The *Standards'* Beliefs Instrument (SBI): Teachers' Beliefs About the NCTM *Standards*

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As a response to a perceived crisis in mathematics education (Crosswhite et al., 1986; Dossey et al., 1988; Educational Testing Service, 1989; National Council of Teachers of Mathematics [NCTM], 1990), the National Council of Teachers of Mathematics has initiated a national reform in mathematics education with the *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989). This document, the cornerstone of the reform, presents NCTM's vision of how mathematics should be learned, taught, and evaluated in grades K-12. The 54 standards, developed over a 3-year period, propose the basis for a balanced curriculum that focuses on both mathematical ideas and processes. They give greater emphasis to conceptual development, mathematical reasoning, and problem solving than was given in previous curricula in mathematics. The *Standards* calls for changes in instructional practices in which the roles of both students and teacher are redefined. The role of the student changes from a passive receiver of information to an active participant in learning; the teacher changes from an active dispenser of knowledge to a passive moderator and manager of learning experiences. The *Standards* portrays mathematics as a connected, cohesive body of knowledge in which teachers encourage students to be actively engaged in making conjectures and discussing ideas.

The purpose of this research was to provide an instrument (the *Standards'* Belief Instrument [SBI]) to assess teachers' beliefs about the NCTM *Standards*, using items representative of beliefs about the *Standards*. For the purpose of this study, a belief was defined as, "a judgment of the credibility of a conceptualization. Credibility of a conceptualization has to do with whether one accepts, rejects, or suspends judgment concerning a set of concepts and the interrelationships among those concepts" (Reyes, 1987, p. 10).

Recent research in mathematics education (Bush, Lamb, & Alsina, 1990; Fullan, 1983; Kesler, 1985; McGalliard, 1983; Silver, 1985; Thompson, 1984) indicate teaching behavior is influenced profoundly or subtly by what teachers believe mathematics should be. For example, Thompson (1984) found that mathematics teachers' views, beliefs, and preferences did influence their instructional practice. This is further illustrated by Ferrini-Mundy (1986) who found many inappropriate teaching practices attributed to teachers' beliefs about mathematics. In addition, Bauch (1984) speculated that "a teacher's adherence to a particular set of instructional beliefs might limit what a student can obtain from schooling" (p. 18).

The cited research suggests an important relationship exists between the teacher's beliefs and the teacher's behavior. With this background in mind, a wide acceptance of the NCTM *Standards* would depend on a teacher's beliefs. This present work was done to answer the need for an instrument to assess teachers' beliefs about the *Standards*.

Development of the Instrument

Items for the SBI were randomly chosen from several levels of the *Standards* to be representative of the *Standards*. Items met three criteria. First, the implication of each item was intended not to be intuitively obvious to avoid a socially desirable (or correct according to the *Standards*) pattern of responding. Second, the item could be clearly stated in a positive or negative manner. Third, the central idea of the item could be incorporated into a single sentence.

The items of the instrument were intended to be representative of the *Standards*, not inclusive. The purpose was to assess beliefs underlying the *Standards*, rather than measure comprehensive knowledge or achievement of specific aspects of the *Standards*. In this context, another issue not addressed by the SBI is the appropriate grade level of the content of each item. Items were randomly chosen on the basis of theme rather than grade level so that the SBI would represent the total elementary, middle, and secondary school mathematics program.

The 16 items of the SBI were either nearly direct quotes or the inverse of direct quotes from the *Standards*. The eight items that agreed with the *Standards* were considered to have positive valence; conversely, the eight items that disagreed with the *Standards* were considered to have negative valence. Therefore, when items were summed to obtain a total score, the negative items were reversed to coincide with the positive items.

