
University of Michigan
First Year Report
to the
National Science Foundation
MSP-Motivation Assessment Program

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MSP – Motivation Assessment Program

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Project Targets, Activities, and Revised Objectives

MSP-MAP has accomplished virtually all of its Year 1 objectives during its first nine months of activity, and it will have completed them all during the remaining quarter. These include the following:

- Conducted extensive reviews of the literature relevant to motivation-related assessment tools
- Developed revised versions of several extant scales
- Created new instruments
- Established collaborative relationships with comprehensive and targeted MSPs and RETAs
- Developed a model Measures of Understanding (MOU) suitable for use in connection with other MSP-MAP RETA projects as well as other RETA projects
- Developed multi-scale customized protocols and administration procedures for MSPs
- Fielded a set of instruments for one large MSP (data set expected soon)
- Presented at one national conference and RETA workshop
- Established our local and national advisory groups

MSP-MAP has also expanded its scope to include the following:

- Teacher as well as student motivation-related assessment
- Extensive cognitive pretesting of instruments
- Item Response Theory (and Rasch) analyses
- A dissemination conference

The following table is an amended version of the activities and timelines provided in our original proposal (gray). It indicates work undertaken or completed in area (blue), new planned activities or extensions of activities not specified in the original proposal (orange), and deleted activities (red). Subsequently, we review each set of activities, indicate our findings, lessons learned, implications, changes, and new directions for MSP-MAP.

Revised MSP-MAP Activities and Timeline (Years and Quarters)

Activities	Year 1				Year 2				Year 3			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Review existing literature and measures: Students												
Develop items and scales: Students												
Review existing literature and measures: Teachers												
Develop items and scales: Teachers												
Needs analysis survey												
Meetings with Local Steering Committee												
National Advisory Meeting												
Solicit/select MSP sites for data collection												
Data collection												
Data analysis												
Create and maintain data base												
Refine and revise scales and tools (students and teachers)												
Cognitive pre-testing study												
Dissemination of tools on web												
Dissemination at conferences												
Preparation for publication												
Host Dissemination Conference												

Part of original plan Work undertaken or completed in this area New planned activity Deleted activity

Reviews and Assessment: Students

Activities	Year 1				Year 2				Year 3			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Review existing literature and measures: Students												
Develop items and scales: Students												

Part of original plan Work undertaken or completed in this area New planned activity Deleted activity

A primary Year 1 goal was to extensively review existing literature pertaining to motivation-related constructs and measures. The original focus was on students, with particular attention to measurement construct validity, mediation, and moderator effects. Several of these reviews are summarized in this report. Although we expected these reviews to be completed in the first six months, it was soon obvious that startup and infrastructure requirements, along with lack of access to MSPs, precluded completing the task during that time. Not only did the time required for the reviews already completed extend the Q4, we also anticipate the activity will require additional time during Year 2, as well as continued monitoring of this rapidly evolving literature for the remainder of the project. Increased knowledge of MSP interventions and evaluation designs (through proposals, direct contact, the January conference, and MSPnet) and a decision to focus on completing one full cycle of collaboration with an MSP (i.e., initial contact, negotiation, selection of motivation-related measures, assessment procedures, IRB requirements, data analysis, etc.) affected the priority with which constructs and their measurement were examined. This privileged measures of students' competence beliefs, interest, and value, followed by perceived context and achievement goals, beliefs about math and science and epistemological beliefs, but the delayed consideration of self-regulation. The decision to focus on motivation-related teacher practices also increased the need for tools to assess student perceptions of the instructional setting. The result was an intensive examination of classroom context.

Reviews and Assessment: Teachers

Activities	Year 1				Year 2				Year 3			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Review existing literature and measures: Teachers												
Develop items and scales: Teachers												

Part of original plan Work undertaken or completed in this area New planned activity Deleted activity

Access to and discussions with MSPs resulted in one major change in MSP-MAP activities: the need to provide instruments to measure teacher motivation. Because virtually all MSP interventions include teacher professional development, MSPs requested scales to assess how teachers, as well as students, were affected. We thus focused on such constructs as teacher efficacy (including collective efficacy), value and interest, teacher expectancy, and how teachers structure their classes in ways that are known to influence motivation (see "TARGET" and other context-related sections to follow). As with student measures, this effort will be extended to the end of this year and into next year's activities.

MSP Needs Analysis

Activities	Year 1				Year 2				Year 3			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Needs analysis survey												

Part of original plan Work undertaken or completed in this area New planned activity Deleted activity

During the planning stages of MSP-MAP we anticipated fielding a systematic survey of MSP needs for motivation-related measures. Subsequently, we determined that a targeted approach, which included discussions with MSPs likely to need such measures (e.g., ones that had included motivation in their evaluation plan), would be more productive than a formal needs survey.

Advisory Structure

Activities	Year 1				Year 2				Year 3			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Meetings with Local Steering Committee												
National Advisory Meeting												

Part of original plan Work undertaken or completed in this area New planned activity Deleted activity

A local advisory group (Caniglia, Coppola, Davis, Silver) met, with additional individual contacts at other times as necessary. A national advisory group has been formed and will meet during the second and the third year (in conjunction with the newly-planned dissemination conference). Discussions with local advisory group members has been useful in providing both perspective and important source material, especially in the area of beliefs about mathematics. The national advisory group will be brought into play as MSP-MAP acquires data using revised instruments (see data collection and analysis sections).

Selection of MSP Sites

Activities	Year 1				Year 2				Year 3			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Solicit/select MSP sites for data collection												

Part of original plan Work undertaken or completed in this area New planned activity Deleted activity

After being granted access in the second quarter we immediately began contacting MSPs and will continue during the remainder of the year, and anticipate continued contact and selection of MSP collaborators during the second (and possibly the third) year. This is an ongoing process, with due consideration for the number of MSPs we can accommodate. The MSP conference in January, 2004 was a critical part of the process, as we approached MSPs considered suitable and were approached by several. Plans are to use the MSP network to solicit sites to host the studies, with the MSPs benefiting in the process. We now have collaborative relationships with several MSPs, with others in the process of being established. Not all projects are NSF-funded MSPs. Rather, several have developed through collaboration with Heather Hill's RETA at the University has been distributed. Graduate students also will be designing studies that can be used for dissertations.

Data Collection

Activities	Year 1				Year 2				Year 3			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Data collection												
Data analysis												
Create and maintain data base												
Refine and revise scales and tools (students and teachers)												
Cognitive pre-testing study												

Part of original plan Work undertaken or completed in this area New planned activity Deleted activity

MSP-MAP has clearly exceeded its goals for Year 1 with respect to data collection, which was originally slated to take place in Year 2. Working with the TEAM-Math MSP, baseline data have been collected from students and will soon be from teachers, with data expected later this summer. The opportunity to begin analyses earlier in the timeline than originally planned will inform decisions regarding scale revisions currently under consideration. Accordingly, and as shown in the revised activity timeline table, we will soon begin creating our databases (in addition to those already created for project tracking) and refining scales. As planned, MSP-MAP will explore the utility of IRT analyses of motivation-related scales. At issue is whether scaling items (e.g., instead of equally weighting them) will be advantageous in terms of scale reliability and provide information that can ultimately improve upon current instrumentation. Activities in this area involve: 1) determining the potential of IRT analyses in the validation of motivation-related measures, 2) preliminary analyses of student achievement goal measures using an existing data set, and 3) capacity building in the form of software acquisition and staff training.

