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Using qualitative methods to develop a survey measure of math and science engagement

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ABSTRACT

Student engagement in math and science is vital to students' academic achievement and long-term participation in science, technology, engineering, and mathematic (STEM) courses and careers. In this study, we conducted in-depth interviews with 106 students from sixth to twelfth grade and 34 middle and high school teachers about how they conceptualized math and science engagement and disengagement. Our qualitative analysis of student and teacher interviews supported the multidimensional construct of engagement outlined in the academic literature. Our analysis also revealed additional indicators that have been included in prior measures of engagement less frequently. We then described how we used this qualitative information from students and teachers to develop and validate a new student self-report measure of math and science engagement.

Student engagement in math and science is vital to students' academic achievement and long-term participation in science, technology, engineering, and mathematics (STEM) courses and careers. A growing body of research links student engagement in math and science to higher grades, higher standardized test scores, and a greater likelihood of enrolling in advanced math and science classes (Lent, Sheu, Singley, Schmdit, & Gloster, 2008; Maltese & Tai, 2010). Because engagement is a robust predictor of educational outcomes and a malleable state that can be increased by making improvements to the social and academic context, it holds tremendous potential as a key target for interventions (Appleton, Christenson, & Furlong, 2008).

Unfortunately, math and science engagement declines during the middle and high school years, particularly among minority and low-income students (Martin, Way, Bobis, & Anderson, 2015; Wigfield, Byrnes, & Eccles, 2006). This is problematic because every career requires a basic understanding of *math*, and advanced careers in the STEM fields are unattainable without a strong foundation of *math* and *science* (e.g., physics, chemistry, biology) skills. Currently, the number of students choosing STEM careers does not meet the demand (U.S. Congress Joint Economic Committee, 2012). An important component of ensuring our nation's economic future is increasing the number of students who pursue STEM careers, especially among students who have been traditionally underrepresented in these domains.

1. What is engagement?

Although there has been a dramatic increase in research on student engagement over the past two decades, inconsistencies in the definitions and measurement of this construct persist (Appleton et al., 2008; Christenson, Reschly, & Wylie, 2012; Fredricks, Blumenfeld, & Paris, 2004). Despite these inconsistencies, there is broad agreement in the academic literature that student engagement is a multidimensional construct, though there has been variation in both the number of dimensions (ranging from 2 to 4) and the indicators of each dimension. The most prevalent conceptualization in the academic literature is that engagement consists of three distinct, yet interrelated dimensions – behavioral, emotional/affective, and cognitive engagement (Fredricks et al., 2004). In the literature, *behavioral engagement* is defined in terms of participation, effort, attention, persistence, positive conduct, and the absence of disruptive behavior (Fredricks et al., 2004). *Emotional engagement* focuses on the extent of positive

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(and negative) reactions to teachers, classmates, academics, or school; individuals' sense of belonging; and identification with school or subject domains (Finn, 1989; Voelkl, 1997). *Cognitive engagement* is defined as the student's level of investment in learning. It includes being thoughtful, strategic, and willing to exert the necessary effort for comprehension of complex ideas or mastery of difficult skills (Fredricks et al., 2004; Meece, Blumenfeld, & Hoyle, 1988).

Recently, some scholars have added a social dimension to these conceptualizations of engagement to reflect the increasingly important role that social interactions play in learning. For example, Linnenbrink-Garcia, Rogat, and Koskey (2011) included a social-behavioral dimension of engagement, which they defined in terms of the social forms of engagement around classroom tasks, including participation with classmates and the quality of social interactions. Additionally, Finn and Zimmer (2012) defined social engagement as students' prosocial behavior in classrooms and the quality of interactions with peers around instructional content. Finally, Rimm-Kaufman, Baroody, Larsen, Curby, and Abruy (2014) included a social engagement scale with items about explaining academic context and discussing ideas in math.

2. Teacher and student conceptualizations of engagement

Although there is a growing body of research on student engagement, we know much less about how teachers and students understand this construct and the majority of this work has focused on behavioral indicators (Harris, 2011; Johnasson, 2013; Zyngier, 2007). It is important to examine teachers' beliefs about engagement because these beliefs shape teachers' behaviors (i.e., teacher involvement, support, and use of autonomy-supportive practices), which have been shown to influence student engagement (Klem & Connell, 2004; Reeve, Jang, Carrell, Barch, & Jeon, 2004; Skinner & Belmont, 1993).

