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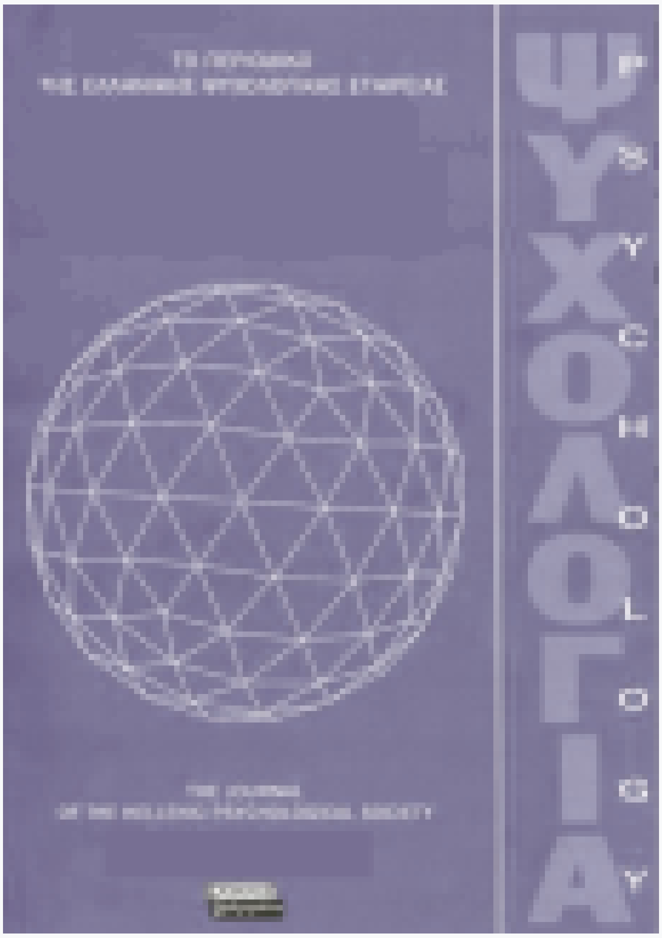

Assessing mathematics self-efficacy: Are skills-specific measures better than domain-specific mesures?

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Assessing mathematics self-efficacy: Are skills-specific measures better than domain-specific measures?

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ABSTRACT The purpose of this study was to discover the optimal manner in which self-efficacy beliefs should be assessed in studies predicting mathematics performance. Participants were 573 high school students enrolled either in remedial algebra, Algebra I, or geometry. Mathematics skills self-efficacy consisted of students' confidence that they possessed the mathematics skills identified by their teachers as essential to the particular mathematics course in which the students were enrolled; mathematics grade self-efficacy consisted of students' confidence that they would pass their mathematics course with term grades ranging from 0 to 100. Performance outcomes were teachers' assessment of their students' mathematics skills and the students' actual term grades. Mathematics grade self-efficacy correlated stronger with other variables prominent in the study of mathematics motivation and predicted both mathematics outcomes better than did students' confidence in their mathematics skills. Findings were consistent for boys and girls and for students enrolled in each of the three courses. Researchers investigating outcomes such as obtained grades or teacher ratings of students' academic skills are better served by assessing students' self-efficacy beliefs about the grades they will obtain than by assessing students' confidence in the specific skills they possess.

Key words: Self-efficacy beliefs, Mathematics skills, Mathematics motivation.

The beliefs that people hold about their capabilities to accomplish tasks and succeed in their activities play a critical role in Bandura's (1986) social cognitive theory. This is because these *self-efficacy* beliefs powerfully influence the manner in which individuals behave and the attainments they achieve. Beliefs of personal competence play an integral role in human motivation because people act on the beliefs they hold about their capabilities: people choose to do things they believe they are capable of doing and avoid those things that they believe are beyond their capabilities.

The process of creating and using self-efficacy beliefs is intuitive. As students engage in an academic task or activity, they interpret the results of their actions. They then use these interpretations to create and develop beliefs about their capability to engage in similar tasks and activities in the future. Ultimately, the beliefs that students develop about their academic capabilities help determine what they do with the knowledge and skills they have learned. Consequently, their academic performances are in part the result of what they come to believe that they have accomplished and can accomplish. This helps explain why students'

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academic performances may differ markedly when they have similar ability.

During the past 25 years, motivation researchers have investigated the influence of students' self-efficacy beliefs on myriad performances across academic domains, and results consistently reveal that these self-perceptions are strong predictors of educational outcomes (Bandura, 1997; Pajares & Schunk, 2001). Numerous studies have shown positive correlations between self-efficacy for learning –the confidence one has regarding one's ability to learn the skills needed to complete a task– and performance attainments (Pajares, 1996; Schunk, 1995). In a meta-analysis of studies published between 1977 and 1988, Multon, Brown, & Lent (1991) showed that self-efficacy beliefs were positively related to academic outcomes (r_u = .38), accounting for 14% of the variance. Basic skills outcome measures (d = .52) and classroom-based indexes (d = .36) such as obtained grades showed the strongest effects.

