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The Mathematics Value Inventory for General Education Students: Development and Initial Validation

**Vickie R. Luttrell,[1] Bruce W. Callen,[1]
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Abstract

The goal of this study was to develop a self-report inventory that measures individual differences in the perceived value of mathematical literacy for general education students. The Mathematics Value Inventory (MVI) is grounded in the Eccles et al. model of achievement-related choices and surveys students' beliefs in four areas: interest, general utility, need for high achievement, and personal cost. This study describes the development and initial score validation of the MVI. As hypothesized, it was found that (a) MVI scores for students who were not majoring in math did not differ by gender, (b) students who had higher MVI scores had completed more college course work in math than did students with lower scores, and (c) MVI scores were not related to scores on a measure of social desirability.

Over the past two decades, mathematics education has emphasized conceptual understanding developed through activity-based curricula that have moved away from rote problem solving and memorization (e.g., Middleton, 1995; Sansone & Morgan, 1992;

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Stipek et al., 1998). These reforms have reshaped math education, but one essential element remains to be addressed. For students to be truly literate, they must *value* this literacy. This is especially true for general education students, who constitute the majority of our educated citizenry. If students do not value mathematics, the curricula we have worked hard to create will have little lifelong impact.

In this article, we report on our efforts to develop the Mathematics Value Inventory (MVI), a self-report inventory that measures the value students place on their under-graduate mathematics education. The MVI is grounded in the expectancy-value theory of achievement motivation (Eccles, Adler, & Meece, 1984; Eccles et al., 1983; Wigfield & Eccles, 2000), which proposes that individuals' choices, persistence, and performance are influenced by their beliefs about how well they will do on an activity and the degree to which they value that activity. We share the conviction that the affective domain must be addressed in investigations of students' achievement-related choices and believe the MVI will be a useful tool for educational researchers who seek to measure their progress toward shaping a mathematically literate public.

Subjective Task Value and Achievement-Related Choices

According to Rokeach (1979), "[v]alues are core conceptions . . . that serve as standards or criteria to guide not only action but also judgment, choice, attitude, evaluation, argument, exhortation, rationalization, and one might add, attribution of causality" (p. 2). Values mediate student decision making regarding the pursuit of scholastic activities (Feather, 1982) and are related to motivation in the sense that the value one instills in a behavior functionally determines the strength with which the behavior is pursued (Rheinberg, Vollmeyer, & Rollett, 2000).

Given that students bring to school a value system that can affect their levels of engagement and persistence, students' values have been investigated extensively. Rotter (1954), for example, proposed that students' expectancies for success and the inherent value they place on that success interactively mediate achievement-related behavior. Unfortunately, investigations of college academic achievement using Rotter's theoretical framework have focused almost exclusively on the expectancy component (i.e., locus of control) of the expectancy-value dichotomy. This is problematic because even if students are certain they can master certain tasks, they may have no incentive to do so (Eccles & Wigfield, 2002).

Grounded in the seminal work of Atkinson (1957), Eccles et al. (1983, 1984) developed a comprehensive model of achievement-related choices, proposing that students' academic performance, perseverance, and scholastic choices are directly affected by their expectancy-related and task-value beliefs. They proposed that subjective task value is multidimensional and is reflected in a student's level of interest in a task (interest value) and its perceived importance (attainment value), utility (utility value), and cost. Using confirmatory factor analysis, Eccles and Wigfield (1995) demonstrated that the three value components could be empirically differentiated in the mathematics domain, supporting the construct validity of their model.

Eccles et al. (1983, 1984) began their work with a particular interest in early motivational factors that give rise to students' gendered choices and patterns of achievement. It is not surprising then that most empirical tests of their theory have been conducted with children and adolescents. Researchers have devoted most of their attention to studying relationships between subjective task valuing and math participation, and findings across studies are consistent. In particular, math value has been shown to predict grades in math (Berndt & Miller, 1990), course enrollment intentions (Meece, Wigfield, & Eccles, 1990), number of math courses taken (Simpkins, Davis-Kean, & Eccles, 2006; Updegraff, Eccles, Barber, & O'Brien, 1996), math-related career aspirations (Jozefowicz, Barber, & Eccles, 1993; Watt, 2006), and plans to attend college (Eccles, Vida, & Barber, 2004). Math value also emerges as a strong mediator of gender-related differences in math participation and career aspirations (e.g., Eccles, 1987; Watt, Eccles, & Durik, 2006).