As we proceed with this phase, analyses will provide additional information about, and may raise critical issues concerning, the collaborative relationship between RETAs and MSPs—one additional benefit of the decision to accelerate completing one collaborative cycle. Note that we have extended both data collection and data analysis activities into Year 3. It is eminently clear, even at this early stage, that this will be necessary given commitments to multi-year MSPs conducting long-term longitudinal designs (some 5 years). It also suggests that MSP-MAP consider requesting supplemental funding beyond the original three years to accommodate those projects.

Furthermore, MSP-MAP will add cognitive pre-testing to its Year 2 activities. Cognitive pre-testing involves structured interviews of respondents to clarify the meaning of items and reasons given for responses. Such information is especially important for younger respondents, which are included in many MSP populations. Whereas pre-testing is sometimes employed in studies that create new scales, it is rarely used extensively. MSP-MAP will design, field, and analyze data from elementary through college students during Year 2. In addition to MSP staff, the study may involve other program graduate students and advanced undergraduates who will gain valuable research experience in the process of data collection and analysis.

Dissemination

Activities	Year 1				Year 2				Year 3			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Dissemination of tools on web												
Dissemination at conferences												
Preparation for publication												
Host Dissemination Conference												

Part of original plan Work undertaken or completed in this area New planned activity Deleted activity

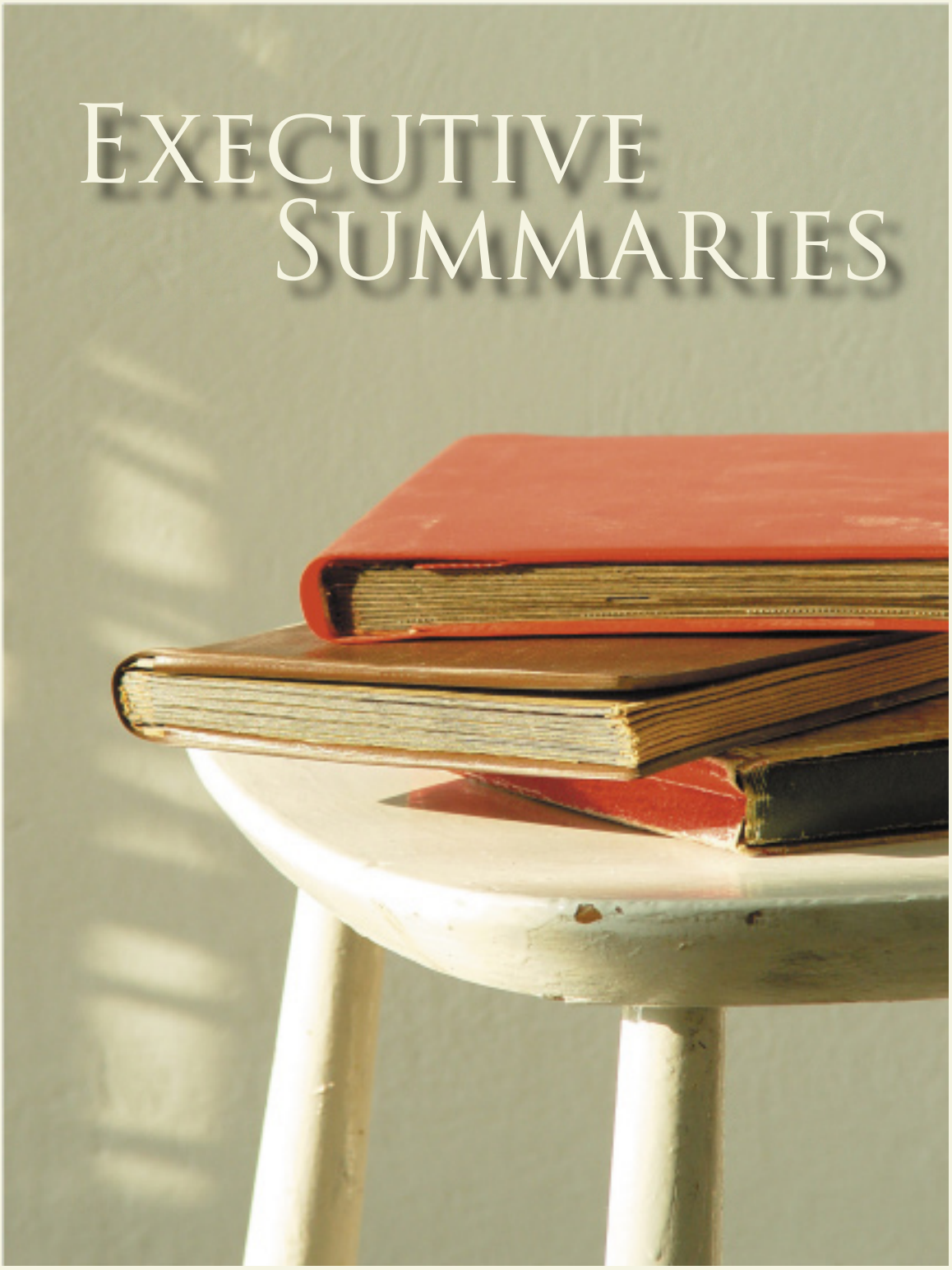
Our approach to dissemination has changed in response to alterations in the project timeline. Generally, as shown above, the consequences will be earlier and more extensive dissemination than originally planned. Initially, as noted elsewhere, MSP-MAP participated in an AERA symposium (April, 2004) in conjunction with other RETAs (a new, completed activity). The presentation featured MSP-MAP programmatic rationale for the inclusion of motivation-related measures in the NSF MSP initiative. Given completion of a collaborative cycle, we have proposed a symposium for the next AERA (2005) with TEAM-Math that will include descriptions of the collaboration (from the perspective of both the MSP and RETA), the process of scale selection, and results from the Year 1 data analysis. At the present time, a second symposium is under consideration on motivation-related measurement. We also anticipate submissions for publication earlier than previously anticipated. Finally, in addition to other forms of dissemination (e.g., web-based tools), we are considering a conference to be held at the University of Michigan during the final quarter of Year 3 that will showcase results of MSP-MAP, include participants from our advisory groups and collaborating MSPs, with invitations extended to the entire MSP network.

Literature Review Executive Summaries

Reviews of pertinent literature on motivation-related constructs and their assessment were conducted. MSP-MAP examined basic assumptions, considered alternative approaches to conceptualizing areas, and responded to the need for instruments that are appropriate for program evaluation. The following sections present executive summaries of these reviews. Generally, they include an overview of each area, definitions, importance, current evidence, and recommended future directions.

Note that in the full report to NSF these executive summaries were accompanied by extensive appended documentation that provided considerable detail and cited literature. Material in the appendices is considered work in progress, however, and deemed premature for dissemination at this point in time.

Executive Summaries



Interest & Value

Overview

This is an executive summary of the work of the group studying interest and value related constructs. To date we have conducted a thorough, if not exhaustive, search of the relevant literature. We have defined constructs, specified models, gathered measures, and made some suggestions for operationalizing important constructs. This summary highlights important points from the reviews and group discussions from the mini-conference on May 27, 2004. We review the reasoning behind studying these constructs, summarize our activities and findings thus far, and describe ongoing work in this area.

Interest — an individual's attraction to or liking of a specific activity or domain.

Task Value — students' beliefs about the interest, utility or importance of a task or domain.