Students' self-efficacy beliefs influence their academic performances in several ways. They influence the choices students make and the courses of action they pursue. In free-choice situations, students tend to engage in tasks about which they feel confident and avoid those in which they do not. Self-efficacy beliefs also help determine how much effort students will expend on an activity, how long they will persevere when confronting obstacles, and how resilient they will be in the face of adverse situations. The higher the sense of efficacy that students hold, the greater will be their effort, persistence, and resilience. Self-efficacy beliefs also influence the amount of stress and anxiety students experience as they engage a task. Confident students engage tasks with serenity; those who lack confidence can experience great apprehension. As a consequence, self-efficacy beliefs powerfully influence the level of accomplishment that students ultimately realize.

The field of mathematics has received special attention from self-efficacy researchers because of its foundational place in the academic curriculum. Succeeding in mathematics is essential for gaining placement into gifted programs at the elementary, middle school, and high school level. Many states require that students pass high stakes exams to move on to the next grade of schooling or graduate from high school. These exams invariably contain a mathematics component. Gaining admission to college and graduate school requires the proficient mastery of mathematics. Lucrative careers in science and technology similarly require strong mathematics capabilities.

Students' mathematics self-efficacy beliefs predict their obtained grades, scores on-end-of unit tests, standardized achievement scores, mathematics problem-solving, researcher ratings of students' mathematics competence, and teacher ratings of students' mathematics competence (e.g., Bong, 2002; Chen, 2003; Hackett & Betz, 1989; Lent, Lopez, & Bieschke, 1993; Pajares, 1996; Pajares & Graham, 1999; Pajares & Miller, 1994, 1995; Pietsch, Walker, & Chapman, 2003; Randhawa, Beamer, & Lundberg, 1993; Stevens, Olivarez, Lan, & Tallent-Runnels, 2004). Researchers have also reported significant correlations between mathematics self-efficacy and other mathematics related variables. For example, college students who choose mathematics as a major and mathematics related careers exhibit strong mathematics self-efficacy beliefs (e.g., Hackett, 1985; Hackett & Betz, 1989, Lent & Hackett, 1987; Lent, Brown, & Gore, 1997).

Researchers have also explored mathematics self-efficacy as it relates to other motivational constructs. For example, there is a negative relationship between mathematics self-efficacy and *mathematics anxiety*, which is typically defined as the feelings of tension, worry, and distress that interfere with students' manipulation of numbers and solving of mathematical problems (Richardson & Suinn, 1972; Pajares & Urdan, 1996). Robust self-efficacy beliefs can protect students from the effects of negative physiological reactions (Hackett & Betz, 1989; Pajares & Kranzler, 1995; Pajares & Miller, 1994, 1995). Self-efficacious students approach mathematics related tasks with lower levels of anxiety than do their less self-efficacious peers.

Mathematics self-efficacy beliefs also correlate with *mathematics self-concept* beliefs (Pajares & Graham, 1999; Pajares & Miller, 1994; Pietsch et al., 2003). In academic contexts, self-concept differs from self-efficacy in that self-efficacy is a context-specific assessment of competence to perform academic tasks or succeed in an academic activity or course. Self-efficacy is, in essence, a cognitive appraisal of one's own confidence. Self-concept is measured at a broader level of specificity than is self-efficacy and includes the feelings of self-worth associated with engaging in a task or activity (see Bong & Skaalvik, 2003, for a discussion of this issue).

Mathematics self-efficacy has also been shown to correlate with *self-regulatory* processes (Bouffard-Bouchard, Parent, & Larivée, 1991; Zimmerman & Martinez-Pons, 1990). In fact, self-efficacy beliefs are influential during all phases of self-regulation-forethought, performance, and self-reflection (see Schunk & Ertmer, 2000, for a review). Students with high self-efficacy also engage in more effective self-regulatory strategies. Confident students monitor their mathematics work time effectively, persist when confronted with challenges, correctly reject incorrect hypotheses prematurely, and solve conceptual problems. And as students' self-efficacy increases, so does the accuracy of the self-evaluations they make about the outcomes of their self-monitoring (Bouffard-Bouchard et al., 1991). Self-efficacy in mathematics is also positively related to the strategy of reviewing notes and negatively related to relying on adults for assistance (Zimmerman & Martinez-Pons, 1990). Studies tracing the relationship between confidence and the self-regulatory strategy of goal setting have demonstrated that self-efficacy and skill development are stronger in students who set proximal goals than in students who set distal goals, in part because proximal attainments provide students with evidence of growing expertise (Bandura & Schunk, 1981). In addition, students who have been verbally encouraged to set their own goals experience increases in confidence, competence, and commitment to attain those goals (Schunk, 1985).