Longitudinal changes in students' valuing of math across the elementary, middle school, and secondary years have been studied extensively. This research finds that as children grow older, they become increasingly pessimistic about math over time (Eccles et al., 1983; Watt, 2004). Some studies also provide evidence that boys value math more than girls do during the elementary and middle school years (e.g., Eccles, Wigfield, Harold, & Blumenfeld, 1993); however, other studies suggest that children's math-related beliefs are becoming more gender neutral (e.g., Hyde, Fennema, & Lamon, 1990; Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002).

In higher education, research on the Eccles et al. (1983, 1984) model is limited. Platt (1988) found that both expectancies and subjective value were directly related to academic achievement in first-term honors engineering students. However, VanZile-Tamsen (2001) found that although task value predicted self-regulated strategy use, perceived value was more important than expectancies for success in keeping students cognitively engaged. Feather (1988) reported that course enrollment in the natural sciences, humanities, and social sciences was directly related to the subjective value students assigned to these courses, and Bong (2001) found that task value predicted both midterm exam scores and future enrollment intentions for education students. Task valuing also predicts college women's general intentions to attend graduate school in all fields (Battle & Wigfield, 2003) and whether they will change their career aspirations out of male-dominated fields (Frome, Alfeld, Eccles, & Barber, 2006).

Rationale for the Study

Guided by the Eccles et al. (1983, 1984) theory of achievement-related choices and, in particular, their work on subjective task value, we conducted a series of studies to develop the MVI. It was hoped that given increased demands for accountability and evidence-based instructional practices, an inventory of this nature would provide instructors and educational researchers a means to evaluate their curricular reform efforts in math education.

Earlier efforts to develop measures to assess math value have focused on elementary and secondary student populations. Eccles et al. (1983) developed the first questionnaire to assess elementary students' ratings of interest, importance, and utility of math and English courses, and several others have adapted their work for other student populations. Lupart, Cannon, and Telfer (2004) developed items to assess interest and value of math, science, English, and computer usage for students in Grades 7 and 10, whereas Watt (2004) developed a questionnaire for precollege Australian students to assess math and English self-perceptions, task perceptions, and task value. Other potentially suitable inventories, such as the Fennema-Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976), were also developed for precollege students and were not grounded in the Eccles et al. (1983, 1984) model.

Designed for college populations, Luttrell (2000) developed a self-report inventory to measure individual differences in the perceived value of higher education in a general sense. The inventory surveys students' beliefs in five areas: achievement value, general education value, scholastic focus, family expectations, and achievement obstacles. Also intended to be general in nature, Battle and Wigfield (2003) designed an inventory to examine how college women's valuing of graduate education predicted their intentions to pursue graduate school. The widely used Mathematics Anxiety Rating Scale (Richardson & Suinn, 1972) measures students' math-related anxiety but fails to assess other relevant dimensions of math value.

Given that existing inventories were developed for elementary and secondary school use, do not focus on math-related value specifically, or do not measure multiple components of math value, we began our efforts to develop a domain-specific assessment tool for college student use. Like other researchers of task value, the development of the MVI was guided by the work of Eccles and colleagues, but we also endeavored to design a more in-depth measurement of math value than other available measures provided.

Consistent with the recommendations of Haynes, Richard, and Kubany (1995), Smith and McCarthy (1995), and the *Standards for Educational and Psychological Testing* (American Educational Research Association, American Psychological Association, & National Council on Measurement in Education, 1999), we used a multistep process to provide evidence that scores on the MVI are reliable and valid. In Study 1, we defined the facets of math-related value, developed an initial item pool, and used multiple judges and formal scaling procedures to provide evidence that the items were both content valid and worded clearly. In Studies 2 and 3, we conducted two large-scale item tryouts to examine the factor structure of the MVI and its internal consistency. In Studies 4 and 5, we examined the temporal stability of MVI scores over short periods and discriminant validity.

Study 1: Delineation of the Construct and Content Validation

The purposes of Study 1 were to identify the most important facets of math-related valuing, to generate items to tap those facets, and to provide evidence for the content

validity of the MVI via expert and student evaluation. Based on a review of the literature (e.g., Atkinson, 1957; Eccles et al., 1983, 1984; Feather, 1988; Rotter, 1954; Wigfield & Eccles, 1992, 2000), we conceptualized the math value domain as encompassing those values that bear directly on a person's motivation for engaging, persisting, and excelling in mathematics. Drawing on the work of Eccles et al. (1983, 1984), we conceptualized the domain to be composed of four interrelated facets, which we tentatively labeled interest, utility, attainment, and personal cost.

