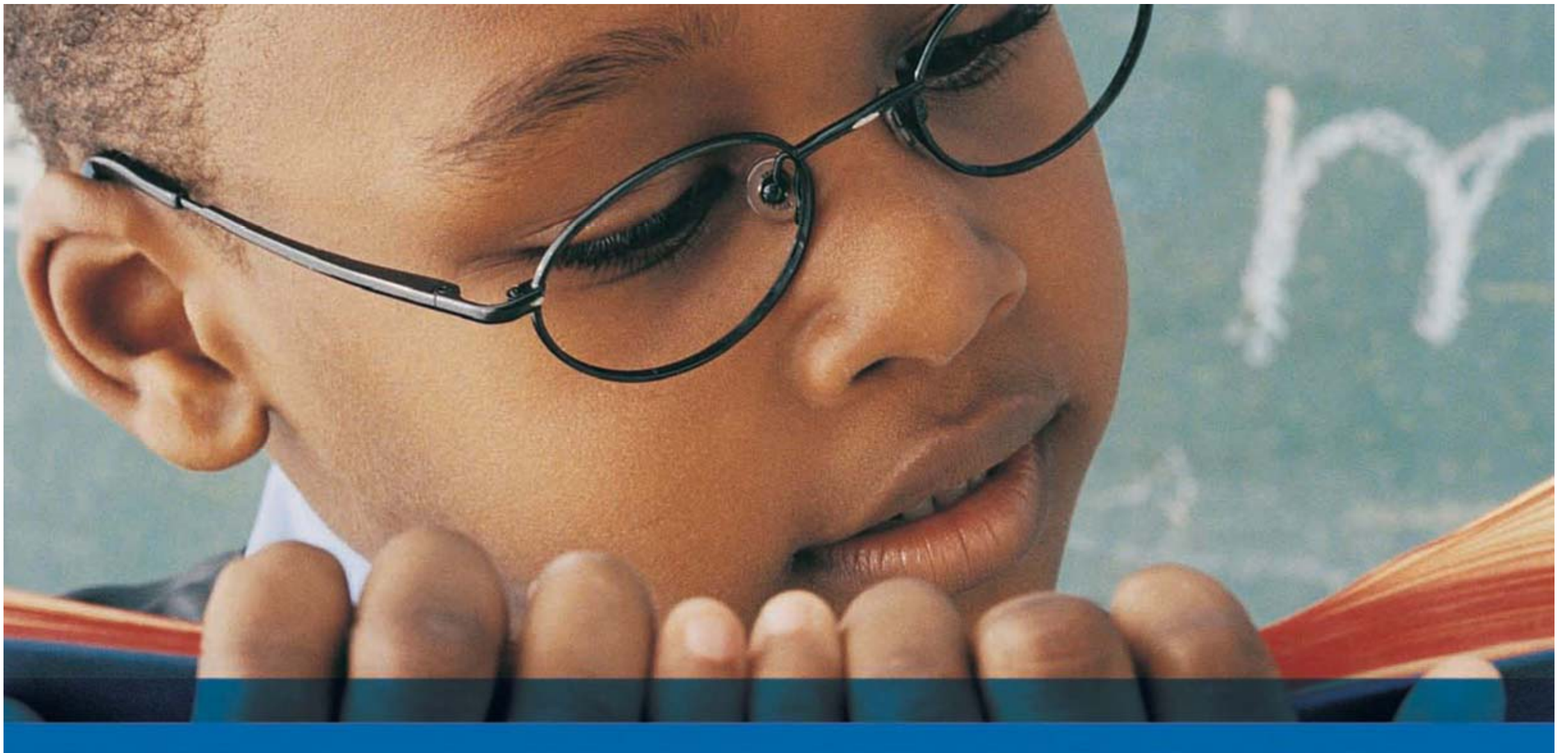

Student Content Engagement as a Construct for the Measurement of Effective Classroom Instruction and Teacher Knowledge

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INTRODUCTION

The effort to link statistically student achievement to measures of teaching or teachers has proven very difficult. Analysts generally agree that the impacts of effective teachers on student achievement are important (Mayer, Mullens, & Moore, 2000; Hanushek, Kain, & Rivkin, 2001; Sanders & Rivers, 1996).[1] The problem for analysts has been in identifying the characteristics of high quality teaching or teachers. Analysts have been able to estimate the size of the impact of teacher quality, through methods that isolate the impact of having one teacher compared with another teacher. But they have been less successful in isolating what it is about higher quality teachers or instruction that produces these effects.

