significant.

19 *Conclusion:* PE could have benefits to increase SC in other school subject such as
20 mathematics. Broader implications of results for the I/E model are discussed.

21

22 Key words: Academic Achievement, Academic Self-Concept, Internal/External Frame of
23 Reference Model, Physical Activity, Physical Education

1 Self-concept theory suggests that the perceptions students have of ability in a
2 given school subject are not an epiphenomenon, but rather an important cognitive state
3 that drives behavior and academic achievement (e.g., Marsh, & Hattie, 1996). In the past
4 decades, researchers have explored the relations between achievement and self-concept in
5 various school subjects (e.g., Byrne, 1986). Studies have highlighted the paradoxical
6 finding that students' achievements can simultaneously enhance and decrease self-
7 concept. Specifically, self-concept studies generally indicate that mathematics and verbal
8 achievements are strong predictors of corresponding self-concepts in these school
9 subjects, but at the same time, achievement in one school subject negatively predicts self-
10 concept in another subject after controlling for previous achievement in the matching
11 domain. This indicates that self-concept in a given subject is influenced not only by
12 specific achievement in that subject, but also by achievement in other subjects. These
13 patterns of relations have been investigated under the well-known Internal/External
14 Frame of Reference Model (I/E model, Marsh, 1986), which has proven quite robust in
15 many different cultures (Marsh & Hau, 2004).

16 Up to now, most studies on the I/E model have focused on the verbal and
17 mathematics domains, but, as argued by Marsh, Kong and Hau (2001), "... the theoretical
18 underpinning of the model suggests that this frame of reference should be a function of
19 all different school subjects (although the amount of weight put on each may vary)" (p.
20 545). However, could achievement in certain less academic school subjects produce a
21 different picture? For example, could achievement in physical education have positive
22 effects on mathematics and verbal self-concepts, after controlling for achievement,
23 instead of negative effects, as predicted by the I/E model? In fact, a host of studies have

1 shown that physical activity has beneficial effects on students' grades, coursework
2 selection, and academic self-concept (see Marsh & Kleitman, 2003).

3 We therefore focused on answering these questions by assessing achievement and
4 self-concepts in verbal, mathematics, and physical education subjects. In the following
5 sections, we present a more detailed discussion of the I/E model and the empirical
6 findings to date, followed by some studies that focus on the effects of physical activity on
7 academic self-concept and achievement. Finally, we present the specific goals of this
8 study.

9 *The I/E model*

10 According to the I/E model, students' academic self-concepts are influenced by
11 both internal and external comparisons. *External reference* refers to a social comparison
12 process by which students compare their self-concept of ability in a particular school
13 subject with the accomplishments of other students in the same school subject. This is
14 based on the assumption that social membership provides a frame of reference, or
15 standard of comparison, which is used by the group members in their self-evaluations
16 (e.g., Chanal, Marsh, Sarrazin & Bois, 2005). *Internal comparison* refers to the process
17 by which students compare their performance in a particular school subject to their
18 performance in another subject, independently of social comparison (e.g., Marsh, Smith,
19 & Barnes, 1985). The external comparison process predicts that better accomplishments
20 in one domain would lead to higher self-concepts in the matching domain. According to
21 the internal comparison process, however, better accomplishments in one domain should
22 lead to lower self-concepts in the non-matching domain, once the positive effects of
23 matching accomplishment are controlled for. For example, students with average

1 achievement in mathematics would gauge their mathematics self-concept depending on
2 whether their achievement in the verbal domain is below or above average. Below
3 average achievement in the verbal domain would lead students to have slightly above
4 average mathematics self-concepts, because the internal comparison process would lead
5 them to slightly overestimate their abilities in mathematics. Conversely, above average
6 achievement in the verbal domain would lead students to have slightly below average
7 mathematics self-concepts. Thus, the I/E model hypothesizes: 1) a strong and positive
8 correlation between mathematics achievement and verbal achievement; 2) a positive path
9 between academic achievement and self-concept in the same domain; 3) a weak
10 correlation between verbal and mathematics self-concepts; and 4) a negative path
11 between achievement in one school subject to self-concept in another subject (see Marsh
12 & Hau, 2004).