The instrument was pilot tested and revised with the aid of 15 teachers familiar with the *Standards*. As a result of the pilot testing, important words in each item were capitalized to better insure that respondents would focus attention on the intent of each item. The capitalized words were chosen as indicative of the meaning of the specific part of the *Standards* the item represented. Before this capitalization was added, respondents appeared to emphasize aspects of items that were distracting. Respondents and reviewers saw value in this capitalization. The 16 items of the SBI, the basis of each item from the *Standards*, and the valence of every item (positive if it agrees; negative if it disagrees with the *Standards*), and the valence of every item (positive if it agrees; negative if it disagrees with the *Standards*) are shown in the Appendix.

The final instrument was tested for construct validity by requesting a panel of experts composed of 17 mathematics educators, who had either helped edit, develop, and/or write parts of the NCTM *Standards*, to evaluate the items in terms of whether or not the item agreed with the *Standards*. The panel consisted of eleven mathematics education professors, four past/present/future state NCTM presidents, one state mathematics consultant, and one classroom teacher who help develop a videotape on the *Standards*. All 17 educators indicated they had studied, discussed with colleagues, and implemented the ideas of the *Standards* as a part of their professions.

Construct validity was further investigated by analysis of the convergent and discriminant nature of correlations between the SBI and other variables. The data used in this analysis were from two groups of teachers who were administered the instrument. These groups consisted of 61 undergraduate practicum teachers in their final semester before student teaching and 72 experienced teachers in graduate courses.

Each subject was administered the SBI using a 4-point Likert scale (1 = strongly agree, 2 = agree, 3 = disagree, 4 = strongly disagree) and a demographic questionnaire during regular class session. Subjects were instructed to leave blank any item they considered confusing. After the data were collected, the responses for eight negative valence items of the SBI were re-aligned (response subtracted from 5.0). Thus the rating of positive and negative valence items would be in a consistent direction ranging from 1.0 to 4.0. The closer the re-aligned response number to 1.0 the stronger the agreement with the *Standards*.

Results

Table 1 shows the mean, valence, and standard deviation for each item. The data suggested that the teachers tended to agree with the *Standards* on most of the items on the SBI, while identifying areas for further inquiry.

The expert panel of 17 mathematics educators was asked to determine whether each item agreed or disagreed with the *Standards*. Table 2 shows these data. An inspection of Table 2 suggests strong support for construct validity in the sense that the experts viewed the items as representing the *Standards* as intended to a very high degree ($\chi^2 = 229.79$, df = 1, $p < .001$).

Information about background, including mathematics ability and mathematics anxiety (rated on a scale of 1 [low] to 5 [high]), familiarity with the *Standards*, and teaching experience were reported by the respondents on a separate questionnaire. Table 3 shows the correlations between individual items and the SBI total agree and disagree subscores, the SBI total score, questions about the respondents' mathematics ability and mathematics anxiety, the respondents' familiarity with the *Standards*, and the respondents' teaching experience. Mathematics ability, mathematics anxiety, familiarity with the *Standards*, and teaching

Table 1

Valence, Mean and Standard Deviation (SD) of Items on the SBI after Adjustment for Valence

Item	Valence	Mean	SD	*n*
1	-	1.955	1.018	134
2	+	1.172	0.398	134
3	+	1.194	0.397	134
4	+	1.481	0.611	133
5	-	1.481	0.734	133
6	+	1.097	0.385	134
7	-	1.716	0.846	134
8	-	2.354	0.930	127
9	-	3.045	0.840	131
10	-	2.646	0.963	130
11	-	2.702	0.909	131
12	-	3.160	0.830	131
13	+	1.647	0.676	133
14	+	2.709	0.940	134
15	+	1.030	0.171	134
16	+	2.326	0.985	132

experience items were a part of the demographic questionnaire.

Correlations between individual items and teachers' mathematics ability and mathematics anxiety were low, ranging from -.16 to .23. Items correlated with familiarity with the *Standards* slightly higher (0.5 to .33) with item 9 highest. Further, each item correlated with total agree, total disagree, and total score from a low of -.16 to a high of .64. Teaching experience had a correlation range from -.16 to .06 with each item.