Definitions

Interest. Personal interest refers to an individual's attraction, general liking, and enjoyment of a specific activity or domain (Pintrich & Schunk, 2002). This general attraction or enjoyment consists of both an affective or feeling component (e.g., liking) as well as a value component (e.g., the personal meaningfulness or relevance of the domain) (Schiefele, 2001). While personal interest can be thought of as arising out of a relatively stable and enduring relation between a person and an area of study (e.g., science), situational interest refers to interest that arises from the context or environment that may or may not last. Both catch and hold components are important. Catch refers to the stimulation of interest, which may be cognitive or sensory. In mathematics, catch could involve cognitive stimulation (puzzles), social stimulation (group work), and/or technology (most likely a form of cognitive stimulation). These catch aspects are distinct from hold in that they only momentarily grab attention but do not maintain engagement. Hidi et al., (2004) refer to these as "triggering" aspects of situational interest. In contrast, hold relates to the empowerment of students (e.g., Does the material help the students to see use the material to reach a goal or purpose? Does it have personal meaning for students?) (Mitchell, 1993). Within the domain of mathematics, hold can be categorized in terms of meaningfulness (are the math topics meaningful to their personal lives) and involvement (engaging students in the act of learning).

Task value. Task value beliefs focus on the general question "Why do I want to do this task?" (Eccles et al., 1998; Pintrich & Schunk, 2002). Four components of task value have been posited: attainment value, intrinsic or interest value, utility value, and cost (Eccles, 1983; Wigfield & Eccles, 2000). Intrinsic or interest value is the enjoyment the individual gets from performing the task, or the subjective interest they have in the subject. Utility value is how the task relates to future goals, and can be seen as capturing more extrinsic reasons for doing the task (e.g., valuing an organic chemistry class because of future plans to be a doctor). Attainment value is the importance to the self of doing well on a task. It is linked with identity and confirming or disconfirming salient aspects of the self, and represents more intrinsic reasons, as the task is valued in itself, not because it will get the individual some other valued goal. Cost refers to the accumulated negative aspects of engaging in the task, including anticipated emotional states (performance anxiety, fear of failure), and the amount of effort required to succeed at the task.

Why is it important to consider task value and interest?

Task Value. Students who believe that the domain is important to them personally and that the domain has some usefulness to them in terms of their future career goals have high task value beliefs. Longitudinal research by Eccles and her colleagues (e.g., Eccles, et al., 1998; Wigfield & Eccles, 2001) has shown that student beliefs about the importance and utility of mathematics lead them to enroll in more math courses in

the future. In addition, this motivational research has shown that task value beliefs lead to enrollment or choices to take more mathematics courses, but that once enrolled in the actual course, efficacy beliefs are more strongly related to actual performance or achievement. This differential role of efficacy and value beliefs is an important finding in motivational research, but still needs to be replicated with science courses as well as with different groups of students. While there is evidence that efficacy and value beliefs work in this manner in a generally white, middle class sample, it is not clear how they may operate with more diverse samples.

Interest. Eccles and her colleagues (Eccles, et al., 1998) have shown that personal interest is an important component of motivation and functions similarly to importance and utility value beliefs. In addition, other researchers have shown that high levels of personal interest lead to more cognitive engagement, self-regulation, and achievement (e.g., Hidi, Renninger, & Krapp, 2004; Koller, et al., 2001; Pintrich & Schunk, 2002) and that personal interest is also associated with the choice to take more courses, at least in the area of psychology (Harackiewicz, Barron, Tauer, & Elliot, 2002). Given the potential benefits of personal interest in predicting engagement, interest researchers (e.g., Hidi et al., 2004; Renninger & Hidi, 2002) have also begun to consider how situational interest might lead to long-term personal interest; however, there is very little empirical research documenting the development of personal interest through situational interest.

In many mathematics and science reform projects, the goal is to increase student interest and positive attitudes towards mathematics and science domains as well as interest in careers in these areas. Interest is an important outcome in its own right, as well as a potentially important mediator of achievement (Koller et al., 2001). The development of a good, valid measure of personal interest in mathematics and science would provide a very useful tool for MSP projects to document the effectiveness of their interventions in changing interest in mathematics and science.

What findings or recommendations have been made thus far?

• Though the original proposal to NSF discussed only personal interest constructs, it is clear that situational interest also is important to include. There are important distinctions between contexts that catch and hold students' interest. In addition, the hold component of situational interest needs to be considered in terms of both cognitive and affective components (e.g., value, feeling).

• Developmentally, research shows declining interest in math. Krapp's (2002) view of the development of interest is that perhaps students are not experiencing a decline in interest, but rather that they have well-developed interest in specific areas (e.g., algebra) but this is not tapped by general questions about "math." It is possible that students' interests become more differentiated over time, which would be difficult to assess using current measures. As we learn more about the curricula that are being implemented it will be possible to design more specific measures.

• There is a gap in research on interest in math and science. Indeed, a qualitative analysis conducted by Renninger, Ewen, and Lasher (2002) showed a different pattern regarding the relation of personal interest (including knowledge and value) with the way that students engaged in solving word problems in math, and their success in solving these problems, compared with the patterns observed between personal interest and text comprehension. This suggests the importance of more carefully examining the role of interest in these contexts. Furthermore, one might expect that the domains of math and science have a high likelihood of promoting situational interest given the current emphasis on authentic tasks. Yet, whether this situational interest eventually fosters personal interest is not clear. A developmental analysis of this process in the domains of math and science would be especially useful.

• Task value is a multifaceted construct, and there are at least three, and perhaps four, important components to consider: attainment value, intrinsic or interest value, utility value, and perhaps cost. The items currently used to measure utility and attainment value can sometimes be quite similar, and our project will need to revise some items (especially those that reference "importance") to better capture this theoretical distinction.

• Eccles et al., have been arguing recently that both absolute and relative values are important to consider. It matters not just whether students value math, but on how they value math compared to how they value other topic areas. These hierarchies likely exist for interest as well, but neither have received much attention to date.

• There is considerable overlap between interest and value constructs, but the terminology can make this difficult to see. When value theorists talk about interest, they consider a very limited construct that deals mainly with affective

responses to tasks or topic areas. When interest researchers consider value, they make no distinction between intrinsic and extrinsic reasons for valuing. We recommend drawing on both of these literatures to get a more complete picture of the motivational dynamics involved in students' decisions about whether they want to do particular tasks.

What work is ongoing?

Discussions at the mini-conference clarified two avenues for future work. First, it was agreed that the interest and value group should adapt and develop measures for personal interest and task value constructs. These measures should tap feeling, value, and knowledge components of interest, and attainment and utility components of task value. Measures of cost components are also being gathered and considered. Second, given the notable overlap between situational interest and measures of context, it was agreed that these two groups would work together to consider how interest is caught and held at the level of the context. The goal will be to have measures of context that incorporate important principles from these different literatures, particularly the larger catch/hold distinction and the different components of hold (feeling, value, involvement).

Situational Interest — arises from the context or environment; may or may not last.

References

Eccles, J. S. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motivation.* San Francisco, CA: W. H. Freeman.

Harackiewicz, J. M., Barron, K. E., Tauer, J. M., & Elliot, A. J. (2002). Predicting success in college: A longitudinal study of achievement goals and ability measures as predictors of interest and performance from freshman year through graduation. *Journal of Educational Psychology, 94,* 562-575.

Hidi, S., Renninger, K. A., & Krapp, A. (2004). Interest, a motivational variable that combines affective and cognitive functioning. In D. Dai & R. Sternberg (Eds.), *Motivation, emotion, and cognition: Perspectives on intellectual development and functioning* (pp. 89-115). Mahwah, NJ: Lawrence Erlbaum Associates.