We defined interest as the importance a student places on math because of a genuine interest in the subject. Interest is conceptually similar to intrinsic motivation, as proposed by Deci and Ryan (1985). Utility was defined as the importance a student places on understanding math because it will help him or her to accomplish a variety of short- or long-term goals. Although a task high in utility value may not be intrinsically interesting, it may still be valued because of its perceived effects on personal development or professional achievement (Husman & Lens, 1999; Kauffman & Husman, 2004). We defined attainment as the importance a student places on doing well in math, which can translate into performing well in math classes or developing solid conceptual understanding.

Extending the work of Eccles, we defined personal cost as the subjective estimate of loss suffered by an individual as a result of trying to develop a good understanding of math or trying to do well in math courses. If the costs of developing mathematical literacy outweigh the benefits, such literacy may be devalued. For example, a person may devalue developing mathematical literacy if learning math is perceived to be too time consuming, difficult, or threatening. Borrowing from Feather (1988), we conceptualized interest value, utility value, and attainment value as task-related beliefs that would increase the value students placed on becoming literate in mathematics. On the other hand, we conceptualized personal cost in terms of beliefs that would lead students to devalue such literacy.

Following facet definition, we constructed a pool of 88 items to reflect the four facets. We chose a 5-point Likert-type response format, with the following response options: 1 (*strongly disagree*), 2 (*mildly disagree*), 3 (*neutral*), 4 (*mildly agree*), and 5 (*strongly agree*).

Method for Content Validation Participants and Procedure

Expert evaluation. Consistent with content validation procedures specified by Haynes et al. (1995), we identified multiple experts in math education to evaluate our preliminary work. In Phase 1, five experts evaluated the clarity of the facet descriptions for interest, utility, attainment, and personal cost using a 5-point Likert-type format, with response options ranging from 1 (*Not at all clear*) to 5 (*Extremely clear*). The experts provided revision suggestions for facet descriptions judged to be unclear. Experts were also asked to provide their recommendations for additional facets that might be related to the perceived value of mathematical literacy that did not surface in our review of the literature.

Phase 2 involved an item sorting task, followed by an evaluation of item clarity. For the sorting task, we typed each item on an index card. Labels representing each of the four facets (interest, utility, attainment, and personal cost) were also typed on individual cards, with an extra card labeled "Other." Using descriptions of the four facets as guides, experts attempted to sort each item into the facet that seemed logically most appropriate. If an item did not seem to fit logically into any of the four facets, we instructed them to sort it into the "Other" category. Items failing to be assigned to the same facet by at least 80% (or 4 out of 5) of the experts were eliminated from the item pool. Experts were then asked to generate additional items for any or all of the four facets. Following the sorting task, experts reviewed each item for technical adequacy, clarity of meaning, and content using a 5-point Likert-type format, with response options ranging from 1 (*Not at all clear*) to 5 (*Extremely clear*). Suggestions for wording revisions were requested.

Using only those items that survived Phase 2, in Phase 3, experts evaluated how well each *individual* item's content reflected the facet from which it was derived as well as the representativeness of the *complete* item pool for each facet. Response options were Likert-type, ranging from 1 (*Poor*) to 5 (*Excellent*). As a final step for logical validation, experts were asked to provide additional items that could enhance the representativeness of the entire item pool.

Student evaluation. Thirty-eight students enrolled in a graduate-level measurement class at a large, state university in the Midwest were asked to participate. Students were informed of the purpose of the MVI and were provided with descriptions of each facet. Students rated the wording of each item using a Likert-type scale, with response options ranging from 1 (*Poor*) to 5 (*Excellent*). Students were asked to provide recommendations for item revisions and were provided an opportunity to generate additional items for any or all of the identified facets.

Results

Expert evaluation. Using the 1 (*Not at all clear*) to 5 (*Extremely clear*) rating scales, clarity of the four-facet descriptions was rated as follows: Interest ($M = 4.7$, $SD = 0.4$), Utility ($M = 3.7$, $SD = 1.2$), Attainment ($M = 4.0$, $SD = 1.0$), and Personal Cost ($M = 4.1$, $SD = 0.9$). We made minor revisions to the facet descriptions based on expert recommendations, but there were no suggestions for additional facets of math value. Following the sorting task, we excluded 4 of the 88 initial items because they did not meet the 80% expert agreement criterion and generated one new item. No additional items were suggested for inclusion.