Total SBI score correlated with totals of the agree items (.66) and disagree items (.90). Total SBI score correlated relatively low with mathematics anxiety (.27), mathematics ability (-.21), and teaching experience (-.14). This last correlation index (SBI with teaching experience) suggests that beliefs about the *Standards* are fairly uniform regardless of experience. Further, respondents reported level of familiarity with the *Standards* correlated moderately with total SBI score (.44).

These patterns of correlations support the integrity of the construct underlying the SBI (Campbell & Fisk, 1959). In other words, construct validity is supported when variables that should highly correlate with the instruments do so in the expected direction and lower correlations are obtained for those variables that should not correlate highly with the instrument. This pattern is found with total SBI score being more related with agree and disagree items than with mathematics ability, or mathematics anxiety items, or with teaching experience.

Reliability of the SBI was investigated with internal consistency procedures. Table 4 displays the Spearman-Brown reliability and the coefficient of alpha for two distinct populations.

Table 2

Expert Panel's Analysis of the SBI (N = 17)

Expert Panel's Classification of Items as Agree or Disagree

Item	Valence	Agreeing	Disagreeing
1	-	0	17
2	+	17	0
3	+	17	0
4	+	17	0
5	-	1	16
6	+	17	0
7	-	0	17
8	-	1	16
9	-	0	17
10	-	0	17
11	-	0	17
12	-	4	13
13	+	13	4
14	+	17	0
15	+	17	0
16	+	16	1

Valence of 16 Items

	Valence	
	Positive	Negative
Agreeing	131	6
Disagreeing	5	130

Table 4 permits comparison of reliability in two separate groups. One is a general population of teachers ($N = 123$); the second is a trained population of 13 teachers who studied the *Standards* as a part of a graduate course in mathematics education. Despite the much smaller sample size ($N = 13$) of the trained group, the Spearman-Brown reliability for this group was much higher (.803, coefficient of alpha approaching .79) than the untrained group (Spearman-Brown .493, coefficient of alpha approaching .65). This evidence for the reliability of the SBI also shows more consistency of ratings from subjects more knowledgeable about the *Standards* and thus suggest evidence for validity of the instrument as well.

Implications for Teaching

Beliefs regarding the new NCTM *Standards* should be examined as mathematics education is reformed. At the personal level, the SBI can serve as a catalysis for reflective thinking and active decision making regarding our own teaching activities.

Second, many mathematics educators possess several traditional, if unfounded, beliefs with respect to the learning and teaching of mathematics. Table 3 correlations show that mathematics ability, teaching experience, or even familiarity with the *Standards* did not indicate that teachers agree with the consensus the *Standards* represents.

The SBI is not intended to assess teachers' knowledge of the *Standards*. Nevertheless, it can be used as a basis for evaluating teachers' perspectives toward the underlying vision of the *Standards*. The SBI can be utilized as a beginning for communications among teachers in a school or in an inservice concerning the real purpose of mathematics education.

Finally, the data of Table 4 show teachers' beliefs apparently can be changed if presented with proper knowledge and sufficient experiences. Thus the SBI can serve a valid instrument for assessing beliefs, both initially and throughout a project, program, inservice, or university course.

Discussion

The objective of this study was to develop an instrument which could be used to access the beliefs of teachers about the NCTM *Standards*. The results of this study suggest that the instrument (SBI) is useful in this regard. First, the instrument was written using the phrasing of the *Standards*. Second, the expert panel of mathematics educators viewed the instrument as representing the *Standards*. Third, convergent and divergent correlations supported the construct validity of the SBI. Fourth, the level of reliability of the instrument implied that it produced a fairly dependable score in subjects who studied the *Standards*.