Krapp, A. (2002). Structural and dynamic aspects of interest development: Theoretical considerations from an ontogenetic perspective. *Learning and Instruction, 12,* 383-409.

Mitchell, M. (1993). Situational interest: Its multifaceted structure in the secondary school mathematics classroom. *Journal of Educational Psychology, 85,* 424-436.

Renninger, K. A., Ewen, L., & Lasher, A. K. (2002). Individual interest as context in expository text and mathematical word problems. *Learning and Instruction, 12,* 467-491.

Schiefele, U. (2001). The role of interest in motivation and learning. In J. M. Collis & S. Messick (Eds.), *Intelligence and personality: Bridging the gap in theory and measurement* (pp. 163-194). Mahwah, NJ: Lawrence Erlbaum Associates.

Wigfield, A., & Eccles, J. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology, 25,* 68-81.

Self-Perceptions of Ability

Overview

MSP-MAP's work in the area of self-perceptions of ability has involved a comprehensive review of recent literature on ability-related constructs including self-concept, perceptions of competence, self-esteem, self-worth, self-efficacy, outcome expectations, expectancy for success, and perceived task difficulty. Efforts were made to clearly define each construct, compare across constructs to highlight conceptual similarities and differences, locate and begin to evaluate available measures, and establish a rationale for why MSPs should or should not include an assessment of each construct in its evaluation plan. Questions and issues in need of further discussion also were posed.

Constructs & Definitions

Self-Concept and Related Constructs. Self-concept refers to a person's appraisal of characteristics of the self, encompassing perceptions of competence in or across multiple domains as well as self-evaluative reactions to such appraisals (Bong & Skaalvik, 2003). Self-concept is most commonly conceptualized at a domain-specific level; however, these appraisals (both cognitive and affective) serve as a basis for general or global evaluations of self (Bandura, 1981; Bong & Skaalvik, 2003; Harter, 1982; Marsh, 1993; Shavelson et al., 1976). Self-concept is considered to be organized, multifaceted, hierarchical, stable, developmental, evaluative, and differentiable. It is primarily derived from social experiences (including opportunities for comparison with others of differing ability as well as feedback or evaluation received from others regarding performance), mastery experiences (including opportunities to test skills) and attributions for successes and failures (Covington, 1992; Skaalvik, 1997). These self-beliefs appear to have strong reciprocal relations with achievement, particularly at the domain-specific level (Skaalvik, 1997).

The cognitive component of self-concept is often assessed by itself (without the affective component) as competence (Harter, 1982), task-specific self-concept or self-concept of ability (Eccles, Wigfield, and colleagues, various studies), and academic self-esteem (Skaalvik, 1986, 1990a, 1990b). All of these terms are intended to capture an individual's estimation of current ability given past experiences or relative to others in a particular domain. This estimation is considered to be relatively stable, although subject-specific self-perceptions of ability have been found to gradually decline over time (Eccles, Midgley, & Adler, 1984; Pintrich & Schunk, 2000).

The affective component of self-concept is generally assessed with measures of self-esteem or self-worth (e.g., "Overall, I have a lot to be proud of"). Self-esteem is more stable over time than are competence beliefs (i.e., the cognitive component of self-concept). Self-esteem is also relatively resistant to changes in self-perceptions of ability (Wigfield, Eccles, & Rodriguez, 1998), however, changes in self-esteem are more likely to occur when ability perceptions decline or improve for a domain which is deemed particularly important to the individual (Harter, 1985, 1990).

Self-Efficacy and Related Constructs. Self-efficacy is defined as a person's belief about what she can accomplish with whatever skills and abilities she possesses (Bong & Skaalvik, 2003). They represent beliefs in one's capability to organize and execute the courses of action required to manage prospective situations and to attain designated types of performances (Bandura, 1986, 1997). Self-efficacy beliefs are future-oriented (short-term or long-term), domain-specific / context specific, and are malleable. Sources of these beliefs include mastery experiences, vicarious experiences (e.g., modeling), social persuasion (e.g., pep talk), and somatic and emotional states (e.g. anxiety) (Bandura, 1997). Self-efficacy beliefs influence a range of behavioral outcomes (e.g., choice, effort, persistence, self-regulation, and performance) and have been found to mediate the effect of prior achievement on performance, and moderate the effect of other motivation-related variables on performance (see Pajares 1997, Pajares & Schunk, 2001 for reviews).

Outcome expectations are defined as the anticipated result of engaging in a task and/or perceived environmental contingency (Bandura, 1986). Outcome expectations can be determined entirely, partially, or not at all by efficacy beliefs. For example, one can have high efficacy for doing math, and hold the expectation that he will get a majority of problems correct. However, any expectation regarding what grade he will likely receive may depend on (be contingent upon) environmental constraints beyond the subject's control (e.g., grading system, teacher bias) (Pajares, 1997). Outcome expectations are related to performance, but are weaker predictors than self-efficacy (Shell et al., 1989).

Expectancy for success is an individual's subjective belief about the probability of "success," however that is defined (Pintrich & Schunk, 2000). This construct is similar to outcome expectations in that they both involve the anticipated outcome of engaging in a task, however expectancy for success represents the assignment of a probability of a "successful" outcome expectation. Expectancies are assumed to be influenced by task-specific beliefs, such as self-concept of ability, perceived task difficulty, goals, self-schema (e.g., sex-role identity), affective memories, individuals' perceptions of previous achievement experiences, and by other socialization influences (Wigfield & Eccles, 2000). For example, a girl's expectancy for success (e.g., how well she expects to do in math this year), may in part be determined by how competent she perceives herself to be in that domain, as well as by the extent to which she endorses stereotypic beliefs about how well girls perform relative to boys in math.

Perceived task difficulty represents students' judgments of the difficulty or demands of a task, particularly in relation to other domains. "Task" is operationalized at a domain-specific level (i.e., doing math) in this scale (Eccles & Wigfield, 1995). According to Eccles (1983), self-concept of ability and perceived task difficulty interact in predicting expectancies for success (although self-concept of ability appears to be the more critical construct). Effects of this variable are consistent but small in terms of predicting achievement expectancies or achievement behavior (Eccles, 1983).

When self-efficacy and self-concept beliefs are assessed at the same level of specificity, they tend to predict achievement equally well.

Rationale for Including Constructs in Evaluation

Academic Self-Concept. Academic self-concept is now most commonly assessed using various measures of subject-specific self-perceptions of competence or ability, sometimes combined with items assessing affect or interest (e.g., Self-Description Questionnaire (SDQ); Marsh, 1992). Although research utilizing the SDQ is still quite common, Eccles and her colleagues have shown repeatedly that interest and competence in particular subjects are predictive of different outcomes. Thus, it seems most appropriate to utilize separate constructs, rather than comprehensive measures like those that appear in the SDQ.

Academic Self-Concept vs. Self-Efficacy. When self-efficacy and self-concept beliefs are assessed at the same level of specificity (such as the domain level of mathematics), they tend to predict achievement equally well (Skaalvik & Rankin, 1996). But when efficacy is assessed at a task-specific level (e.g., "How confident are you that you can get all of the following math problems correct?"), it is a stronger predictor of performance than domain-level self-concept (e.g., "I am good at mathematics.") (Pajares & Graham, 1999; Pajares & Miller, 1994). Self-efficacy may be more resilient to changes in achievement than academic self-concept, as it is often focused on specific tasks rather than general abilities. Research suggests that self-efficacy can be improved in relatively short periods, by teaching students to use more efficient learning strategies and to set goals, and by providing appropriate attributional and progress-related feedback. Increases in efficacy were found to relate to increases in achievement (Schunk, 1982, 1993). Competence beliefs, however, may change more slowly, and show less change with respect to teacher practices or interventions.