From Phase 3, using the scale anchored at 1 (*Poor*) to 5 (*Excellent*), the degree to which the content of *each* of the 85 items reflected its respective facet was rated as follows: Interest (20 items; $M = 4.70$, $SD = 0.58$), Utility (24 items; $M = 4.80$; $SD = 0.48$), Attainment (14 items; $M = 4.52$, $SD = 0.69$), and Personal Cost (27 items; $M = 4.22$, $SD = 0.89$). Using the same scale, the degree to which the *complete* item pool represented its respective facet was rated as follows: Interest ($M = 4.9$, $SD = 0.2$), Utility ($M = 4.9$, $SD = 0.2$), Attainment ($M = 4.2$, $SD = 0.8$), and Personal Cost ($M = 4.2$, $SD = 0.8$). After reviewing the item pool in its entirety, the experts suggested no

additional items for inclusion, and we elected to eliminate 12 items that were highly similar to others in the pool, leaving 73 items in total.

Student evaluation. Using a scale with anchors at 1 (*Poor*) and 5 (*Excellent*), student ratings of item clarity ranged from 3.84 to 4.79 (73 items; $M = 4.42$, $SD = 0.92$). On the same scale, student ratings of the item pool for each facet were as follows: Interest (15 items; $M = 4.58$, $SD = 0.82$), Utility (24 items; $M = 4.36$, $SD = 0.94$), Attainment (14 items; $M = 4.43$, $SD = 0.87$), and Personal Cost (20 items; $M = 4.31$, $SD = 1.02$). Items judged to be unclear were examined for revision and three items were removed from the pool. Students were encouraged to generate additional items for any or all of the four facets. No recommendations were submitted.

Studies 2 and 3: Large-Scale Item Tryouts

The purpose of Studies 2 and 3 was to examine the internal consistency and factor structure of the MVI using independent samples of college students attending a large state university in the Midwest. We report the factor analytic results from the first item tryout (Study 2) in summary form only; a detailed description of the factor structure of the MVI is provided for the final item tryout (Study 3). In Study 3, we also tested two hypotheses based on our understanding of gender-related differences in math value and reported relations between task-related value and math participation. First, consistent with longitudinal findings that gender-related differences in math value disappear by Grade 12 (e.g., Jacobs et al., 2002) and that gender-related differences in mathematics performance are negligible when highly selective samples are excluded (Hyde et al., 1990), we hypothesized that there would be no gender-related differences in MVI performance—at either the subscale or full-scale level—for general education college students.

Second, given the documented relationship between math value and math participation (e.g., Simpkins et al., 2006; Updegraff et al., 1996; Watt, 2006; Watt et al., 2006), we hypothesized that students who had completed three or more college math courses would have higher MVI scores than would students who had completed fewer courses. We hypothesized that this relationship would hold across the subscales and on the inventory as a whole.

Study 2: First Item Tryout

In our first large-scale item tryout of the 70-item MVI, 944 nonmath majors agreed to participate, producing a participant-to-item ratio of 13.5. Participants ranged in age from 17 to 59 years ($M = 20.47$, $SD = 4.95$) and were predominantly female (71.9%), Caucasian (90.1%), and first- or second-year college students (78.5%). We used these data to conduct exploratory item level, factor structure, and internal consistency analyses. Each item was evaluated for skewness, kurtosis, and interitem correlations. Those items with nonnormal distributions were eliminated, and highly intercorrelated items (Pearson's $r \geq .70$) were examined for redundancy of content and possible removal. Using these criteria, four items were eliminated from the item pool.

To examine factor structure, we subjected the remaining 66 items to a principal components analysis with maximum likelihood extraction. In addition to examining the results of Cattell's (1966) scree test and the Kaiser-Guttman criterion (i.e., eigenvalue >1), we also applied a parallel analysis (Velicer, Eaton, & Fava, 2000) to determine empirically the number of factors to retain. Consistent with the a priori theoretical model, four factors met extraction criteria with item content that matched the facets of interest, utility, attainment, and personal cost after rotation.

As expected, the four factors were not completely independent: factor intercorrelations ranged from .24 to .49. Consequently, the retained factors were subjected to oblique (promax) rotation to allow for these correlations when determining the principal factor to which an item belonged and also during data reduction. For refinement, we eliminated items for the following reasons: (a) initial communality below .20, (b) pattern or structure coefficient below .45 on the principal factor, or (c) complex pattern/structure coefficients.

The .45 criterion was set based on recommendations in the literature (Comrey, 1973; Floyd & Widaman, 1995; Henson & Roberts, 2006; Stevens, 1992). Complex coefficients were defined as loadings ≥.45 on the principal factor *and* ≥.30 on one or more other factors (Nunnally & Bernstein, 1994). After applying the elimination criteria, 39 items were removed from the pool. When we reran the factor analysis with the 27 remaining items, the four-factor solution accounted for 68% of variance explained.