13 Several studies conducted in different countries have supported postulates of the I/E
14 model for the verbal and mathematics domains (e.g., Abu-Hilal & Bahri, 2000; Dai,
15 2002; Kong, 2000; Lee, Yeung, Low, & Jin, 2000; Marsh, Kong, & Hau, 2001; Skaalvik
16 & Rankin, 1995). For example, Marsh and Hau (2004) performed a cross-cultural study
17 in 26 countries among 55,582 participants, revealing that, despite some disparities among
18 countries, invariance tests supported the generalizability of the model across cultures.

19 Some studies have attempted to extend the I/E model to other academic subjects.
20 For instance, in a 5-year longitudinal study based on a large representative sample of high
21 school students in Hong Kong, Marsh, Kong and Hau (2001) tested the I/E model using
22 three school subjects: Chinese, English, and Mathematics. Results showed that
23 Mathematics, English, and Chinese achievements had positive effects on matching self-

1 concept dimensions, but, as expected, these achievements also had negative effects on
2 non-matching domains. Similarly, Marsh and Yeung (2001) demonstrated that
3 Mathematics, English, and Spanish achievement all had positive effects on matching self-
4 concepts, but negative effects on self-concepts in other dimensions. Sparfeldt, Schilling,
5 Rost, and Thiel (2006) tested the I/E model using Mathematics, Physics, German, and
6 English. Results confirmed that, among the twelve path coefficients between grades and
7 self-concepts, seven were negative, four were not statistically significant, and only one
8 coefficient was positive, between grades in mathematics and self-concept in physics.

9 In sum, although one study demonstrated a positive effect of achievement in one
10 school subject on students' self-concept in a non-matching school subject, negative
11 effects appear to be the most common result found in studies testing the I/E model for
12 school subjects other than Mathematics or Verbal.

13 *Physical activity, academic self-concept, and academic achievement*

14 A number of studies have tested the effects of physical activity on a host of
15 educational outcomes. Participation in interscholastic sports, intramural sports, or
16 athletics was associated not only with reduced dropout rates (e.g., Mahoney, & Cairns,
17 1997) and higher grades (e.g., Marsh, & Kleitman, 2003), but also with higher social and
18 academic self-concepts (e.g., Marsh, 1993). For example, Marsh and Kleitman (2003)
19 showed that the more students participated in physical activity, the higher their grades
20 and self-esteem. Studies have also established a positive relationship between physical
21 fitness and academic achievement. For example, Castelli, Hillman, Buck, and Erwin
22 (2007) showed that physical fitness indices (i.e., aerobic capacity and body mass index)
23 were related to academic achievement in third- and fifth-grade students. More precisely,

1 children who displayed better physical health (as assessed by high aerobic capacity and
2 low body mass index) showed, among others, better performance in mathematics and
3 reading.

4 Despite these findings, no studies to our knowledge have investigated the effects of
5 achievement in physical education on mathematics and verbal self-concepts. Although
6 various positive effects of physical activity on academic achievement and self-concept
7 have been found, the results were mostly observed in contexts where physical activity
8 was not a compulsory academic school subject for all students. Therefore, when assessing
9 the effects of achievement in physical education on self-concepts in other school subjects,
10 would we observe negative or positive effects? In fact, students might form their self-
11 concepts in various school subjects using the internal and external comparison processes
12 of the I/E model, for a negative effect of achievement in physical education on
13 mathematics and verbal self-concepts. Alternatively, we could argue that students might
14 use their achievement in physical education to foster their mathematics and verbal self-
15 concepts. Specifically, some models (e.g., Broh, 2002) suggest that physical activity may
16 contribute to academic skills by fostering work ethics, respect for authority, and
17 perseverance. Moreover, the positive effects of physical activity on children's cognitive
18 functioning have been supported in recent meta-analyses (e.g., Etnier, & Sibley, 2003).
19 Thus, better grades in physical education could indicate that students have developed
20 cognitive skills (e.g., problem solving skills, attention process, and decision making) that
21 are beneficial for more academic school subjects. In turn, these skills could foster higher
22 self-concepts, thereby leading to a positive relationship between achievement in physical
23 education and self-concepts in other school subjects. Finally, we could assume that

1 students might be unable to use an internal frame of reference based on their achievement
2 in physical education when it comes to assessing self-concept in more academic school
3 subjects. In fact, physical education differs significantly from other school subjects,
4 principally because achievements in this area reflect physical rather than intellectual
5 skills. Therefore, the internal frame of reference effect might be less likely to occur
6 between achievement in this subject and self-concepts in school subjects that require
7 intellectual skills.