Outcome Expectations. The assessment of outcome expectations is probably of low priority unless MSPs are particularly interested in students' perceptions of environmental constraints that influence the contingency between effort/capability and "success" (e.g., teacher bias). Otherwise, since 1) the effect of outcome expectations on achievement-related behaviors is assumed to be mediated by self-efficacy judgments, 2) these beliefs are weaker predictors of academic performance than are self-efficacy beliefs, and 3)

outcome expectation scales are operationally similar to perceptions of utility value, there seems to be few other reasons to offer such a measure.

Expectancy for Success. Measuring expectancy for success may be preferable to measuring self-efficacy in the following situations: 1) when exploring research questions aligned with an expectancy-value framework, 2) when outcome variables involve course selection or career choice, which are influenced by whether or not the student expects to get a good grade or achieve "professional success," particularly when contingency is between one's capability to perform requisite skills and success is perceived to be low (e.g., women in mathematics-related careers).

Measuring expectancy for success may be preferable to measuring self-efficacy when exploring research questions aligned with an expectancy-value framework.

Perceived Task Difficulty. Perceived task difficulty would not be a suitable substitute for any of the other constructs discussed in this document. However, since it is one of a set of variables that directly influence expectancy for success it may be useful in situations in which MSPs are 1) very interested in the nature of students' expectations for success, or 2) implementing challenging curricula and are interested students' perceptions of such curricula relative to other subjects.

Questions/Issues

• Appropriate use of self-efficacy measures would require a detailed account of the MSPs intervention (in order to make the assessment task-specific and aligned with the performance / achievement outcomes); however it has been difficult getting this level of detail from our collaborators.

• Would we include task-level efficacy statements as well as domain-level efficacies? For example, if interventions are targeted at improving specific mathematical or scientific skills through teacher training interventions? If so, then an efficacy scale that captures greater specificity than competence or efficacy at the domain level would be appropriate.

• We could assess both domain and task-specific efficacies, testing the theory that efficacy, like self-concept, is hierarchical in nature; i.e., that specific efficacies predict variance in general efficacies.

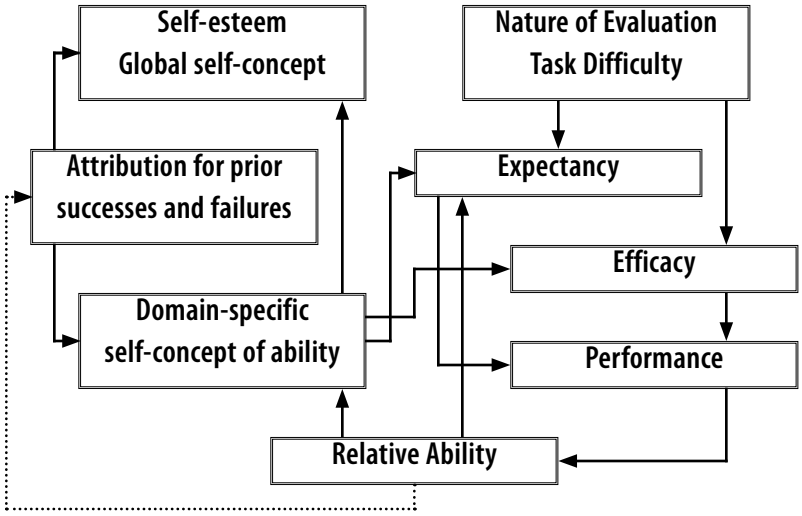
• Is it redundant to assess both efficacy and expectancy? Expectancy is generally domain-specific, can include comparisons to others, and is focused on the outcome; whereas efficacy is often task-specific, goal-referent, and focused on what it takes to get to a successful outcome (capability). However, both are predictive of achievement-related outcomes. How do we make this decision?

• Should competence beliefs be assessed in addition to efficacies? Are we as a group interested in helping to clarify the relation between competence, efficacy, and achievement, for either teachers or students?

Future Directions

Discussions clarified two avenues for future work. First, it was agreed that MSP-MAP should create self-efficacy scales at a "middle-level" of specificity. That is something more specific than "I'm certain I can do everything taught in math this year" but not quite as specific as "I'm certain I can correctly answer the following problem..." Second, we decided that it would be helpful to create a list of situations in which the use of academic self-concept (competence) would be preferable to self-efficacy and vice versa. A similar procedure will be followed for the expectancy for success construct. Rationale will need to accompany these recommendations.

Overall Model of Self-Perceptions and Achievement



Contextual Factors

- Feedback from peers and teachers
- Goal structure of classroom
- Opportunities for challenge and mastery

Measures Reviewed

- Self Description Questionnaire (SDQ) (Marsh, 1992)
- Academic SDQ (ASDQ I and II) (Marsh, 1992)
- Task-Specific Self-Concept (Wigfield et al., 1997)
- Perceived Competence Scale (Harter, 1982)
- Academic Self-Esteem Scale (Skaalvik, 1986)
- Rosenberg Self-Esteem Inventory (Rosenberg, 1965)
- Academic Self-Efficacy (PALS; Midgley et al., 2000)
- Problems Self-Efficacy (Pajares & Graham, 1999)
- Tasks Self-Efficacy (Pajares & Miller, 1995)
- Writing Self-Efficacy Instrument (Shell et al., 1989)
- Efficacy Beliefs in Science (CRESST, 2000)
- Outcome Expectations (Shell et al., 1995)
- Expectancy Beliefs (Wigfield et al., 1997)
- Perceived Task Difficulty (Eccles & Wigfield, 1995)

References

Atkinson, J. (1957). Motivational determinants of risk-taking behavior. *Psychological Review, 84,* 359-372.

CRESST (2000). *CRESST high school science study construct codebook, General science survey for students.* University of California, Los Angeles: CRESST.

Eccles, J., Midgley, C., & Adler, T. (1984). Grade-related changes in the school environment: Effects on achievement motivation. In J. G. Nicholls (Ed.), *The development of achievement motivation.* Greenwich, CT: JAI Press.

Harter, S. (1985). *Manual for the self-perception profile for children.* Denver: University of Denver.

Marsh, H. (1989). Age and sex effects in multiple dimensions of self-concept: Preadolescence to early adulthood. *Journal of Educational Psychology, 81,* 417- 430.

Marsh, H. (1992). *Self Description Questionnaire (SDQ) I: A theoretical and empirical basis for the measurement of multiple dimensions of preadolescent self-concept: A test manual and research monograph.* Macarthur, New South Wales, Australia: University of Western Sydney, Faculty of Education.

Marsh, H. (1992). *Self Description Questionnaire (SDQ) II: A theoretical and empirical basis for the measurement of multiple dimensions of adolescent self-concept.* Macarthur, New South Wales, Australia: University of Western Sydney, Faculty of Education.

Marsh, H. (1992). *Self Description Questionnaire (SDQ) III: A theoretical and empirical basis for the measurement of multiple dimensions of late adolescent self-concept: An interim test manual and research monograph.* Macarthur, New South Wales, Australia: University of Western Sydney, Faculty of Education.