A stumbling block in the effort to identify key aspects of teachers and teaching has been the lack of adequate measures of potentially important characteristics of teaching and teachers (see for reviews of measures of instruction Burstein et al., 1995; Mayer, 1999; Mullens, 1995; Mullens & Gayler, 1999). In the absence of appropriate measures analysts are left using whatever measures are available to them and labeling the measures as proxies for potentially important characteristics of teaching or teachers. It is not surprising, then, that analysts have struggled to link characteristics of teachers or teaching to student achievement.

Much of the analysis of extant survey measures of instruction has focused on reliability and validity (including generalizability) issues associated with asking teachers to self-report on something as complex and sensitive as instruction (see, for instance, Lanahan, Scotchmer, & McLaughlin, 2004). Less attention has been devoted to concerns about what actually are important things on which to survey teachers. Important work remains in mapping out for survey designers the topics that warrant investigation. Although the research is thin on what is important about teaching and teachers, there have been many decades of basic research on how people learn and there is accumulating research on appropriate instructional methods for specific subject matter.

In this paper, we present a framework that divides characteristics of teaching and teachers into four categories representing elements that research on learning suggests need to be in place in order for students to learn. The framework is intended for use in helping to develop and organize

[1] The impact of good teaching over one school year may be relatively small, but the cumulative effect could be large. A 1 standard deviation difference in teacher quality is likely to produce an impact on students on the order of 0.1 standard deviation of the distribution of all students' test scores on a given subject (Hanushek, Kain, & Rivkin, 2001; Rowan, Correnti, & Miller, 2002). This effect is generally considered a small effect (Cohen, 1988). However, the cumulative effect of higher quality teaching over the 13 years of mandatory schooling would be more than 1 standard deviation—a very large effect.

survey or observational measures of teaching and other measures of teacher characteristics, such as teacher knowledge.

LEARNERS, KNOWLEDGE, AND THEIR ENGAGEMENT

Our framework for describing teaching and teachers is based on a broad review of the major literatures addressing human learning. The literatures reviewed include behaviorism, Piagetian theory and the constructivist tradition that followed Piaget, the so-called "co-constructivist" theory associated with Vygotsky, Bandura's social cognitive or social learning theory, connectionist theories of cognition and learning, and other recent developments in cognitive psychology and neuroscience.

A challenge in reviewing such a broad set of literatures is determining the extent to which differences in theories on learning represent meaningful differences for identifying and measuring the important classroom elements for learning. For example, whether learning is described in terms of the brain's accommodation to new information, as in Piaget, or in terms of the associations sparked in the brain by new stimuli, as in connectionist theories, may matter little to the identification of important classroom elements. In either case, students require exposure to new knowledge in order to learn. On the other hand, whether people learn primarily through hands on encounters with situations that upset their prior understanding of the world, as in Piaget, or whether people learn primarily vicariously, through observation of the world around them, as in Bandura, may make for substantial differences in how one thinks looks at classrooms.

Much of the work of reviewing these literatures, then, was the translation of ideas across disciplines and then the search for commonalities and differences. In some cases, theories described the same phenomenon in different terms and therefore appeared to contradict each other when, for our purposes, they did not. In other cases, differences did matter for our purposes. On points on which theories differed substantively, the team examined the relative weight of evidence supporting the theories.

We attempted to draw from the literature review a set of foundational statements about human learning—the major elements involved in learning and the roles played by these elements. We did not look for fundamental differences in how students learn across the subjects to be learned (reading, mathematics, science, etc.). Our initial review of the literatures that looked at human learning broadly did not suggest there would be fundamental differences across subject matter in the basic processes of knowledge and skill accumulation, or, learning. However, the manifestation of learning may look different across subjects and the best practices for instruction may vary across subjects.

Findings of the literature reviews are discussed in the descriptions of each of the framework's four components. A single, summary statement about learning served as the basis for the overarching measurement construct:

At the most general level, learning occurs through the cognitive engagement of the learner with the appropriate subject matter knowledge. The two central figures in this statement are the learner and the subject matter knowledge. The action that occurs is the cognitive engagement of the learner with the subject matter knowledge. The most important elements of instruction, then, are those that influence the cognitive engagement of learner and subject matter knowledge.