Cronbach alpha coefficients for scores on the four subscales were as follows: Interest (9 items), $\alpha = .95$; Utility (6 items), $\alpha = .89$; Attainment (6 items), $\alpha = .90$; and Personal Cost (6 items), $\alpha = .87$. Alpha for the full scale scores (27 items) was .94. All alphas are above recommended minimums (cf. Henson, 2001; Nunnally & Bernstein, 1994).

Study 3: Second Item Tryout

To ensure equally proportionate item representation across content domains, we generated five new test items and, using the same procedures described in Study 2, conducted a second large-scale item tryout with a 32-item inventory ($n = 1,096$ non-math majors, 59.0% female, 92.6% Caucasian, 77.2% first- or second-year students). Factor intercorrelations ranged from .38 to .55, justifying oblique rather than orthogonal rotation. For each of the four factors, we retained the seven items with the highest structure coefficients and also showed the largest reduction in Cronbach's alpha when deleted. When we reran the factor analysis on the remaining 28 items, the four-factor solution accounted for 71% of variance explained.

After a close examination of the items in each subscale, we assigned content-relevant labels to the components, some of which differ slightly from the labels provided in the Eccles et al. (1983, 1984) model. The four factors were named as follows (if altered, the original theoretically derived facet labels appear parenthetically): Interest, General Utility (*utility*), Need for High Achievement (*attainment*), and

Personal Cost. Although the conceptual similarity between the subscale labels and their respective facet labels is obvious, the revised labels better reflect the content of the actual items. In the case of the attainment facet, the items retained reflected not just a need to succeed in math but a desire to succeed at high levels.

Table 1 provides the pattern and structure coefficients from the final principal components analysis as well as subscale descriptive statistics, Cronbach alphas, and component correlations. To interpret the scale scores, it may be helpful to recall that item scores can range from 1 (*strongly disagree*) to 5 (*strongly agree*), yielding subscale scores (7 items each) ranging from 7 to 35. The maximum MVI total score is 140, with higher scores reflecting greater perceived value of math. All items in the Personal Cost subscale are reversed scored, so that *higher* scores on Personal Cost reflect *greater* value placed on math, in line with the other subscales. Internal consistency estimates for scores pertaining to the four value-related subscales suggest that item relatedness is exceptionally high at the subscale level and across the entire scale. Subscale intercorrelations were all statistically significant ($p < .001$).

Gender-related differences in math valuation. We explored the possibility of gender-related differences in performance on the MVI at the subscale level and on the test as a whole using independent-samples *t* tests and Cohen's *d* (mean of the women minus the mean of the men divided by the pooled standard deviation). After controlling for experiment-wise error rate, differences between MVI scores for women and men were not statistically significant and effect sizes were small. Specifically, and as hypothesized, there were no statistically significant differences in Interest, $t(1052) = -1.56$, $p = .11$, $d = -.26$; General Utility, $t(1059) = .29$, $p = .77$, $d = .05$; Need for High Achievement, $t(1064) = 1.96$, $p = .05$, $d = .32$; Personal Cost, $t(1061) = -1.09$, $p = .27$, $d = -.18$; or on the inventory as a whole, $t(1012) = -.72$, $p = .47$, $d = -.21$.

Relationship between math valuation and math participation. Drawing on longitudinal findings that secondary students who value math highly tend to take more high school math courses (zero courses, one course, two courses, or three or more courses) than do students who value math to a lesser extent, we hypothesized that students who had completed three or more college math courses would have higher MVI total scores than would students who had completed fewer courses. We anticipated that this difference would also be found across the interest, utility, achievement, and personal cost subscales.

MVI descriptive statistics for the four math participation groups are provided in Table 2. Differences in MVI scores across the four math participation groups were initially compared using one-way ANOVA. Analyses suggested that MVI total scores varied statistically according to amount of math course work completed. In addition, there were statistically significant differences across math participation groups on three of the MVI subscales: Interest, General Utility, and Personal Cost. Need for High Achievement did not vary statistically according to amount of math course work completed.