In a phenomenological study of teachers' conceptions of student engagement, Harris (2011) identified six qualitatively different conceptions including: 1) behaving; 2) enjoying; 3) being motivated; 4) thinking; 5) seeing purpose; and 6) owning and valuing learning. A few studies have also examined teachers' perceptions of classroom misbehavior and disengagement (Cothrane & Ennis, 2000; Little, 2005; Ravet, 2007). In these studies, teachers tend to focus on the behavioral and emotional indicators of engagement in relation to classroom management, as opposed to cognitive indicators that are associated with student learning (Harris, 2011). For example, Ravet (2007) found that teachers conceptualized disengagement in terms of behavioral (e.g., daydreaming, chatting, disruptive behavior) and emotional (e.g., boredom, anger, anxiety) indicators.

There is even less research on the meaning of engagement and disengagement to students. In an ethnographic study of academically successful students, Pope (2001) found that most high achieving students explained engagement in terms of behavioral indicators, describing school in terms of just going through the motions or "doing school." In addition, a few studies have focused on students' conceptualizations of behavioral disengagement (Sun & Shek, 2013; Supaporn, Dodds, & Griffin, 2003). For example, Sun and Shek (2013) used qualitative interviews to examine students' perceptions of classroom misbehavior. They identified 19 categories of student misbehavior, such as talking out of turn, disrespecting the teacher, not paying attention, and aggression.

Studies that examine how teachers and students think about engagement and disengagement can help to move the discussion of this construct beyond behavioral indicators to consider how engagement is a multidimensional construct that is socially and contextually conceptualized (Viberts & Shields, 2003; Zyngier, 2008). Investigating teachers' and students' conceptualization of engagement is also important for developing a measure that reflects the everyday language that teachers and students use around doing tasks and learning.

3. Measurement of engagement

Some scholars have suggested that a more systematic and thoughtful attention to the measurement of engagement is the most pressing and imperative direction for future research (Fredricks & McColskey, 2012; Glanville & Wildhagen, 2007; Veiga, Reeve, Wentzel, & Robu, 2014; Wang & Degol, 2014). Recently, Fredricks and McColskey (2012) reviewed the literature to identify instruments that have been used to assess student engagement in the upper elementary to high school years. In this review, they found a limited number of self-report engagement measures that included scales to assess all three of the dimensions. Moreover, the items in these instruments were used inconsistently across behavioral, emotional/affective, and cognitive engagement. For example, some measures included effort as an indicator of behavioral engagement to reflect compliance with required work in school, while others included effort as an indicator of cognitive engagement to describe the degree of psychological investment in learning. There was also limited evidence to support the validity of several of these measures.

Another concern was that the majority of measures identified in the review focused on general engagement in school rather than on engagement in specific subject areas (Fredricks & McColskey, 2012). The limited number of subject-specific engagement measures makes it difficult to determine which aspects of engagement are similar across subject areas and which aspects are domain-specific. In the motivational literature there is some support for the domain specificity of some motivational constructs, especially for constructs that are situation and subject relevant, such as valuing, expectancy for success, and self-concept (Green, Martin, & Marsh, 2007; Wigfield, 1997).

The research on the conceptualization and instrumentation of engagement in math and science is especially limited (see Kong, Wong, & Lam, 2003, for one exception). It is important to develop domain-specific measures because changes in instruction, the types of tasks, and increased emphasis on collaboration and cognitively challenging tasks in math and science classrooms can shape and interact with how students engage behaviorally, emotionally, and cognitively (Blumenfeld et al., 1991; O'Donnell & Hmelo-Silver, 2013; Sinatra, Heddy, & Lombardi, 2015). Key aspects of math and science outlined in both the Common Core State Standards Initiative in Mathematics (CCSI, 2015) and the Framework for Science Education (NRC, 2012) include a greater emphasis on group work, complex problem solving, quantitative data analysis, abstract reasoning, argumentation, and communication. By transforming the nature of academic tasks and the social learning formats in class, these instructional reforms will likely have a significant impact on how students engage in math and science classes. For example, cognitively challenging tasks call on students to apply cognitive strategies with effort and persistence. Completing challenging tasks in the context of a learning environment that emphasizes collaboration and social interaction impacts on the quality of students' behavioral, emotional, and social involvement in class.

4. Purpose

This study contributes to our understanding of the conceptualization and measurement of engagement and disengagement in math and science. In the first section, we describe how we used