Finally, it comes as no surprise that self-efficacy beliefs correlate with students' mathematics *engagement* (see Miller, Greene, Montalvo, Ravindran, & Nichols, 1996; Pajares & Graham, 1999). This construct is typically operationalized as the effort and persistence that students report putting forth in an academic area such as mathematics. Recall that social cognitive theory posits that self-efficacy beliefs influence academic achievement through their effect on variables such as engagement.

Of course, discovering the most appropriate manner in which to operationalize self-efficacy is critical to maximizing its predictive ability and practical utility (Bong & Skaalvik, 2003; Pajares, 1997). Bandura (1997) underscored the need to measure efficacy beliefs at the level that most closely corresponds with the outcome with which the beliefs will be compared. Studies following this guideline have yielded significant effects. Self-efficacy assessments have included asking students to provide judgments of confidence to solve particular mathematics problems, succeed in math-related courses, complete math-related tasks, or obtain specific grades in mathematics. Although corresponding assessments of self-efficacy and outcome provide the strongest relationships, self-efficacy predicts mathematics performances at varying levels of generality. For example, Pietsch et al. (2003) used a 5-item instrument in which they asked students if they would pass their mathematics course with a grade of 50%, 70% or 90%. They reported that this assessment correlated both with students' performance on an end-of-unit test and a test assessing mastery of percentages.

The issue at stake in the present study involves the optimal manner in which self-efficacy beliefs should be assessed in studies predicting mathematics performances. Bandura (1997) observed that the optimal level of generality at which self-efficacy beliefs should be assessed depends both on the situational demands and on what the researcher wishes to predict. Thus, one would expect a skills-specific self-efficacy assessment to correspond closely with a performance outcome that reflects with some fidelity the skills assessed. Similarly, a broader, domain-specific assessment should better predict a domain-specific performance. As we have noted, of course, task-specific self-efficacy assessments predict even general measures of student performance (Lent, Lopez, & Bieschke, 1993), and domain-specific self-efficacy predicts both specific and general performance outcomes (Pietsch et al., 2003).

Consequently, we investigated the psychometric benefits of assessing mathematics self-efficacy at two levels of specificity –one relatively discreet and the other one broader– and we used these scores to predict corresponding outcomes. The first self-efficacy scale, which can be viewed as skills-specific, asked students to provide ratings of their confidence that they possessed the specific mathematics skills required to master the concepts covered in the mathematics class in which they were enrolled. For a corresponding performance outcome, the students' teachers provided their own assessment of the degree to which each student actually possessed these skills. The second, a broader, domain-specific scale, asked students to provide ratings of their confidence that they would receive various grades in the mathematics class in which they were enrolled. The corresponding performance outcome for this assessment was the student's actual grade at the end of the 12-week academic term. Self-efficacy and performance assessments each met Bandura's (1997) guidelines regarding correspondence between belief and outcome. It is important to note that researchers typically assess efficacy beliefs in academic areas using one of the two methods we identify above (e.g., Hackett & Betz, 1989; Pajares & Miller, 1994; Pajares & Valiante, 1997, 1999, 2001; Shell, Murphy, & Bruning, 1989; Shell, Colvin, & Bruning, 1995). Similarly, performance outcomes are often obtained grades or teacher ratings of student skill acquisition (see Pajares, 1997).

Our primary objective, then, was to determine the optimal manner of assessing mathematics self-efficacy given the performance outcomes typically used by researchers. We also sought to address construct validity by exploring the correlations between the self-efficacy scales and motivation constructs typically included in studies of academic motivation and discussed earlier (mathematics self-concept, self-efficacy for self-regulation, math anxiety, achievement goal orientations in mathematics, and mathematics engagement). We also sought to determine whether results would be consistent across gender and level of mathematics ability (pre-algebra, algebra, and geometry). Given the nature of the self-efficacy and performance assessments, we hypothesized that the self-efficacy scale asking students the degree to which they possessed specific mathematics skills would be a better predictor of teachers' ratings of students' mathematics skills than would students' grade self-efficacy. Conversely, we expected that mathematics grade self-efficacy would be a better predictor of obtained grades than would teacher ratings of students' skills. In other words, we expected that the corresponding assessments would have the stronger relations. Let us emphasize that we selected obtained grades and teacher ratings of students' competence as the outcomes of interest because these are typically the favored outcomes in investigations of academic self-efficacy beliefs.