We break these important elements into four categories based on how they influence this engagement. First, the subject matter knowledge must be appropriate, which is to say that it must be part of the curriculum and it must be something with which the student can make a cognitive link, given what the student already knows. We call this first category "*Subject Matter Content Level*." Second, the student must be doing something that involves cognitive engagement with the subject matter knowledge. In the research literature, this cognitive engagement is often called processing. Learners must participate in an activity that supports the kind of processing they need to do in order to learn. We call this second category "*Occasion for Processing*." Third, this engagement, of course, is an active process for the learner. Learning requires the attention of the learner to the intended subject matter knowledge and requires additional mental processing that ensures the subject matter is learned and can later be retrieved. Physiological barriers, such as disabilities or psychological states that interfere with attention or other mental processes, can make students unable to engage with the intended subject matter knowledge. We call this third category "*Physiological Readiness*." Finally, because learning is an active process, cognitive engagement is influenced by the willingness of the learner. In some cases, for example lessons learned through accidents, people learn without being willing participants in an activity. However, nearly all classroom learning experiences require the willingness (though not necessarily the cheerful willingness) of the student to participate. We call this fourth component, "*Motivation*."

Described in classroom terms, we divide the conditions that support student learning in classrooms into four categories:

1 *Subject Matter Content Level*—instruction subject matter should be part of the curriculum and should be at an appropriate level given the student's prior knowledge;
2. *Occasion for Processing*—instruction should foster the kinds of mental processing required by the subject matter and students for effective learning;

3. *Physiological Readiness*—instruction should be presented in an environment that supports the basic physiological needs of the student; and
4. *Motivation*—instruction should support the willingness of the student to participate in learning activities.

The important elements that influence these conditions are many, including a host of characteristics of the student, the subject matter, the teacher, instructional activities, and other aspects of the classroom setting. For instance, students will vary dramatically in how easy it is to design instruction that meets their needs on these four conditions or components. Also, instructional activities will influence each of the four components and the same activity may be wonderful for one component, such as *Occasion for Processing*, but negative on another component, such as *Motivation*. We describe student characteristics, instructional activities, and other aspects of the classroom setting in terms of their influence on *Subject Matter Content Level, the Occasion for Processing*, the *Physiological Readiness* of the student, and *Student Motivation*.

STUDENT CONTENT ENGAGEMENT

The overarching framework is called "*Student Content Engagement*" (SCE). The term is intended to draw attention to the two central figures in the learning process—the student and the subject matter knowledge the student is expected to learn—as well as to the importance of the activity that draws student and subject matter knowledge together. *Content*, in this formulation, includes all the stimuli faced by the student during a learning event. That is, content includes the subject matter knowledge to be learned, as well as everything else about the instruction in which the subject matter knowledge is embedded—including the activity of the instruction and the input of teachers and peers in the instruction. Content offers knowledge, and offers activities that help students interact with subject matter successfully. It also offers stimuli from teachers, fellow students, the instructional activities, and the instructional setting that influence student motivation and other aspects of student's readiness to interact successfully with subject matter knowledge. *Engagement*, in the student content engagement framework, refers to the form of the cognitive interaction between the student and instructional content. Engagement may take the form of attending to a lecture or discussion, comparing new information against prior understanding, rehearsing a set of facts, or attending only peripherally (or not at all) to the intended focus of instruction. In these examples, the instructional content is the lecture or discussion, the new information, or the set of facts; engagement describes how the student and instructional content interact. Engagement describes the aspects of instructional content with which the student interacts and how (and if), in cognitive terms, that interaction occurs. In sum, the term student content engagement establishes three categories into which all the influences on learning can be sorted—the student, instructional content, and the engagement of the two.

While student content engagement leads to learning, student content engagement and learning are not synonymous. Student content engagement occurs when its four conditions are successfully satisfied. However, the moment of actual processing cannot currently be measured. Therefore, we cannot be sure of what kind of processing is occurring. Also, we expect students to vary in how much and what kind of processing helps them to learn effectively. Finally, determining what has been learned is very difficult. Retrieval of what has been learned is so dependent on the cues that are used to try to tap the learned skills or information and how they compare with the cues the learner applied while learning that it is very difficult to say with certainty whether or not the instance of student content engagement led to learning. However, students are assessed on their learning and student content engagement should be a necessary condition for learning. Therefore, more student content engagement should be associated with more learning. We simply note that we cannot say that student content engagement and learning are synonymous.