Tukey's HSD post hoc tests indicated that students who had completed zero, one, or two college math courses did not differ greatly from one another in math value

Table 1. Pattern and Structure Coefficients From Principal Components Analysis With Subscale Descriptive Statistics, Cronbach Alphas, and Component Correlation Matrix

Item	Factor				Total Scale
	I	II	III	IV	
I. Interest					
I find many topics in mathematics to be interesting. (12)	.95 (.92)	.02 (.51)	−.04 (.39)	−.06 (.43)	
Solving math problems is interesting for me. (24)	.95 (.93)	−.04 (.48)	−.01 (.42)	.01 (.48)	
Mathematics fascinates me. (27)	.94 (.89)	−.02 (.46)	−.05 (.37)	−.05 (.42)	
I am interested in doing math problems. (20)	.87 (.90)	−.02 (.49)	.05 (.46)	.04 (.50)	
It is fun to do math. (16)	.86 (.89)	−.03 (.47)	−.01 (.41)	.10 (.52)	
Learning new topics in mathematics is interesting. (2)	.80 (.84)	.09 (.52)	−.02 (.40)	−.01 (.44)	
I find math intellectually stimulating. (9)	.67 (.80)	.12 (.55)	.15 (.51)	.00 (.45)	
II. General Utility					
There are almost no benefits from knowing mathematics. (3r)	−.05 (.43)	.90 (.86)	.00 (.36)	−.03 (.28)	
I see no point in being able to do math. (17r)	−.05 (.47)	.84 (.86)	.03 (.41)	.09 (.39)	
Having a solid background in mathematics is worthless. (13r)	−.06 (.43)	.82 (.83)	.07 (.41)	.02 (.33)	
I have little to gain by learning how to do math. (6r)	.08 (.51)	.79 (.82)	−.08 (.33)	.06 (.37)	
After I graduate, an understanding of math will be useless to me. (10r)	−.01 (.43)	.78 (.78)	−.01 (.34)	.02 (.31)	
I do not need math in my everyday life. (23r)	.03 (.42)	.74 (.74)	−.07 (.29)	.03 (.30)	
Understanding math has many benefits for me. (21)	.19 (.55)	.71 (.79)	.02 (.39)	−.08 (.30)	
III. Need for High Achievement					
Earning high grades in math is important to me. (19)	−.04 (.40)	.10 (.45)	.88 (.89)	−.04 (.33)	
It is important to me to get top grades in my math classes. (8)	−.02 (.37)	.01 (.37)	.88 (.85)	−.06 (.29)	
If I do not receive an "A" on a math exam, I am disappointed. (4)	−.04 (.32)	−.08 (.29)	.85 (.81)	.01 (.30)	
Only a course grade of "A" in math is acceptable to me. (25)	.06 (.40)	−.23 (.23)	.84 (.82)	.17 (.44)	
I must do well in my math classes. (28)	−.01 (.37)	.10 (.42)	.82 (.82)	−.13 (.24)	

151

Table 1. (continued)

Item	Factor				Total Scale
	I	II	III	IV	
I would be upset to be just an "average student" in math. (11)	.09 (.46)	-.14 (.31)	*.77 (.81)*	.18 (.47)	
Doing well in math courses is important to me. (14)	-.02 (.42)	.30 (.57)	*.72 (.80)*	-.12 (.28)	
IV. Personal Cost					
Math exams scare me. (26r)	-.04 (.40)	-.04 (.27)	-.02 (.30)	*.89 (.95)*	
Trying to do math causes me a lot of anxiety. (22r)	.04 (.47)	.02 (.34)	-.05 (.32)	*.85 (.86)*	
Taking math classes scares me. (5r)	.04 (.50)	.06 (.40)	.01 (.38)	*.83 (.87)*	
I worry about getting low grades in my math courses. (7r)	-.01 (.37)	-.08 (.22)	-.02 (.27)	*.83 (.79)*	
I have to study much harder for math than for other courses. (1r)	-.01 (.42)	-.06 (.28)	.08 (.38)	*.82 (.82)*	
Mathematical symbols confuse me. (15r)	.02 (.42)	.13 (.37)	-.05 (.28)	*.67 (.71)*	
Solving math problems is too difficult for me. (18r)	-.05 (.45)	.23 (.48)	.05 (.40)	*.67 (.76)*	
Mean	18.22	26.16	24.49	21.06	90.11
Standard deviation	7.41	6.27	6.83	7.38	21.80
Coefficient alpha	.95	.92	.92	.91	.95
Component correlation matrix					
I	—				
II	.55	—			
III	.47	.44	—		
IV	.52	.38	.40	—	

Note: Item numbers are in parentheses following item content. Lowercase "r" indicates reverse-scored item. Structure coefficients are in parentheses next to pattern coefficients. Primary pattern and structure factor coefficients are italicized.