Clearly, researchers are well-served by creating and using self-efficacy assessments that have the greatest predictive utility for the outcome of interest, and this important guideline is at the heart of our study. The matter has practical import, given that skill-specific scales typically consist of more items than do domain-specific scales (in our case, 12 to 14 items versus 7). Indeed, if scales at differing levels of specificity predict different mathematics performances equally well, the more parsimonious scale would have clear advantages.

Methods and procedures

Participants

Participants consisted of 573 students in Grades 9 and 10 (297 girls, 276 boys; mean age

14.6 in Grade 9; 15.6 in Grade 10) who attend high school in the South East United States. They were enrolled in one of three mathematics courses: remedial algebra (n = 98), Algebra I (n = 222), or geometry (n = 253). Instruments were administered in the students' mathematics classes late in the second semester of the academic year. Students were first given verbal instructions and then asked to complete the instrument on their own. No teachers were present during data collection. Written permission to gather data was provided by the school administration. The socioeconomic status of the schools and of the areas the schools serve were largely middle class, and students were primarily white. Procedures were consistent with those typically used by self-efficacy researchers.

Variables in the study

Students' mathematics self-efficacy was measured at a skills specific level and at a broader, domain specific level. The self-efficacy scales created to measure *students' mathematics skill self-efficacy* were developed in consultation with the mathematics department of the high school in which the study took place. The Mathematics Department identified the specific mathematics skills that students were to have mastered at the 12-week point of the second semester. In all, three mathematics skill self-efficacy scales were completed. The first measured students' mathematics confidence that they possessed 12 skills required to succeed in geometry (sample item: «How confident are you that you can apply properties dealing with parallel lines and proportion?»); the second measured students' confidence that they possessed 14 mathematical skills required to succeed in Algebra I (sample item: «How confident are you that you can apply the laws of exponents to simplify expressions containing integer exponents?»); and the third measured students' confidence that they possessed 12 skills required to succeed in remedial algebra (sample item: «How confident are you that you can solve problems involving simple radical equations?»). Students were asked to rate their confidence to perform each discrete skill on scale of 0 (no chance) to 100 (complete certainty). Coefficient alphas were .84 for the remedial algebra items, .90 for the Algebra I items, and .87 for the geometry items.

For *mathematics grade self-efficacy*, students were asked to provide a judgment of confidence to obtain a particular grade at the end of the term. For example, students responded to items such as «How confident are you that you will pass your geometry class with a grade better than 70%?». Predictions were measured using an 8-point Likert scale ranging from 1 (not confident at all) to 8 (completely confident). Assessing self-efficacy in this way proved consistent with guidelines set forth by Bandura (2001), who provided examples for measuring student self-efficacy for problem solving using percentages (e.g., 10%, 30%, and so forth). Pietsch et al. (2003) reported Cronbach's coefficients of .79 when measuring mathematics self-efficacy in this manner. We obtained .91 for the remedial algebra items, .94 for the Algebra I items, and .95 for the geometry items.

Items measuring *mathematics anxiety* were adapted from Betz's (1978) Mathematics Anxiety Scale (MAS) following guidelines put forth by Pajares and Urdan's (1996) factor analysis. Students were asked to rate their mathematics anxiety on 10 items (sample items: «Schoolwork makes me feel uneasy and confused», «Just thinking about schoolwork makes me feel nervous»). Researchers have typically reported reliability coefficients ranging from .86 to .92 on the original MAS (e.g., Hackett & Betz, 1989; Pajares & Kranzler, 1995; Pajares & Urdan, 1996). We obtained .78 for the full sample.

Mathematics self-concept was measured using 10 items taken from Marsh's (1992a, 1992b) Self-Description Questionnaire II (SDQII). The questionnaire was developed specifically to measure adolescents' academic self-concept. The SDQII contains 13 scales covering a range of academic subjects. The mathematics subscale consists of 10 items (sample item: «I have always done well in mathematics»). Marsh (1992a) reported coefficient as ranging from .89 to .95. We obtained .84 for the full sample.

Seven items were used to assess *self-efficacy for self-regulated learning*. They were taken from the self-efficacy for self-regulated learning scale of Bandura's Children's Multidimensional Self-Efficacy Scales (see Zimmerman, Bandura, & Martinez-Pons, 1992) and included items such as «how well can you finish your homework on time» and «how well can you motivate yourself to do your school work». Psychometric testing has established the reliability of the scale. For example, Zimmerman and Martinez-Pons (1988) conducted a validation study and found that a single factor underlay the study whereas Zimmerman et al. (1992), reported an alpha coefficient of .87. We obtained .78 for the full sample.