Student content engagement is described in terms of the student's in-the-moment engagement with instructional content. Both the student and the instructional content contribute to the student's engagement. The student brings to instruction many relatively stable characteristics, including physiological needs, favored motivators, and prior knowledge. Effective instructional content must meet the needs presented by those characteristics and provide activities that allow students to process and learn the intended content knowledge.

COMPONENTS OF STUDENT CONTENT ENGAGEMENT

The first two components of SCE come directly from statements we draw from review of the literature on learning. The first component involves the actual elements of knowledge or the level of knowledge that students are expected to learn. The second component pertains to learning activities that provide students with occasions for cognitive processing. The other two components also derive from the research on learning, but they have more specific literatures that required further review. The third component is informed by the literatures on the physical demands of learning students and the fourth addresses the motivation required for students to learn. In the sections that follow we discuss each component of student content engagement in more detail.

SUBJECT MATTER CONTENT LEVEL

One finding that crosses all the literatures on learning is the dependence of new learning on the prior knowledge of the learner: Learning involves the generation of knowledge within the context of prior knowledge (Bruner, 1973; Piaget & Inhelder, 1969; Pintrich, Marx, & Boyle, 1993; Resnick, 1991; Vygotsky, 1978). Every new thing that a person learns must be attached to what the person already knows. Descriptions of the processes through which people fit novel understandings or skills with existing ones differ across learning models. However, all major theories on learning highlight the importance of a person's prior knowledge in how the learning of new knowledge occurs. In the paragraphs that follow, we describe briefly what some of the major models of human learning say about the match between new knowledge and prior knowledge.

One of the central tenets of Piaget's (Piaget & Inhelder, 1969; see also Brainerd, 1978 and Green & Gredler, 2002) theory of learning was the role of novel information in creating cognitive disequilibrium in the mind. This cognitive disequilibrium he considered crucial to learning. People learn through encountering discrepancies or conflict between their ideas about the world as they perceive it and new information presented in the environment. If new information is at odds with what they already believe to be true, this contradiction leads them to question their understanding and to seek refinement of their ideas. In the process of making sense of this new information, mental structures may change in fairly substantial ways to accommodate the new information (Piaget called this learning process accommodation); they may also change in less substantial ways and may actually alter the new information somewhat in the process of making sense as the new information is assimilated into the mental structures (Piaget called this learning process assimilation). If the new information is only slightly novel, assimilation may predominate. If the new information is more dramatically different, accommodation is likely to predominate. However, if the new information is blatantly contrary to what is believed, learners may have difficulty making any sense of it. Much of Piaget's thinking is still in currency and is represented in other models on learning, especially among modern constructivists.

Vygotsky (1978) described learning in terms of social interaction. One of his discoveries was that there exists a difference between what a person can do on his or her own and what he person can do with the help of a more knowledgeable other. This difference or gap can serve as a useful tool for learning, as the more knowledgeable other guides the learner toward higher levels of proficiency. He called this difference the zone of proximal development. The zone of proximal development consists of skills that are currently developing or maturing in the child. The level of instruction should not be pitched higher than the top of the zone of proximal development, because the learner cannot perform at the level even with the help of another. Pitching the level of instruction beneath the bottom of the zone of proximal development makes little sense, because there is no opportunity for learning beneath the zone of proximal development. The knowledge supports provided by a more knowledgeable other within the zone of proximal development are called scaffolding. Vygotsky's theories on the zone of proximal development and the role of a mentor or teacher in providing supports for learning are prevalent in current practical guides for teachers, as well as major theoretical work by researchers describing learning in terms of mentoring or apprenticeships or in terms of the social processes involved in learning (Cole, 1995; Lave & Wenger, 1991; Rogoff, 1990; Tudge & Winterhoff, 1993).

Much of the work in cognitive psychology and neuroscience over the last 30 years has focused on studying the brain and learning in terms of the networks of associations that are made in the brain when processing information. Many of these connectionist theorists use a model of the brain as something like a computer or an information processor. The brain is made up of a network of neural cells and knowledge is held in those networks cells that are activated in association with each other. Theorists who describe a connectionist model also speak to the importance of prior knowledge in learning processes. Prior knowledge determines, in part, what is attended to in the environment (Broadbent, 1958; Kahneman, 1973), and therefore subsequently learned. As this learning occurs, the structure of the brain is fundamentally changed as information is organized and reorganized (Diamond, 1988; Diamond, Krech, & Rosenzweig, 1964). In the computational and brain models of learning processes, knowledge comprises the connections between brain cells or parts of the brain. As people learn more about a given topic, the networks of cells that are activated when the topic arises are expanded and connections become different and stronger, and the patterns of associations between neurons activate in concert more often. This alteration is equivalent to learning. The information processing model of learning is widely accepted today and most theorists recognize its importance in the acquisition of knowledge. For more on this theory, see the *Occasion for Processing* section below.