Marsh, H., Roche, L., Pajares, F., & Miller, D. (1997). Item-specific efficacy judgments in mathematical problem solving: The downside of standing too close to trees in a forest. *Contemporary Educational Psychology, 22,* 363-377.

Pajares, F. (1994). Inviting self-efficacy: The role of invitations in the development of confidence and competence in writing. *Journal of Invitational Theory and Practice, 3,* 13-24.

Pintrich, P. R., & Schunk, D. (2001). *Motivation in education: Theory, research, and applications.* Upper Saddle River, NJ: Merrill-Prentice Hall.

Shavelson, R., Hubner, J., & Stanton, G. (1976). Self-concept: Validation of construct interpretations. *Review of Educational Research, 46,* 407-441.

Skaalvik, E. (1986). Sex differences in global self-esteem: A research review. *Scandinavian Journal of Educational Research, 30,* 167-179.

Stipek, D., & Mac Iver, D. (1989). Developmental change in children's assessment of intellectual competence. *Child Development, 60,* 521-538.

Wigfield, A. (1995). Middle grades schooling and early adolescent development: Interventions, practices, beliefs, and contexts. *Journal of Early Adolescence, 15,* 5-8.

Wigfield, A., Eccles, J., & Rodriguez, D. (1998). The development of children's motivation in school contexts. In A. Iran-Nejad & P. D. Pearson (Eds.), *Review of research in education* (Vol. 23, pp. 73-118). Washington, DC: American Educational Research Association.

Classroom Context

Overview

The primary objective of the context review involved examining established measures of students' perceptions of the classroom context that have been found to relate to student motivation. (Note that while there are also scales that assess students' perceptions of the school context and those that assess teacher's perceptions of both the classroom and school context, we do not include these scales in our review.) As a portion of this review, we created an accompanying heuristic schematic to represent the collected classroom context measures (see Figure 1). This schematic provides a visual representation given our collected measures and review of the literature on perceptions of the classroom context. A major reason for this current effort is that the perceptions of context literature presents such a wide range of constructs assessing the various features of the context. Our next steps involve reviewing these measures with a different lens focused on grappling with the theoretical and measurement issues raised by these scales.

Perceptions of the Classroom Context

As a first level of organization, we distinguish between measures that assess students' perceptions of the classroom environment (e.g. academic tasks, climate) from those scales that specifically relate to perceptions of the classroom teacher (e.g. quality of teacher's instruction, teacher support). As a second tier of this organization, we have classified scales specific to perceptions of the classroom environment into 3 primary categories (see Figure 1). The TARGET acronym, first coined by Epstein in 1989, has since been used by numerous researchers to describe six primary features of the classroom that are believed to affect motivation (Ames, 1992). They include Task, Autonomy, Recognition, Grouping, Evaluation, and Time. Because different motivational theories and their perspectives have contributed to this literature on classroom perceptions we include their work subsumed under the TARGET framework as well. For example, while the research emerging from Self-Determination Theory (SDT) does not use the language of TARGET per se, their proposed construct of autonomy relates to that conceptualized by Epstein and Ames. Also classified under the TARGET acronym are measures of perceived classroom goal structure. Classroom goal structure is intimately related to many of the TARGET dimensions. For example, Ames (1992) argues that a mastery-focused classroom (as assessed by a classroom mastery goal structure scale) would be characterized by challenging tasks that allow students to develop their understanding/skills, non-normative evaluation practices, the promotion of autonomy and decision making, and cooperative reward structures. In contrast, a performance-focused classroom (assessed by a classroom performance goal scale) is one that emphasizes competition, social comparison, and normative grading practices. Due to the highly interrelated nature of these two types of measures, we have aligned them closely within the flow chart.

A second category under perceptions of the classroom environment is standards-based reform measures. In particular, the standards-based reform movements in the areas of math and science have generated new curricula that reflect current standards and have created professional development efforts to encourage teachers' familiarity with standards (e.g., Race & Powell, 2000). These reform efforts draw heavily from a social constructivist philosophy and hands-on learning, inquiry and problem-based instruction, and an emphasis on student construction of knowledge (e.g. through group work and discourse). A few of these reform efforts also have created or collected survey measures to asses students' perceptions of these instructional practices and aspects of the classroom climate. While we have subdivided this broader category into sub-emphases (i.e., real world applications), the general category is designed to hit measures that assess students' perceptions of these reform efforts at a more global level. One of the major questions that we have been considering regarding these standards-based reform measures concerns those issues that arise when working with measures that assess multiple constructs within one scale. We are currently grappling with the utility, advantages, and disadvantages posed by such scales (discussed during the mini-conference on May 27, 2004).

A third category classified under students' perceptions of the classroom environment is classroom management. The notion of classroom management includes the presence of rules and procedures used in classrooms, teacher control, and time on task (e.g. Moos, 1980). Because these components also may draw on students' perceptions of their teacher (and not just perceptions of the classroom environment), the operationalization of the classroom management construct may fall under both of these classifications.

Teacher-Related Perceptions

Measures that specifically relate to students' perceptions of their teacher were included in this category of classroom context. The three main subcategories under this heading include students' perceptions of the quality of instruction, teacher support, and teacher motivation.

In terms of measures assessing the quality of instruction, it is important to note that many of the established measures rely on objective accounts of instructional practice, and therefore rely on classroom observations. We conceptualized quality of instruction as encompassing such teacher strategies as scaffolding student understanding and pressing for student understanding, because these are representative of the few instructional practices that have survey measures. Here, we assert that it is the students' *perceptions* of what is occurring in the classroom that will ultimately impact their learning and achievement, regardless of what an objective measure may conclude; therefore, it is important to note that while these measures can be assessed from teacher questionnaires and observations, we have focused mainly on how students perceive teacher actions and attitudes as influencing the classroom context. One concern of this particular subcategory is the relatively few measures that have been designed to assess student perceptions of the quality of instruction. In particular, there are a variety of features of a teacher's instruction that are not being tapped by these survey measures and a heavier emphasis on social constructivist practices.

The second subcategory is teacher support with a focus on students' perceptions of their relationship with their classroom teacher. These scales range from teachers' support of group work to students' perceptions that their teacher is respectful, fair, caring, and helpful when students have questions. Given the reviewed measures, we make a distinction between classroom level and individual level teacher support. This dichotomy was maintained because of the framing of different scales that examine perceptions of teacher support. For example, some measures assess how students feel the teacher treats them as an individual (e.g., "My teacher really cares about me"), while others assess more classroom level support (e.g., "My teacher encourages us to ask questions when we do not understand something").

The third subcategory is teacher motivation. Within our review, we have found only a few scales that assess students' perceptions of their teacher's motivation for teaching or the subject area. We conceptualize this particular category as incorporating those survey items that ask students to report on their teacher's levels of enthusiasm and energy when teaching and their general affect in the classroom. Thus far, however, we have only found a few items that can be classified here. These items ask students to report on their teacher's liking of their subject area (e.g. "The teacher likes math"). We continue to search for the literature for related scales.

Future Directions

Discussions at the mini-conference focused mainly on two recommendations for future work. First, there is an issue concerning the considerable conceptual overlap among scales. In particular, as was noted in issues related to standards-based reform assessment above, there are classroom perception scales that incorporate multiple constructs. This issue calls for us to re-classify scales into our proposed organization system before embarking on a more thorough review of theoretical issues related to these measures.