Engagement is considered an important consequent of efficacy beliefs and a determinant of academic performances (Miller et al., 1996; Pintrich & De Groot, 1990; Pintrich & Schrauben, 1992; Schunk, 1984). It was assessed using three items previously used by Pajares and Graham (1999) to assess effort and persistence in math (sample items: «When a mathematics problem is difficult for me to solve, I just put more effort into it», «I will work as long as necessary to solve a difficult mathematics problem»). Pajares and Graham obtained coefficient alpha scores of .71 and .75 in two administrations. We obtained an alpha coefficient of .75 for the full sample.

Students' mathematics performance consisted of two outcomes. The first was the students' *end-of-term grades* for the 12-week term in the second semester. These grades ranged from 0 to 100 (mean grades were 72 for the remedial algebra students, 76 for the algebra students, and 81 for the geometry students). For the second performance measure, teachers were asked to provide ratings of how well they believed each of their students possessed the mathematics skills on which the self-efficacy scales were based. We asked teachers to use the same metric used to compile grades (mean ratings were 71 for the remedial algebra students, 77 for the algebra students, and 82 for the geometry students). As expected, the correlations between grades and ratings were strong (.93 for remedial algebra students, .71 for algebra students, and .82 for geometry students). It bears noting that teachers' ratings of their students' competence is remarkably accurate (see Hoge & Butcher, 1984).

Data analysis

First, we wanted to ensure that the items in each of the two self-efficacy scales formed correlated yet independent factors. To this end, we conducted confirmatory factor analysis (CFA) to identify the latent constructs underlying the items. The analysis included all items used to assess mathematics skills self-efficacy and mathematics grade self-efficacy. We factor analyzed all items, assessing the various sources simultaneously, for each of the three courses, and we set the factor solution to produce the two most evident factors. We used the maximum likelihood method of extraction (Jöreskog & Lawley, 1968) because this is the method believed to produce the best parameter estimates (Pedhazur, 1982). All analyses were conducted using the SAS system's FACTOR procedure (SAS Institute, Inc., 1999). To address the main objective of the study, we first noted the correlations between the self-efficacy scores and performance scores to assess the strength of their statistical correspondence. We noted also the correlations between the self-efficacy scores and scores on the various motivation measures to determine which of the self-efficacy assessments was better related to these measures. Hierarchical multiple regression was then used to determine the predictive utility of self-efficacy and its corresponding performance assessment. In other words, mathematics skills self-efficacy was used to predict the teacher ratings on which these skills were based, and mathematics grade self-efficacy was used to predict students' mathematics grade. We analyzed for the full sample, by course, and by gender. Each of the models included the motivation variables identified earlier, as this is a typical practice in self-efficacy research. The inclusion of mathematics motivation variables in models testing the predictive utility of self-efficacy exercises a strong control and reveals whether self-efficacy makes an independent contribution to the prediction of an academic outcome when other variables presumed to predict that outcome are included in the model. Because the independent variables are typically significantly correlated, the regression analyses were supplemented by a regression commonality analysis to determine the proportion of the explained variance of the dependent variable associated uniquely with each independent variable and with the common effects of each (Rowell, 1996) and by obtaining regression structure coefficients (Thompson & Borrello, 1985). Structure coefficients are not suppressed or inflated by collinearity between the independent variables.

Results

Recall that, before we addressed the main objective of the investigation, we wanted to ensure that the items in each of the two self-efficacy scales formed correlated yet independent factors. CFA results from the geometry students showed that the skills self-efficacy items loaded on different factors. Factor 1 comprised 6 of the 7 grade self-efficacy items, with loadings ranging from .49 to .99. Item 7 on this scale loaded weakly. Factor 2 comprised the 12 skills self-efficacy items with loadings ranging from .36 to .72. None of the items showed double loadings. The interfactor correlation was .43. For the Algebra I students, Factor 1 comprised the 12 skills self-efficacy items with loadings ranging from .45 to .82, and Factor 2 comprised the 7 grade self-efficacy items, with loadings ranging from .51 to .94. None of the items showed double loadings. Interfactor correlation was .31. For the remedial algebra students, a 2-factor solution proved problematic, with several items failing to load. However, a 3-factor solution revealed that Factor 1 comprised the 14 skills self-efficacy items with loadings ranging from .40 to .73, Factor 2 comprised the first 5 grade self-efficacy items, with loadings ranging from .55 to .99, and Factor 3 the last 2 grade self-efficacy items. These results did not altogether surprise us, coming as they were from the weaker mathematics students. Items 6 and 7 on the grades self-efficacy scale represented obtaining grades of 90% and 95%, which were grades these students seldom obtained. Consequently, it made good sense that these items would load on their own factor. Interfactor correlations ranged from .31 to .57. In total, these results clearly showed that mathematics skills self-efficacy and mathematics grade self-efficacy form correlated yet independent factors (see Table 2 for factor loadings).