The items of the instrument were intended to be representative of the *Standards*, not inclusive. The purpose here was to measure teachers' beliefs underlying the *Standards*, rather than assess comprehensive knowledge of specific aspects of the *Standards*. Items were chosen on the basis of them and general underlying perspective towards the *Standards*, rather than concern for grade level, and thus, the SBI should represent the total elementary, middle, and secondary school program.

Table 3

Correlations Between Items, and Agree and Disagree Subtotals, Total Score, and Selected Background Characteristics

	Variable	(17)	(18)	(19)	(20)	(21)	(22)	(23)
1	Item 1	-11	-16	07	07	57	48	04
	n	131	130	131	130	124	123	133
2	Item 2	-03	-00	26	34	08	21	06
	n	131	130	131	130	124	123	133
3	Item 3	05	00	16	38	22	34	-01
	n	131	130	131	130	124	123	133
4	Item 4	-16	11	19	53	27	45	-16
	n	130	129	130	130	123	123	132
5	Item 5	-06	09	05	-08	44	31	-04
	n	130	129	130	129	124	123	132
6	Item 6	06	-01	11	32	-02	12	-05
	n	131	130	130	130	124	123	133
7	Item 7	-06	10	15	37	54	58	00
	n	131	131	131	130	124	123	133
8	Item 8	-05	08	12	11	53	46	03
	n	126	125	126	126	124	123	127
9	Item 9	-10	20	33	28	57	56	-04
	n	130	129	130	128	124	123	131
10	Item 10	-08	11	31	32	63	64	01
	n	129	128	129	128	124	123	130
11	Item 11	-09	23	18	05	60	48	-11
	n	128	127	128	129	124	123	130
12	Item 12	-15	09	18	-05	29	20	-16
	n	128	127	128	128	124	123	130
13	Item 13	-00	05	12	49	04	26	-08
	n	130	129	130	130	124	123	132
14	Item 14	-03	08	25	51	06	31	-09
	n	131	130	131	130	124	123	133
15	Item 15	-07	04	07	21	00	09	-02
	n	131	130	131	130	124	123	133
16	Item 16	-13	18	22	60	18	42	-06
	n	129	128	129	130	124	123	131
17	Math ability		-52	-26	-11	-18	-21	-00
	n		130	131	127	123	122	131
18	Math anxiety			32	54	-17	27	30
	n			130	127	126	122	121
19	Familiar with standards				41	33	44	-16
	n				127	123	122	131
20	SBI agree total					26	66	-14
	n					123	123	129
21	SBI disagree total						90	-11
	n						123	124
22	SBI total score							-14
	n							123
23	Teaching experience							

Note: Leading decimals omitted.

Table 4

Internal Consistency Reliability of SBI before (n = 123) and after (n = 13) Training in the NCTM Standards

Item	Before Training		After Training	
	mean if item deleted	alpha if item deleted	mean if item deleted	alpha if item deleted
1	29.74	.608	23.46	.757
2	30.48	.632	23.92	.764
3	30.46	.622	23.92	.764
4	30.15	.605	*	*
5	30.14	.623	23.54	.735
6	30.56	.637	23.92	.764
7	29.95	.588	23.15	.746
8	29.34	.611	23.31	.715
9	28.62	.587	22.54	.795
10	29.05	.573	23.31	.717
11	28.92	.600	23.23	.750
12	28.53	.653	21.69	.768
13	30.00	.637	23.46	.784
14	28.98	.639	23.31	.761
15	30.63	.636	23.85	.760
16	29.33	.624	23.39	.782
Spearman Brown		.493		.803

*There was no variation in the responses of the 13 subjects after training and therefore the effects of this item could not be analyzed.