Second, as noted in the interest/value report, the overlap of context measures and components of situational interest warrants further work to identify whether and how a distinction between the two constructs is warranted. The need for conceptual clarity when referring to various constructs is extremely important and will serve as a useful and necessary tool when discussing the influence of classroom context on student achievement.

In terms of next steps, the classroom context group intends to continue the collection and organization of appropriate measures. In addition, we will continue to consider which of these measures are most appropriate for recommending to participating MSPs. Again, given the wide range of potential scales and constructs that could be assessed in science and mathematics classrooms, it is critical to consider the relevance and influence of measures on student achievement and motivation-related outcomes. Finally, a large portion of our upcoming work will be to highlight and explore the issues of currently employed measures.

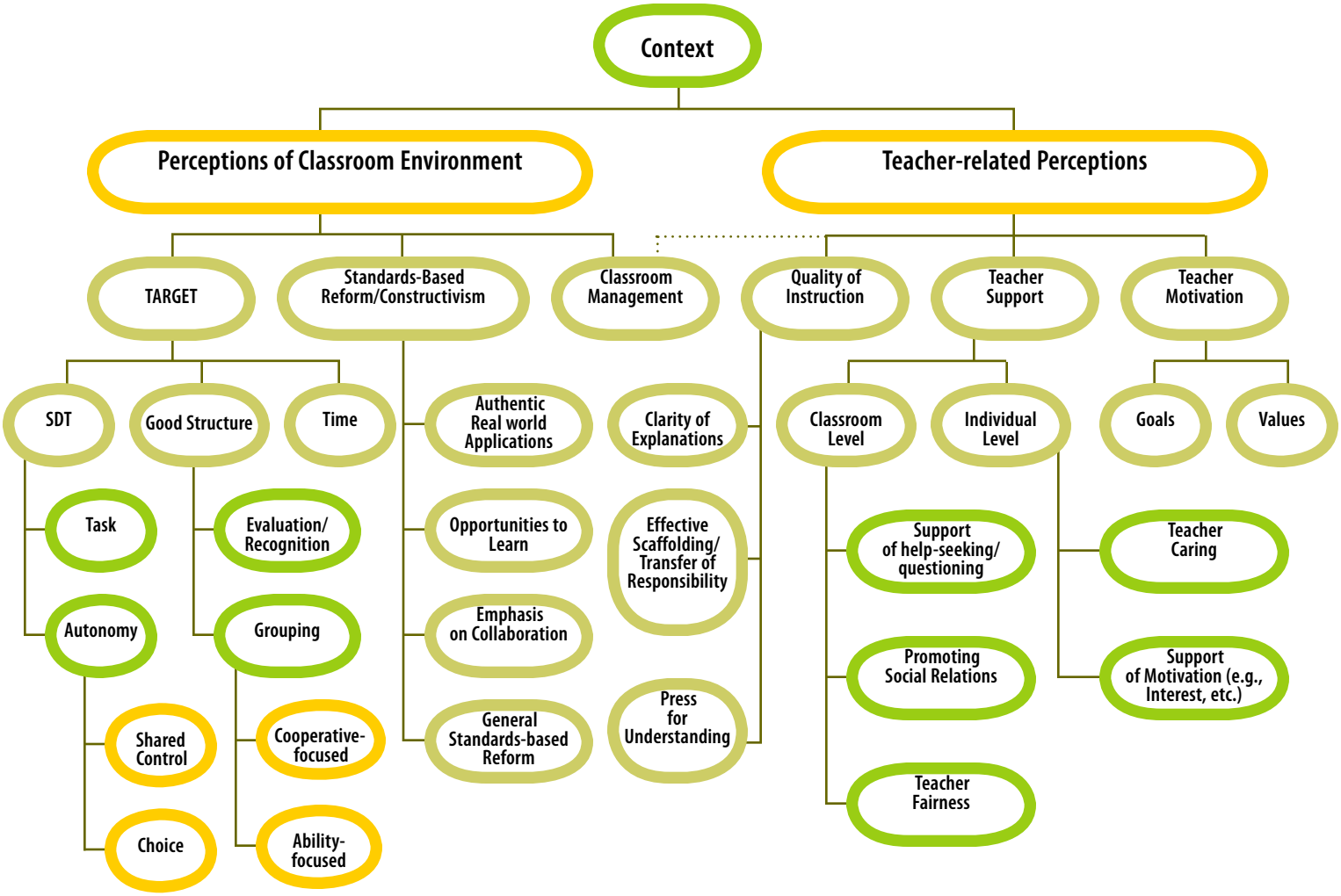


Figure 1. Schematic of context-related constructs and their relationships.

Teacher Identity

Overview

The teacher identity group has been focused on developing a substantive conceptual analysis of the link between identity and teacher practice. This analysis stands as a precursor to the development of an appropriate measure of teacher identity that has relevance to the existing MSP projects that we support. The clear rationale for including measures of identity in the measurement bank is that how teachers teach is affected by who they believe themselves to be. Teacher identity is thus the filter for, and determinant of, teacher practice.

How teachers teach is affected by who they believe themselves to be.

This rationale is developed in extant models that present teacher identity as a way of seeing, defining or being a self (Beijaard, Verloop, & Vermunt, 2000; Eick & Reed, 2002; Friesen, Finney, & Krentz, 1999; Helms, 1998; Volkmann & Anderson, 1997). A distinction is often drawn between personal identity and professional identity, where the former is a unique self that is a counterpoint to the latter, which is described in terms of social roles and expectations. These models of teacher identity reflect an underlying division between the personal and social determinants of identity. This is an overarching theme pervading all theory and research upon identity, which does not have teacher identity as its sole subject.

This distinction between personal and social determinants of identity runs through familiar and popular identity constructs that have not specifically treated teachers as a subject, such as Erikson's psychodynamic model (Erikson, 1959; Erikson, 1968; Erikson, 1982), followed by Marcia's and then Adams's ego identity status model (Adams, Shea, & Fitch, 1979; Marcia, 1966). Models which specifically highlight the distinction are Cheek's (Cheek & Briggs, 1982) and Côte's (Côté & Schwartz, 2002): others include identity theory (Burke & Tully, 1977; Stryker & Burke, 2000), social identity theory (Tajfel, 1982; Turner, 1978) and approaches that highlight narrative (McAdams, 1988) or social construction (Vygotsky, 1978; Wenger, 1998).

There are few established empirical measures of identity. Paper and pencil measures include the Twenty Statements Test (Kuhn & McPartland, 1954), the Aspects of Identity Questionnaire (Cheek & Briggs, 1982), the Objective Measure of Ego Identity Status (Bennion & Adams, 1986). None of these was formulated specifically with teachers in mind and none is particularly suitable for the measurement of teacher identity. Measurement of teacher identity has predominantly been conducted using qualitative techniques and has relied in the main upon interview data. The primary task of the identity group, then, is to develop items for a new teacher identity measure that will capture both the social and personal determinants of identity formation as they relate to the particular context in question, that is the mathematics or science classroom.

References

Adams, G. R., Shea, J., & Fitch, S. A. (1979). Toward the development of an objective assessment of ego-identity status. *Journal of Youth and Adolescence, 8*(2), 223-237.

Beijaard, D., Verloop, N., & Vermunt, J. D. (2000). Teachers' perceptions of professional identity: an exploratory study form a personal knowledge perspective. *Teaching and Teacher Education, 16,* 749-764.