With CFA analyses completed, we move to the main objective of the investigation. Means, standard deviations, and correlations for the variables in the study are each provided in Table 1. Results are consistent with those of previous investigations using similar constructs. We first bring to the reader's attention the fact that the correlations between mathematics grade self-efficacy and each of the performance assessments were considerably stronger (.57 and .63) than were those between mathematics skills self-efficacy and performance (.24 and .24). The Williams T2 statistic was used to determine that the correlations between grade self-efficacy were indeed stronger than the correlations between skills self-efficacy and performance. The correlation between grade self-efficacy and skills self-efficacy was a modest .36, and between grades obtained and teacher ratings of skills .81.

As was foreshadowed by the correlations, when each of the performance outcomes were regressed on the two self-efficacy measures as codetermining independent variables, mathematics grade self-efficacy predicted each outcome (β = .624 for obtained grade, R^2 = .39; β = .551 for

Table 1
Means, standard deviations, and zero-order correlations for variables in the study

Variables	*M*	*SD*	1	2	3	4	5	6	7	8
1. Skills self-efficacy	77.76	13.45								
2. Grade self-efficacy	5.72	1.67	.36***							
3. Engagement	4.98	1.71	.30***	.38***						
4. Anxiety	3.25	1.44	-.28***	-.40***	-.33***					
5. Self-concept	4.62	1.43	.34***	.51***	.34***	-.38***				
6. Self-regulation	5.37	1.32	.33***	.44***	.59***	-.37***	.33***			
7. Teacher rating of skills	77.86	10.97	.24***	.57***	.18***	-.30***	.38***	.21***		
8. Term grade	77.53	11.38	.24***	.63***	.27***	-.27***	.39***	.30***	.81***	
9. Gender			-.02	.00	-.01	-.06	.14**	-.04	-.07*	-.10*

Note: Means for skills self-efficacy, grade self-efficacy, teacher rating of skills, and grade reflect a 0-100 score. All other variables reflect the 8 points of the Likert-type scale.

* $p < .05$, ** $p < .001$, *** $p < .0001$.

Table 2
Factor loadings of self-efficacy items by mathematics level

	Remedial Algebra			Algebra		Geometry	
Items	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 1	Factor
E1	.67	-.02	.04	.55	.01	-.03	.52
E2	.61	-.05	.04	.58	-.05 .05	.49	
E3	.40	-.03	.00	.44	-.03	-.04	.58
E4	.56	.11	.18	.75	.06	-.16	.59
E5	.54	-.12	.27	.71	.06	.04	.36
E6	.61	.02	.25	.74	.04	.10	.47
E7	.73	.05	.03	.82	.02	.10	.49
E8	.53	.06	.16	.79	-.09	.16	.44
E9	.65	.06	.03	.75	-.04	-.02	.69
E10	.67	.00	.13	.74	-.02	.01	.72
E11	.52	.13	-.07	.50	.14	.20	.39
E12	.49	-.01	-.22	.45	.05	.09	.53
E13				.54	.05		
E14				.48	.00		
GE1	.00	.80	.11	-.09	.87	.75	.02
GE2	.04	.99	-.14	-.09	.90	.91	-.18
GE3	.01	1.01	-.04	-.02	.94	.99	-.11
GE4	.00	.83	.19	.06	.92	.90	.07
GE5	-.01	.55	.53	.05	.88	.73	.22
GE6	-.06	.21	.87	.08	.72	.49	.35
GE7	-.07	.02	.97	.12	.51	.27	.34

Table 3

Standardized regression coefficients for the prediction of mathematics skill self-efficacy and mathematics grade self-efficacy for full sample, gender, and course