8 *The present investigation*

9 The central goal of our study was to verify whether achievement in physical
10 education positively or negatively predicts academic self-concepts in the mathematics
11 and verbal domains. The study was conducted in a French high school where physical
12 education was compulsory for all students. We chose two traditional school subjects that
13 have been investigated in previous studies (i.e., mathematics and verbal: in this case,
14 French) in addition to physical education. The model tested is illustrated in Figure 1.

15 In line with previous work (e.g., Marsh & Hau, 2004), we hypothesized that
16 correlations between achievements in the various domains would be relatively strong,
17 whereas correlations between self-concepts would be fairly weak. Moreover, we
18 predicted that achievements in each traditional school subject (i.e., mathematics and
19 verbal) would positively predict corresponding self-concepts and negatively predict non-
20 corresponding self-concepts. In addition, we posited that achievement in physical
21 education would positively predict physical education self-concept. We did not make any
22 predictions about the effects of achievement in physical education on mathematics and
23 verbal self-concepts.

1 Method

2 *Participants and procedure*

3 Participants were 451 students (242 boys and 209 girls) attending a high school in
4 France. Average age was 13.5 years (SD = 1.3). The study took place over one school
5 year. Data were collected at the end of the school year (i.e., before the final report card of
6 the year, in early June 2004). Students who agreed to participate in the study completed a
7 questionnaire to assess their self-concepts in three different school subjects: Mathematics,
8 French (i.e., the verbal component) and Physical Education. Questionnaires were
9 administered in class.

10 *Measures*

11 *Academic self-concept measures. Mathematics and French self-concepts* were
12 measured with 5 items each (e.g., “I find mathematics lessons *very* difficult.”) taken from
13 the French version of the Self-Description Questionnaire II (Guerin, Marsh, & Famose,
14 2003). The *physical education self-concept* was measured with 6 items (e.g., “In physical
15 education lessons, I am good at most physical activities and sports) slightly adapted from
16 the Sports competence subscale of the French version of the Physical Self-Description
17 Questionnaire (Guerin, Marsh, & Famose, 2004). For each item in this dimension, we
18 clearly specified to students that we were interested only in their general perceptions of
19 competence in the sports and activities they practiced under the physical education
20 program. Answers on all items were rated on a 6-point Likert type scale ranging from (1)
21 False to (6) True. Cronbach’s alpha coefficients for all three measures were excellent (see
22 Table 1).

1 *Academic achievement measures.* For all students who completed the
2 questionnaire, achievement scores on a 20-point scale in the three school subjects at the
3 beginning of the school year (November 2003) were gathered from the official student
4 records. We made this choice because many authors have supported the utility of the
5 prospective design over a cross-sectional design (e.g., Bollen, 1989; Rogosa, 1980). In
6 France, physical education is a compulsory subject for all high school students (see
7 Wang, Papaioannou, Sarrazin, Jaakola, & Salmon, 2006). Students practice different
8 sports and physical activities throughout the school year, following a 10-week cycle (i.e.,
9 10 lessons of 2 hours). Although health is a concern, student evaluations were
10 predominantly based on their performance. Student achievement in our study is
11 determined by the mean of grades received in the various activities performed during the
12 trimester (from two to four activities). Previous studies have demonstrated the relevance
13 of using grades instead of standardized tests (e.g., Guay, Marsh, & Boivin, 2003), and
14 that grades are a very good indicator of student achievement (Jussim & Harber, 2005).
15 Studies carried out in PE in France reported high correlations ($r_s > .70$) between students'
16 performance and grades, in a swimming cycle (Trouilloud, Sarrazin, Martinek, & Guillet,
17 2002) or gymnastics cycles (Boiché, Sarrazin, Grouzet, Pelletier, & Chanal, in press).
18 andand

19 *Data analysis*

20 *Handling of missing data.* We observed less than 2% missing data for the overall
21 dataset. Since many studies underscore the inappropriateness of pairwise and listwise
22 strategies for handling missing data (e.g., Graham & Hoffer, 2000), we used the FIML
23 (Full Information Maximum Likelihood) method, using LISREL (version 8.80), to

1 estimate missing values. In brief, this methodology rebuilds the covariance matrix and
2 sample means estimates.