Bennion, L. D., & Adams, G. R. (1986). A revision of the extended version of the Objective Measure of Ego Identity Status: An identity instrument for use with late adolescents. *Journal of Adolescent Research, 1,* 183-198.

Burke, P. J., & Tully, J. (1977). The measurement of role identity. *Social Forces, 55,* 881-897.

Cheek, J. M., & Briggs, S. R. (1982). Self-consciousness and aspects of identity. *Journal of Research in Personality, 16,* 401-408.

Côté, J. E., & Schwartz, S. J. (2002). Comparing psychological and sociological approaches to identity: identity status, identity capital, and the individualization process. *Journal of Adolescence, 25,* 571-586.

Eick, C. J., & Reed, C. J. (2002). What makes an inquiry-oriented science teacher? The influence of learning histories on student teacher role identity and practice. *Science Teacher Education, 86,* 401-416.

Erikson, E. H. (1959). *Identity and the life cycle* (Vol. 1, No. 1). New York: International Universities Press.

Erikson, E. H. (1968). *Identity: Youth and crisis.* New York: Norton.

Erikson, E. H. (1982). *The life cycle completed: A review.* New York: W W Norton & Company.

Friesen, D. W., Finney, S., & Krentz, C. (1999). Together against all odds: towards understanding the identities of teachers of at risk students. *Teaching and Teacher Education, 15,* 923-932.

Helms, J. V. (1998). Science - and Me: subject matter and identity in secondary school science teachers. *Journal of Research in Science Teaching, 35*(7), 811-834.

Kuhn, M. H., & McPartland, T. S. (1954). An empirical investigation of self-attitudes. *American Sociological Review, 19*(1), 68-76.

Marcia, J. E. (1966). Development and validation of ego identity status. *Journal of Personality and Social Psychology, 3,* 551-558.

McAdams, D. P. (1988). *Power, intimacy, and the life story.* New York: The Guilford Press.

Stryker, S., & Burke, P. J. (2000). The past, present, and future of an identity theory. *Social Psychology Quarterly, 63*(4), 284-297.

Tajfel, H. (1982). *Social identity and intergroup relations.* New York: Cambridge University Press.

Turner, J. C. (1978). Social categorization and social discrimination in the minimal group paradigm. In H. Tajfel (Ed.), *Differentiation between social groups: Studies in the social psychology of intergroup relations.* London: Academic Press.

Volkmann, M. J., & Anderson, M. A. (1997). Creating professional identity: dilemmas and metaphors of a first-year chemistry teacher. *Science Teacher Education, 82,* 293-310.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge: Harvard University Press.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity* (1999 ed.). Cambridge: Cambridge University Press.

Epistemological Beliefs

Overview

Beliefs about knowledge and knowing appear to influence achievement in math and science.

Beliefs about knowledge and knowing, or what has been called "epistemological beliefs" or "personal epistemology," appear to influence achievement in math and science, and thus this is one of the areas in which we are working to review and develop assessment instruments for math and science educators. The first year of the project has been focused on initiating a review of the extant literature, examining existing instruments that measure beliefs in math and science, discussing the needs of interested project directors, and working on development of instruments that may be useful to MSP projects.

We have reviewed three approaches to measuring epistemological beliefs through written instrumentation that could be potentially germane to this project: 1) use of a domain-general instrument (Schommer, Crouse, & Rhodes, 1992; Schraw, Bendixen, & Dunkle, 2002); 2) use of domain-specific instruments that can be adapted to particular disciplines (Buehl, 2001; Hofer, 2000); and 3) use of instruments that are specific to beliefs in particular disciplines, e.g., "math beliefs" (Peterson, Fennema, Carpenter, & Loef, 1989; Schoenfeld, 1992; Schommer et al., 1992) and "science beliefs" (Conley, Pintrich, Vekiri, & Harrison, 2004; Elder, 2002; Songer & Linn, 1991). Earlier work in this area suggests that the domain-general approach is likely to be least productive or theoretically sound (Hofer & Pintrich, 1997) and that students do have differing beliefs both by discipline (Buehl, Alexander, & Murphy, 2002; Hofer, 2000) and about disciplines (Hammer, 1994; Hofer, 1999; Schoenfeld, 1983). We have concluded that a domain-specific instrument that combines elements of the second two approaches identified above would be of most use to math and science educators.

Our current working strategy is to adapt an existing domain-specific instrument (Hofer, 2000) to uses within the MSP projects. This instrument, devised from a thorough review of the literature on epistemological beliefs, has 35 items measured on a Likert-type scale. Students are asked to indicate level of agreement with such items as "In this subject, most questions have only one right answer." The instrument has a header that specifies the subject under consideration, and can be used in a general manner to distinguish disciplines such as "math" or "science" or can be directed toward more specific subfields such as "geometry" or "chemistry." We have been continuing to refine this instrument to increase reliability of the measures and plan further testing and analyses this coming year. Although our review of the literature suggests that most of the epistemological beliefs pertinent to math and science learning can be captured in this way, we are also identifying beliefs that are more specific in nature. Thus the instrument will also include the addition of beliefs about math and science (e.g., "Scientific knowledge is verified by experiment," and "Mathematics is a solitary activity, done by individuals in isolation").

During the second year of the project we plan to continue refining the instrument, testing it within interested projects, working on the relation between teacher and student beliefs and how teacher belief instruments can be utilized within those projects focused on teacher training, and identifying how epistemological beliefs serve as mediator and moderator of achievement in mathematics and science.

References

Buehl, M. M., & Alexander, P. A. (2001). Beliefs about academic knowledge. *Educational Psychology Review, 13*(4), 385-418.

Buehl, M. M., Alexander, P. A., & Murphy, P. K. (2002). Beliefs about schooled knowledge: Domain specific or domain general? *Contemporary Educational Psychology, 27,* 415-449.

Conley, A. M., Pintrich, P. R., Vekiri, I., & Harrison, D. (2004). Changes in epistemological beliefs in elementary science students. *Contemporary Educational Psychology, 29,* 186-204.

Elder, A. D. (2002). Characterizing fifth-grade students' epistemological beliefs in science. *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 321-346). Mahwah, NJ: Erlbaum.

Hammer, D. (1994). Epistemological beliefs in introductory physics. *Cognition and Instruction, 12*(2), 151-183.

Hofer, B. K. (1999). Instructional context in the college mathematics classroom: Epistemological beliefs and student motivation. *Journal of Staff, Program, and Organizational Development, 16*(2), 73-82.

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology, 25,* 378-405.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research, 67,* 88-140.

Peterson, P. L., Fennema, E., Carpenter, T., & Loef, M. (1989). Teachers' pedagogical content beliefs in mathematics. *Cognition and Instruction, 6,* 1-40.

Schoenfeld, A. (1983). Beyond the purely cognitive: Belief systems, social cognitions, and metacognitions as driving forces in intellectual performance. *Cognitive Science, 7*(4), 329-363.

Schoenfeld, A. (1992). Learning to think mathematically: Problem solving, metacognition and sense making in mathematics. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 334-370). New York: Macmillan.

Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs and mathematical text comprehension: Believing it is simple does not make it so. *Journal of Educational Psychology, 82,* 435-443.

Schraw, G., Bendixen, L. D., & Dunkle, M. E. (2002). Development and evaluation of the Epistemic Belief Inventory (EBI). In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 261-275). Mahwah, NJ: Erlbaum.

Songer, N. B., & Linn, M. C. (1991). How do students' views of science influence knowledge integration? *Journal of Research on Science Teaching, 28,* 761-784.