	Full sample		Gender				Course					
			Boys		Girls		Remedial Algebra		Algebra I		Geometry	
Variables	β (SC)	U	β (SC)	U	β (SC)	U	β (SC)	U	β (SC)	U	β (SC)	U
Mathematics term grade												
Grade self-efficacy	.584*** (.976)	52%	.561*** (.962)	47%	.555*** (.987)	51%	.733*** (.984)	58%	.530*** (.960)	44%	.426*** (.945)	58%
Engagement	ns (.421)	0%	ns (.455)	1%	ns (.382)	0%	ns (.343)	1%	ns (.431)	0%	ns (.479)	1%
Self-concept	.081* (.603)	1%	.177* (.674)	2%	ns (.583)	1%	ns (.570)	0%	ns (.660)	1%	.186* (.600)	0%
Anxiety	ns (-.426)	0%	ns (-.375)	0%	ns (-.500)	1%	ns (-.428)	0%	ns (-.490)	1%	ns (-.250)	0%
Self-regulation	ns (.471)	0%	ns (.463)	0%	ns (.465)	0%	ns (.383)	0%	ns (.545)	0%	ns (.554)	0%
Model R^2	.41***		.43***		39***		.53***		36***		.40***	
Teacher rating of mathematics skills												
Skills self-efficacy	.115* (.560)	6%	ns (.447)	1%	.157* (.647)	12%	ns (.604)	4%	ns (.388)	3%	.204* (.740)	16%
Engagement	ns (.423)	0%	ns (.425)	0%	ns (.387)	0%	ns (.384)	0%	ns (.353)	0%	ns (.433)	1%
Self-concept	.271*** (.871)	30%	.395*** (.940)	44%	.200* (.786)	20%	.382** (.870)	11%	.251** (.878)	27%	.258* (.777)	25%
Anxiety	-.149** (-.705)	10%	ns (-.623)	5%	-.191* (-.733)	17%	ns (-.632)	5%	-.212* (-.805)	20%	ns (-.387)	1%
Self-Regulation	ns (.500)	1%	ns (.465)	0%	ns (.477)	0%	ns (.450)	0%	ns (.481)	0%	.217* (.608)	12%
Model R^2	.19***		.24***		17***		.31***		17***		20***	

Note: Structure Coefficients (SC) are in parentheses below beta coefficients. *U* represents the percentage of the explained variance (R^2) in the dependent variable associated uniquely with the independent variable.

teacher ratings, R^2 = .32) whereas mathematics skills self-efficacy did not. In other words, the broader, domain-specific assessment proved a better predictor of mathematics performance assessed either as obtained mathematics grades or as teacher ratings of their students' possession of the specific mathematics skills.

When each of the performance outcomes were regressed on its corresponding self-efficacy measures and the motivation measures, note that grade self-efficacy consistently proved a better predictor than did skills self-efficacy (see Table 3). This was the case for the full sample, at each course, and for both boys and girls. For the full sample, grade self-efficacy strongly predicted obtained grades (β = .584) whereas skills self-efficacy exercised only a modest influence on teacher ratings of these skills (β = .115). Mathematics self-concept also had a significant effect in each model, but the difference in magnitude in each model was notable (β = .081 in the model predicting mathematics grades; β = .271 in the model predicting teacher ratings of students' mathematics skills). Moreover, mathematics anxiety also proved significant in the model predicting teacher ratings of students' skills (β = -.149). These findings were consistent across mathematics course and gender. It also bears noting that the model in which grade self-efficacy predicted mathematics grades accounted for 41% of the explained variance, whereas the model in which skills self-efficacy predicted teacher ratings of students' mathematics skills accounted for only 18%.

Discussion

The primary objective of our study was to determine the optimal manner in which self-efficacy beliefs should be assessed in studies predicting mathematics performances when these performances are operationalized either as obtained grades in mathematics or teachers' ratings of their students' mathematics skills, two performance outcomes often used in self-efficacy research. To this end, we created mathematics self-efficacy scales at two levels of specificity –one relatively discreet and the other relatively broad– and we used these scores to predict their corresponding outcomes. Items on the mathematics skills-specific scale asked students to provide ratings of their confidence that they possessed the specific mathematics skills required to master the mathematics class in which they were enrolled. For a corresponding performance outcome, the students' teachers provided their own assessment of the degree to which each student actually possessed these skills. Items on the second scale asked students to provide ratings of their confidence that they would receive various grades in the mathematics class in which they were enrolled. The corresponding performance outcome for this assessment was the student's actual grade at the end of the 12-week academic term.

We hypothesized that a skills-specific self-efficacy assessment would best correspond with an outcome that mirrored the skills tapped in that assessment. That outcome consisted of teachers' ratings that students possessed the skills on which students based their self-efficacy. Conversely, we believed that students' confidence in the grade they would obtain at end-of-term would best predict that grade. Self-efficacy scales have been found to correlate with outcomes at differing levels of specificity, but one would expect a skills-specific self-efficacy assessment to correspond closely with a performance outcome that reflects the skills assessed. Similarly, a domain-specific assessment should better correlate with a domain-specific outcome. Simply stated, we sought to determine whether mathematics self-efficacy assessed at two different levels of specificity would differentially predict two mathematics outcomes typically used in studies of self-efficacy. Our broad aim was to discover the psychometric and practical benefits of assessing mathematics self-efficacy in a particular manner given the outcome of interest.