3 *Statistical analysis.* We began by assessing a Confirmatory Factor Analysis (CFA)
4 model in order to test the construct validity of the variables included in the model before
5 assessing a Structural Equation Model (SEM). CFA and SEM were conducted with
6 LISREL (version 8.80), using maximum likelihood estimation (for further discussion, see
7 Jöreskog & Sörbom, 1996). To ascertain model fit, we used the root-mean-square error of
8 approximation (RMSEA), the chi-square test statistic, the chi-square/degrees of freedom
9 ratio (χ^2/df), and the Nonnormed Fit Index (NNFI). A non-significant chi-square
10 indicates that the model adequately represents sample data. Browne and Cudeck (1993)
11 suggest that RMSEAs less than 0.05 are indicative of a “close fit” and that values up to
12 0.08 represent reasonable errors of approximation. The Chi-Square/Degrees of Freedom
13 (χ^2/df) Ratio is a test of model misfit (χ^2), compared to the parsimony of the model as
14 indicated by the model’s degrees of freedom (df). In general, a χ^2/df ratio of less than 2 is
15 indicates a relatively good model fit. The NNFI varies along a 0–1 continuum, where
16 values greater than .95 typically correspond to excellent fit to the data.

17 Results

18 *CFA and SEM*

19 The CFA model tested provides adequate data fit: $\chi^2(140, N = 451) = 273.24$,
20 RMSEA = .046, $\chi^2/df = 1.75$, NNFI = .995¹. All factor loadings are statistically significant
21 and substantial (.66 to .88, mean = .79). Because the CFA and SEM models are
22 equivalent (i.e., the number of parameter estimates are the same), the goodness of fit is

1 the same. The critical parameter estimates are the path coefficients between previous
2 achievement levels and subsequent self-concepts. SEM results are presented in Figure 1.

3 *Grade effects on self-concepts.* Results show: a) strong and positive paths between
4 mathematics and verbal achievement and matching self-concepts ($\beta = .83$ and $\beta = .76$, p
5 $<.05$); b) substantial correlations between mathematics and verbal achievement ($r = .69$, p
6 $<.05$), but not for self-concepts ($r = .02$, $p > .05$); and c) negative paths between
7 achievement in mathematics and the verbal domain and non-matching self-concepts in
8 the mathematics and verbal domains ($\beta = -.37$ and $\beta = -.23$, $p <.05$).

9 Turning to the various relations involving physical education, we observe a
10 positive association between achievement and self-concept in physical education ($\beta =$
11 $.50$, $p <.05$). Physical education achievement correlates with mathematics and verbal
12 achievement ($r = .19$, and $r = .15$, $p <.05$, respectively), whereas physical education self-
13 concept correlates only slightly with mathematics self-concept ($r = .12$, $p <.05$), and does
14 not correlate with verbal self-concept ($r = .02$, $p > .05$). Of the four path coefficients
15 between achievement and self-concept in physical education and achievement and self-
16 concepts in the other two school subjects, only two are significant: the path between
17 verbal achievement and physical education self-concept is negative ($\beta = -.18$, $p <.05$),
18 while the path between physical education achievement and mathematics self-concept (β
19 $= .08$, $p <.05$) is positive.²

20 Discussion

21 The main purpose of our study was to test an extension of the Internal/External
22 Frame of Reference Model to physical education. Specifically, we tested possible
23 negative or positive relations between physical education achievement and students'

1 mathematics and verbal self-concepts. A one-school-year study involving 451 students
2 was conducted in a French high school. First, the results of the study reproduced those of
3 previous research on the traditional I/E model (e.g., Marsh & Hau, 2004), corroborating
4 the existence of: (1) a strong relationship between achievements in mathematics and the
5 verbal domain; (2) no relationship between mathematics and verbal self-concepts; and (3)
6 negative paths between mathematics achievement and verbal self-concept, and inversely,
7 between verbal achievement and mathematics self-concept.