Table 2. MVI Descriptive Statistics for Students With Different Levels of Math Participation in College

	Level of Math Participation in College					
Scale	0 Courses, M (SD), d	1 Course, M (SD), d	2 Courses, M (SD), d	3 or More Courses, M (SD), d	F (df)	Eta^2
MVI total	86.66 (21.76), —	90.35 (20.70), 0.17	90.94 (21.69), 0.28	98.85 (24.11), 0.53	8.09 (3, 1,010)***	.02
Interest	17.29 (7.31), —	18.14 (7.05), 0.12	18.45 (7.59), 0.22	21.30 (8.20), 0.52	7.67 (3, 1,051)***	.02
Utility	24.57 (6.37), —	26.39 (5.98), 0.29	27.18 (6.00), 0.58	28.38 (6.55), 0.59	13.80 (3, 1,061)***	.04
Achievement	24.21 (6.87), —	24.57 (6.78), 0.05	24.40 (6.67), 0.04	25.28 (7.21), 0.15	.66 (3, 1,061)	.00
Cost	20.51 (7.40), —	21.02 (7.18), 0.07	20.88 (7.37), 0.07	23.41 (7.92), 0.38	4.04 (3, 1,061)**	.01

Note: MVI = Mathematics Value Inventory. Effect sizes for pairwise comparisons were computed using Cohen's d. Effect sizes are only provided for comparisons involving 0 courses (i.e., 0 courses vs. 1 course, 0 courses vs. 2 courses, and 0 courses vs. 3 or more courses).
**$p < .01$. ***$p < .001$.

153

(analyses not shown). However, as depicted in Table 2, it was generally the case that students who had completed one, two, or three or more college math courses found math to be more interesting and useful than did students who had completed no course work in math. For example, students who had completed three or more courses in math had higher interest scores ($M = 21.30$, $SD = 8.20$) than did students who had completed no college math courses ($M = 17.29$, $SD = 7.31$). The effect size for this difference was .52 (Cohen's *d*). These students also experienced fewer perceived costs when studying math and had statistically higher total MVI scores than did students who had taken fewer courses. In all, the effect estimates were generally small, ranging from 0.04 to 0.59.

Study 4: Temporal Stability

The purpose of Study 4 was to examine the temporal stability of MVI scores over a 2-week period. To examine test–retest reliability, we administered the inventory to a sample of undergraduate students enrolled in introductory psychology classes at a small liberal arts university in the Midwest. Students were asked to complete the MVI again 2 weeks later, and 55 students (70.9% women, 90.9% Caucasian) participated in both the test and the retest sessions. From the first testing session, internal consistency estimates for scores pertaining to Interest, General Utility, Need for High Achievement, and Personal Cost were $\alpha = .96$, .90, .91, and 91, respectively. For the entire scale scores, $\alpha = .95$. The test–retest subscale coefficients were as follows: Interest, $r = .92$; General Utility, $r = .88$; Need for High Achievement, $r = .92$; and Costs, $r = .94$. The 2-week retest correlation of the MVI total scale score was $r = .96$.

Study 5: Discriminant Validity

The purpose of Study 5 was to provide evidence for the discriminant validity of scores on the MVI against the Marlowe-Crowne Social Desirability Scale (MCSDS; Crowne & Marlowe, 1960). The MCSDS consists of 33 items that are scored as 1 (*Yes*) or 0 (*No*). Thus, total scores on the MCSDS can range from 0 to 33, with higher scores reflecting a greater tendency to produce socially desirable responses. We hypothesized that scores on the MVI and MCSDS would not be related to one another.

We administered the MVI and MCSDS to a sample of 30 undergraduate students enrolled in two sections of a mathematics course for nonscience/nonmath majors at a small liberal arts university in the Midwest. On the MVI, internal consistency estimates for scores pertaining to Interest, General Utility, Need for High Achievement, and Personal Cost were $\alpha = .97$, .89, .95, and .93, respectively. For the entire scale scores, $\alpha = .96$. The correlation between socially desirable response tendencies and MVI total scores was only small to moderate in strength (Pearson's $r = .33$), which was in the direction of our hypothesis.

Discussion

In this article, we discussed the development and initial validation of MVI, a self-report survey that measures the value students place on mathematical literacy. Similar to the work of Eccles et al. (1983, 1984), the MVI surveys students' beliefs in four areas: interest, general utility, need for high achievement, and personal cost. However, unlike other value inventories designed for undergraduate purposes (Battle & Wigfield, 2003; Luttrell, 2000), the MVI focuses on the value students place on mathematics, specifically, because students, even as early as first grade (Eccles et al., 1993), value different subjects in different ways.