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Appendix

The Standards' Beliefs Instrument (SBI), Valence, and Item Basis

Item	Valence	Item Basis in *Standards*
1. Problem solving should be a SEPARATE, DISTINCT part of the mathematics curriculum.	-	Problem solving is not a distinct topic but a process that should permeate the entire program and provide the context in which concepts and skills can be learned (p. 23).
2. Students should share their problem-solving thinking and approaches WITH OTHER STUDENTS.	+	Ideally, students should share their thinking and approaches with other students and with teachers (p. 23).
3. Mathematics can be thought of as a language that must be MEANINGFUL if students are to communicate and apply mathematics productively.	+	Mathematics can be though of as a language that must be meaningful if students are to communicate mathematically and apply mathematics productively (p. 26).
4. A major goal of mathematics instruction is to help children develop the belief that THEY HAVE THE POWER to control their own success in mathematics.	+	A major goal of mathematics instruction is to help children develop the belief that they have the power to do mathematics and they have control over their own success or failure (p. 29).
5. Children should be encouraged to justify their solutions, thinking, and conjectures in a SINGLE way.	-	Children should be encouraged to justify their solutions, thinking processes, and conjectures in a variety of ways (p. 29).
6. The study of mathematics should include opportunities of using mathematics in OTHER CURRICULUM AREAS.	+	In grades K-4, the study of mathematics should include opportunities to make connections so that students can use mathematics in other curriculum areas (p. 32).
7. The mathematics curriculum consists of several discrete strains such as computation, geometry, and measurement which can be best taught in ISOLATION.	-	The mathematics curriculum is generally viewed as consisting of several discrete strands. As a result, computation, geometry, measurement and problem solving tend to be taught in isolation. It is important that children connect ideas both among and within areas of mathematics (p. 32).

8. In K-4 mathematics, INCREASED emphasis should be given to reading and writing numbers SYMBOLICALLY.	-	Summary of changes in content and emphasis in K-4 mathematics--decreased attention-number: early attention to reading, writing, and ordering numbers symbolically (p. 21).
9. In K-4 mathematics, INCREASED emphasis should be given to use of CLUE WORDS (key words) to determine which operation to use in problem solving.	-	Summary of changes in content and emphasis in K-4 mathematics--decreased attention-problem solving: use of clue words to determine which operation to use (p. 21).
10. In K-4 mathematics, skill in computation should PRECEDE word problems.	-	Traditional teaching emphasis on practice in manipulating expressions and practicing algorithms as a precursor to solving problems ignore the fact that knowledge often emerges from the problems. This suggests that instead of the expectation that skill in computation should precede word problems, experience with problems helps develop the ability to compute (p. 9).
11. Learning mathematics is a process in which students ABSORB INFORMATION, storing it in easily retrievable fragments as a result of repeated practice and reinforcement.	-	In many classrooms, learning is conceived of as a process in which students passively absorb information, storing it in easily retrievable fragments as a result of repeated practice and reinforcement. Research findings from psychology indicate that learning does not occur by passive absorption alone (p. 10).
12. Mathematics SHOULD be thought of as a COLLECTION of concepts, skills and algorithms.	-	This notion is based on the recognition of mathematics as more than a collection of concepts and skill to be mastered; it includes methods of investigating and reasoning, means of communication, and notions of context (p. 5).
13. A demonstration of good reasoning should be regarded EVEN MORE THAN students' ability to find correct answers.	+	In fact, a demonstration of good reasoning should be rewarded even more than students' ability to find correct answers (p. 6).
14. Appropriate calculators should be available to ALL STUDENTS at ALL TIMES.	+	Because technology is changing mathematics and its uses, we believe that appropriate calculators should be available to all students at all times (p. 8).
15. Learning mathematics must be an ACTIVE PROCESS.	+	Young children are active individuals who construct, modify, and integrate ideas by interacting with the physical world, materials, and other children. Given these facts, it is clear that the learning of mathematics must be an active process (p. 17).
16. Children ENTER KINDERGARTEN with considerable mathematical experience, a partial understanding of many mathematical concepts, and some important mathematical skills.	+	Children enter kindergarten with considerable mathematical experience, a partial understanding of many concepts, and some important mathematics skills (p. 16).