8 Results also revealed that relationship patterns between the two traditional school
9 subjects and physical education differ appreciably. First, while relationships between
10 traditional academic subject self-concepts and physical education self-concepts appear
11 relatively weak or non-significant (cf. Figure 1), correlations between achievements in
12 mathematics and physical education ($r = .19$) and between achievements in verbal and
13 physical education ($r = .15$) are weaker than the correlation between mathematics and
14 verbal achievements ($r = .69$). In other words, students with high achievement in
15 mathematics also had high achievement in verbal, and to a lesser extent, physical
16 education. These positive relationships between academic results and physical education
17 are in line with previous results (e.g., Marsh & Hau, 2004; Marsh, & Kleitman, 2003),
18 and they emphasize the particularity of achievement in physical education in the school
19 context. In fact, albeit positive, the relationships between achievement in physical
20 education and achievements in academic school subjects are low, perhaps because
21 abilities assessed in physical education (i.e., motor abilities) are not related to abilities
22 assessed in academic school subjects.

1 Concerning the relations between verbal and physical education, results show that
2 achievement in physical education is not linked to verbal self-concept, whereas verbal
3 achievement negatively predicts physical education self-concept. The non-significant
4 relationship between achievement in physical education and verbal self-concept could be
5 explained by the non-academic status of physical education. In effect, there is a hierarchy
6 among school subjects in which physical education (as well as art, music, and other less
7 academic school subjects), is largely considered by students, parents, and teachers as a
8 less important subject than mathematics or verbal subjects. As a result, achievement in
9 physical education does not seem to be involved in the internal comparison process for
10 verbal self-concept. In other words, students do not gauge their verbal self-concept based
11 on their achievement in physical education. In contrast, there is a negative relationship (-
12 .18) between verbal achievement and physical education self-concept, after controlling
13 for physical education achievement. Thus, physical education self-concept appears to be
14 gauged by verbal achievement. This relationship is in line with the predictions made for
15 the I/E model.

16 Concerning the relationships between mathematics and physical education, results
17 show that achievement in mathematics is not negatively linked to physical education self-
18 concept, whereas a positive link between achievement in physical education and
19 mathematics self-concept is found. Two explanations may be advanced to account for this
20 positive association: (1) transfer of learning skills that are applicable to all subjects;
21 and/or (2) transfer of learning skills that are specific to certain subjects. First, learning in
22 physical education might foster some students' academic skills (e.g., Broh, 2002),
23 cognitive functioning (e.g., Etnier, & Sibley, 2003), and self-regulation skills (e.g.,

1 Milosis, & Papaianou, 2007) that are compatible with learning in more academic school
2 subjects. For example, in an intervention study based on the multidimensional model of
3 goal orientations, Milosis and Papaianou (2007) found that students who were taught to
4 use and transfer certain self-regulation skills (i.e., goal setting and self-talk) in physical
5 education classes had better self-concepts in mathematics and verbal domains. However,
6 although these explanations support a positive association between achievement in
7 physical education and other school-subject self-concepts, they do not explain why a
8 beneficial effect on self-concept was found only for mathematics and not the verbal
9 domain.

10 Thus, the second explanation, transfer of skills applicable to specific school
11 subjects, might be more compelling. In fact, there appear to be linkages between
12 mathematics performance and spatial ability. Numerous studies have demonstrated
13 correlations between mathematics performance and spatial ability (e.g., Battista, 1990;
14 Kaufmann, 1990; Hegarty, & Kozhevnikov, 1999; Sherman, 1979). Specifically, the
15 better the students' spatial ability, the better they performed in mathematics. From this
16 perspective, experience in spatial activities (e.g., gymnastics) in physical education
17 classes might be an important cause of improved spatial abilities. Therefore, we can
18 speculate that physical education could increase students' spatial abilities, leading to
19 better achievement in mathematics, which would lead in turn to the development of a
20 better mathematics self-concept. This skill transfer might explain why beneficial effects
21 were observed only for mathematics and not the verbal domain. Nevertheless, this
22 reasoning is speculative, and further studies are required to support this notion before any
23 definitive conclusions can be drawn.