As expected, the four components of math value were correlated, with subscale intercorrelations on the final inventory ranging from $r = .42$ to.59. The strongest correlations were found between students' interest in mathematics and the three other facets of math-related value, with the most robust relationship found between interest and utility scores. The interest–utility association has implications for reform-minded educators who seek to bolster motivational outcomes and student learning. Enjoyment is a critical component of intrinsic motivation (Deci & Ryan, 1985), and it is associated with greater persistence, increased use of active problem-solving tactics, and greater cognitive flexibility (Hidi, 1990; Schiefele & Csikszentmihalyi, 1995; Stipek et al., 1998). Attempts at increasing students' interest are reported to be more successful when teachers focus on why the subject matter is meaningful and how it is relevant to their lives (Csikszentmihalyi, 1997; Meece et al., 1990; Middleton, 1995; Shernoff, Csikszentmihalyi, Schnieider, & Shernoff, 2003). Unfortunately, Weiss (1990) found that mathematics teachers tend to emphasize as objectives "to have students learn mathematical facts and principles and to have them develop a systematic approach to problem solving" (p. 151). Helping students become more interested in the subject and having them become more aware of the importance of mathematics in their everyday lives were among the least emphasized objectives.

Also consistent with prior work (e.g., Feather, 1988), interest, utility, and achievement were positively correlated with one another but inversely related to personal cost. Although we acknowledge the correlational nature of this association, these relationships suggest the possibility that students' interest, utility, and/or achievement motivation might increase as perceived costs are diminished. Few studies have addressed the cost dimension of Eccles's subjective task value construct (Ryan, 2000), but studies do suggest that taking steps to minimize negative emotions (e.g., anxiety, threats to self-esteem) enhances achievement motivation, perceived competency, and fluency (e.g., Cates & Rhymer, 2003; Ruffins, 2007; Stipek et al., 1998).

We have presented evidence that MVI scores are internally consistent and very stable over a 2-week window for students who are not enrolled in math classes (cf. Vacha-Haase, Henson, & Caruso, 2002; Wilkinson & APA Task Force on Statistical Inference, 1999). However, for the MVI to be a useful tool for educational reform, it is imperative to show that subscale scores can change over time. Are students' math values "set in stone" on college entry or are they still malleable? To begin to address such questions, we are currently collecting pre- and posttest data from nonmath majors

who are enrolled in general education math courses at institutions that vary in size, geographical location, gender composition, level of ethnic diversity, and strength of religious affiliation. Although our analyses are not complete, we have preliminary data to suggest that math-related value *can* change over the course of a semester. Our ongoing and future investigations, both quantitative and qualitative, may allow us to assess how student values are affected by instruction and what their values suggest about the structure of effective curricula at institutions of higher learning.

As hypothesized, gender-related differences in MVI scores were not statistically significant, a finding that is consistent with claims that math is becoming more gender neutral, at least in U.S. samples (e.g., Hyde et al., 1990; Jacobs et al., 2002; Watt et al., 2006). Other studies report more pronounced gender-related differences, favoring boys, for both highly selective samples and samples of highly precocious students (Hyde et al., 1990), and it is still the case that girls and women are more likely than are boys and men to opt out of male-dominated fields, such as science, technology, engineering, and math (Jacobs et al., 2002; Watt et al., 2006). However, these findings are not in conflict with our results: The MVI was developed with an eye toward general education students who have chosen *not* to major in math. Consequently, it is not surprising that these students evaluate the value of math in very similar ways.

We also tested the hypothesis that students who value math more than others will have completed more math classes in college. Longitudinal, prospective studies have shown that high school students who value math highly have higher rates of math participation than do students who value math to a lesser extent. Our findings extend this work to a college population. Although we found the association between course participation and MVI subscale scores to be generally weak, students who had taken three or more college math courses had higher interest and utility scores than had students who had taken fewer courses and also perceived fewer costs to learning math than did other students. Unfortunately, given the retrospective nature of our design, it is difficult to interpret the relationship. It is possible that students who value math more take additional college courses in the subject. It is equally likely, however, that students who take more math courses in college come to value math more because of the experience it brings. Future, prospective research will allow us to examine more carefully math value–participation links, to include MVI relations to prior high school coursework, preadmission standardized test scores, choice of college major/minor, and future academic achievement in math.

Finally, we investigated the relationship between MVI scores and scores on the MCSDS, a measure of socially desirable response tendencies. The correlation between MVI and MCSDS scores was only moderate, suggesting that the two tests reasonably discriminate different traits.

We are beginning to gain insights about how values are affected by instruction and what student values suggest about the structure of effective curricula at institutions of higher learning. We are also in the initial stages of examining how MVI scores relate to preadmission standardized test scores, selection of college major, and future academic achievement. The affective domain must be addressed, particularly when

working with those students who have chosen majors and careers outside the fields of mathematics, and the MVI can provide a measure of a community's effectiveness in convincing students that math matters.

Acknowledgments

Declaration of Conflicting Interests

Funding

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