Admittedly, our findings surprised us. We found that the broader –and shorter– self-efficacy assessment tapping students' confidence in the grades they would obtain predicted each of the mathematics outcomes better than did students' reported confidence in their mathematics skills. Moreover, the broader assessment also correlated better with other variables prominent in the study of mathematics motivation - math anxiety, mathematics self-concept, self-efficacy for self-regulation, and engagement. This was the case for our full sample, as well as for boys and girls and for students enrolled in three levels of high school mathematics - remedial algebra, Algebra I, and geometry.

We emphasized in the introduction that, if the two self-efficacy scales predicted related performances equally well, researchers should obviously assess self-efficacy in the most parsimonious manner possible. We discovered that students' confidence in the grades they would obtain at end-of-term predicted not only the actual grades obtained but their teachers' assessment of the mathematics skills the students possessed. Conversely, students' confidence in the specific mathematics skills identified by their teachers as essential to mastering the material poorly predicted their teachers' assessment of their students' skills. Our obvious recommendation, then, is that researchers investigating outcomes such as obtained grades or teacher ratings of students' capability and skills are better served by assessing students' self-efficacy beliefs about the grades they will obtain than by assessing students' confidence in the specific skills they possess. Of course, one should also question the practical utility of administering a 12- or 14-item instrument when greater prediction may be had from a shorter and more parsimonious instrument.

These findings notwithstanding, they beg the important question of why a skills-specific self-efficacy assessment would so poorly predict an outcome that reasonably corresponds with it. After all, students' confidence that they possess the skills required to succeed in geometry should strongly predict their teachers' assessment of the students' possessed skills. We have put this question to colleagues and teachers of mathematics, and two possibilities have been raised in the form of questions. First, is it possible that students can know what to do without recognizing, in prose, the «formal skill» required to do it? To frame this using an item from our self-efficacy scale, might a student be able to «recognize and apply properties of similar polygons using ratio and proportion» but not realize, in prose, what this skill entails. In the academic field of writing, this would be tantamount to a student being able to write an excellent expository paragraph without knowing what an «expository» paragraph really is. In essence, this would mean that students didn't fully understand the self-efficacy items they were asked to complete. To the degree that this is the case, it would serve to weaken statistical correlations between belief and outcome. We acknowledge that this might be a possibility, but we emphasize that the teachers in our study made it clear to us that they regularly went over the prose objectives with their students. Consequently, we have good reason to believe that students understood the nature of the skills on which they provided their efficacy judgments.

A second question put to us was whether it was possible that the self-efficacy and performance assessment did not correspond as closely as we suggest they did. After all, the self-efficacy assessment asked students to report on a dozen or so mathematics skills, whereas the performance assessment asked teachers to provide a «wholistic» score that reflected their view of how well each student possessed these skills «in total». A better correspondence would have required a specific outcome consisting of assessments for each skill, even if these were then summed and averaged. For example, we could have given the students a mathematics examination in which particular items would be used to assess particular skills. Or we could have asked teachers to provide a score for each skill for each student. We do believe that such a performance assessment would have been preferable, and we urge researchers to take this into consideration when considering a replication or subsequent investigation. But here again, we point out that the grade self-efficacy assessment better correlated with motivation variables typically used to predict academic outcomes. This speaks to the construct validity of this variable, as well as to its practical usefulness.

Another possibility occurs to us, and that is that students know their grades better than they know the skills they use to obtain those grades. After all, grades are sometimes infected with all sorts of confounding information that cannot easily be assessed (e.g., effort, behavior, halo effects). In addition, grades are quite stable, in the sense that good students tend to make good grades, average students average grades, and poor students poor grades. By high school, students have a very good idea of the grade they will make in a mathematics class. It makes sense that students' confidence in the grades they will obtain will be highly predictive of the grades they do obtain. Also, the fact that grades and teacher ratings were highly correlated suggests that teachers think in terms of their students' obtained grades when thinking of such ratings, even if they have been instructed not to do so.

These possibilities notwithstanding, we again remind readers that researchers often use obtained grades or teacher ratings of student competence as outcome measures in self-efficacy studies, and they use skills-specific measures of self-efficacy to predict these outcomes. Findings from our study suggest that this is an unwise procedure that serves to minimize the predictive utility of self-efficacy beliefs. If researchers wish to predict the outcomes used in this study, we urge them to consider using a self-efficacy assessment similar to the one we used on the grade self-efficacy scale. We believe that such an assessment not only has greater construct validity but serves to maximize the predictive utility of self-efficacy. The result will be a stronger corre-spondence between belief and outcome, as well as greater correlation between self-efficacy and related motivation constructs.

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