1 Conclusion

2 Our study contributes to the existing literature by presenting an original effect of
3 academic achievement in an unexplored school subject on self-concept in other school
4 subjects. Perhaps because physical education is less academically oriented, negative
5 relationship patterns between achievement in physical education and self-concepts in
6 other school subjects were not observed in our study, and only a positive link was found.
7 An effect of self-concept enhancement in mathematics was therefore obtained without a
8 negative counterpart for student's academic self-concept in other subjects. This result has
9 not been previously demonstrated for any other school subjects considered in I/E model
10 studies.

11 Our results have some implications for educational psychologists and practitioners.
12 As emphasized in previous works (e.g., Valentine, Dubois, & Cooper, 2004), better self-
13 concept leads to better achievement, even after controlling for prior achievement. Thus,
14 the demonstration of positive effects of achievement obtained in a less academically
15 oriented school subject on student self-concept highlights other potential benefits of such
16 school subjects in the educational system. Extensions of the I/E model to other less
17 academically oriented school subjects (i.e., art, music, and technology) might reinforce
18 this result.

19 Some potential limitations to our study have to be pointed out. First, there are
20 limitations in the methodology used. Longitudinal design studies with more than two
21 waves of measurement are needed to validate the causal effect between grades and self-
22 concept. Moreover, even if grades are good indicators of achievement, they imperfectly
23 capture student's performance. Finally, links found between grades and self-concept in

1 PE have been found to be high and could be very different across countries and cultures
2 where PE goals are not the same than in the French system. Therefore, replications are
3 needed before generalization of our results.

4 In sum, it appears that physical education has benefits not only to reduce obesity
5 and improve physical and mental health, but also to increase self-concept in mathematics.
6 This study provides further support for the maintenance of physical education in
7 educational systems at a time when the practice is being brought into question.

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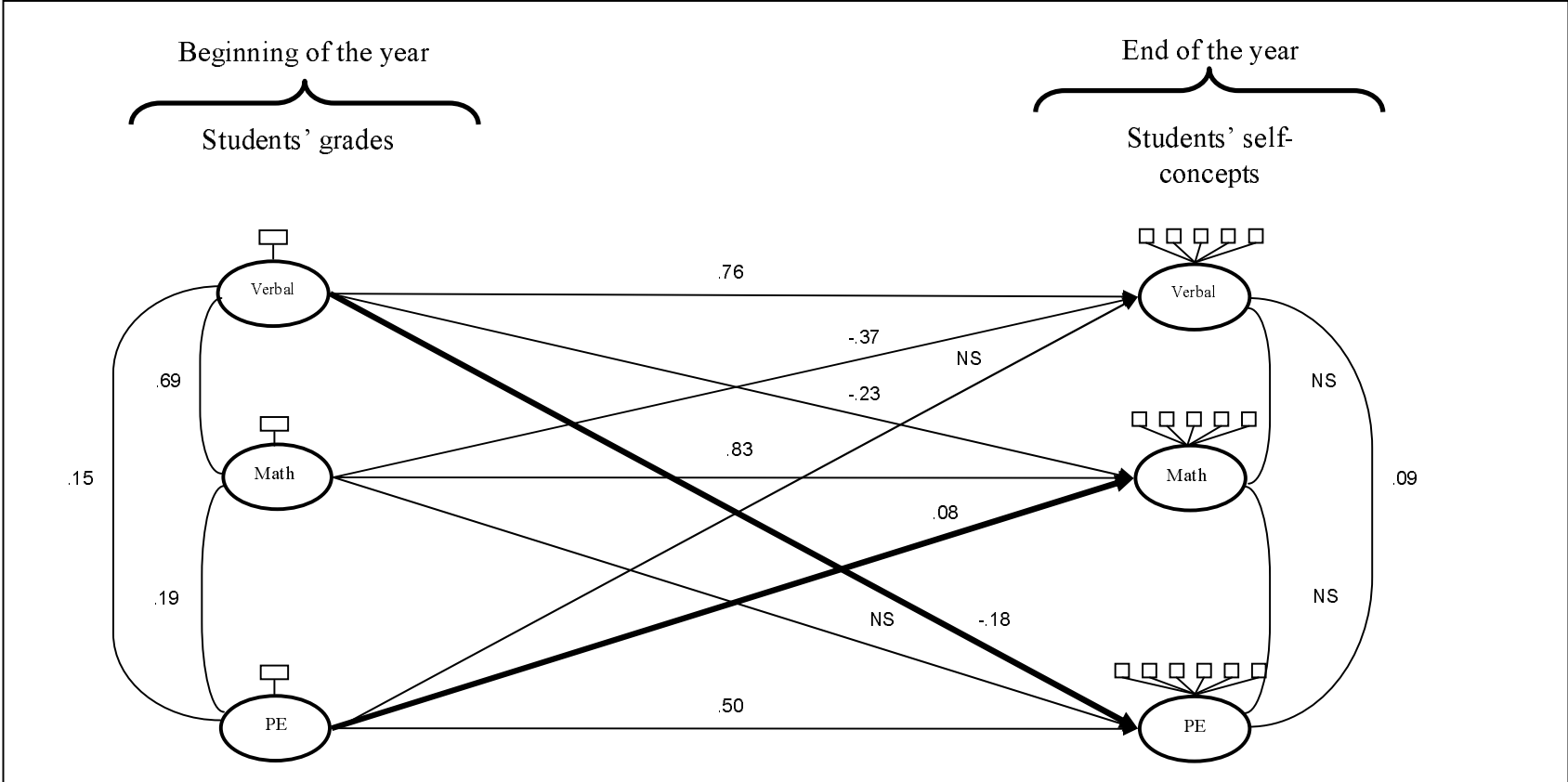
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Footnotes

1
2
3 1. We added some equality constraints in our CFA model to test the differences that
4 might exist in the associations between achievement and self-concept in the various
5 school subjects. Analyses revealed that the correlations between achievement and self-
6 concept for verbal ($r = .50$) and physical education ($r = .48$) domains are not statistically
7 different ($\chi^2(141, N = 451) = 274.02, \Delta\chi^2 = .78, \Delta df = 1, p = .38$) and that the correlation
8 between achievement and self-concept for mathematics ($r = .68$) is higher than for
9 physical education ($\chi^2(141, N = 451) = 300.69, \Delta\chi^2 = 27.45, \Delta df = 1, p < .001$) and for
10 verbal ($\chi^2(141, N = 451) = 291.71, \Delta\chi^2 = 18.47, \Delta df = 1, p < .001$) domains.

11 Equality constraints were also used to test the differences that might exist between
12 the associations between achievements in the various school subjects. Analyses revealed
13 that the correlations between achievement in physical education and mathematics ($r =$
14 $.19$) or verbal ($r = .15$) are statistically different ($\chi^2(141, N = 451) = 360.86, \Delta\chi^2 = 87.62$
15 $\Delta df = 1, p < .001$, and $\chi^2(141, N = 451) = 414.86, \Delta\chi^2 = 141.62, \Delta df = 1, p < .001$,
16 respectively for mathematics and verbal) than the correlation between achievement in
17 mathematics and verbal ($r = .69$) domains.

18 2. Considering the weakness of the coefficient path, we tested a new model without this
19 path in order to know if it contributes significantly to our model. Results showed that
20 removing this path from the model provoke a significant decrease in the chi-square test
21 statistics ($\Delta\chi^2 = 4.25, \Delta df = 1, p < .05$), so this path contributes significantly to the global
22 adjustment of the model.



1

1 Figure Captions

2

3

4 *Figure 1.* SEM of the effect of Physical Education (PE) achievement on mathematics and
5 French academic self-concepts and achievements. NS = Non-significant. Curved lines are
6 correlated residuals between latent constructs

1 Table 1

2 *Cronbach's Alpha Coefficients, Mean Ratings, Standard Deviations and Correlations of Variables of the Model Tested*

Variables	<i>α</i>	<i>M</i>	<i>SD</i>	1	2	3	4	5	6
1. French grades	-	11.60	2.72	-					
2. Math grades	-	11.78	3.42	.69	-				
3. PE grades	-	13.58	2.44	.15	.19	-			
4. French self-concept	.88	3.95	1.32	.50	.15	.01	-		
5. Maths self-concept	.90	3.93	1.46	.36	.69	.20	.02	-	
6. PE self-concept	.91	4.41	1.20	-.06	.03	.48	.02	.12	-

3 *Note.* N = 451. All Correlations are significant at the .05 level except those ranging between .10 and -.10.

4