Subject Matter Content Level

The dependence of new learning on the prior knowledge (or mental structures or level of development or networks of associations) of the student makes appropriate matching of the *Subject Matter Content Level* of instruction and the student a necessary condition for learning in classrooms.

It also places a focus on knowledge as the core resource in learning processes. We close this section with two notes on knowledge that are important for understanding the *Subject Matter Content* Level component.

Context Specificity of Knowledge.

The prior knowledge that an individual has developed over time is highly context-specific; however, students can employ knowledge developed in one setting in other settings. The idea that all new knowledge must be associated with existing knowledge has led some researchers to assert that all learning is context-specific (Greeno, 1997; Lave & Wenger, 1991). However, while new information is naturally associated with the environmental cues in which is was learned, those cues can be so widely diversified—through effective instruction, if through no other means—that transfer is a possibility in all learning situations (Anderson, Greeno, Reder, & Simon, 2000; Brown & Kane, 1988; Greeno, 1997). A student always comes into a learning situation with some prior knowledge. This knowledge may have tenuous ties to the subject matter that is presented. Students may enter a calculus classroom knowing nothing about calculus. But they will surely have knowledge of *something* (e.g., other mathematics content, typical classroom procedures, fellow students, etc.) in that classroom. What students learn will develop within the context of whatever that developed structure, that *something,* is. In order for new material to be integrated, it is advantageous for the learner to be exposed to as wide a variety of viable connections from the existing to new knowledge as possible. Instruction that provides a multitude of opportunities to trigger the activation of prior knowledge is more likely to be effective. In addition, the ability to ascertain the structure and content of a student's prior knowledge will make instruction more efficient. Over time, instruction can shape the structure of prior knowledge. Learning is cumulative, and prior knowledge changes with every learning opportunity—what is new material today is prior knowledge tomorrow. It is important to consider the sequence of what is learned and how yesterday's learning influences today's learning and how today's learning will influence tomorrow's.

Forms of Knowledge

Finally, knowledge is knowledge. For our purposes, we can think of all types of knowledge—semantic and procedural, simple or complex—largely the same way. For the purposes of describing a model of student content engagement, content knowledge includes the semantic knowledge or storehouse of information that students build over time *and* the procedural memory required to perform tasks or demonstrate skills. Semantic knowledge includes facts, concepts, and learned beliefs that one acquires with time, while procedural knowledge refers to behavioral knowledge, such as skills, talents, and learned actions. According to a connectionist model, “packets” of information are stored in essentially the same way, so whether a concept is considered easy or difficult to understand, or involves knowing or doing something, the process by which it is learned is identical. Ultimately, all prior knowledge can be used for learning new information. What is important is the structure of that knowledge and how accessible it is during a learning opportunity. Effective instruction will pitch the level of subject matter content of what is to be learned at a level just above what is already known while providing ample opportunities to relate the new material to established concepts.

Occasion for Processing

Processing is the means by which the brain receives, uses, stores, and retrieves information from the environment. Cognitive psychologists differ on the exact model of brain behavior that leads to learning, but certain commonalities exist among the models (Atkinson & Shiffrin, 1968; Baddeley, 1996; Craik & Lockhart, 1972; McClelland & Rumelhart, 1986). It is assumed that the mental system that takes in information from the environment has a limited capacity. That capacity may differ from individual to individual, and may be amenable to training, but is limited nonetheless. Also, each model of information processing assumes a control mechanism that determines precisely what information is attended to, its relative importance, and where and when it is processed. There is a two-way flow of information during processing, between our senses and the information stored in memory. The control mechanism, or executive function, of the brain oversees this iterative process. A final assumption of most established processing theories is that humans are designed to organize information in specific ways, developing schemas for concepts as learning occurs.

It is this processing that produces the change in the brain that we call learning. And so, one of the necessary components for learning in classrooms is that students engage in an activity that provides the *Occasion for Processing* necessary to learn the subject matter. Here, the appropriate processing is the amount and type of processing required by the student to learn the given subject matter and be able to retrieve that learning at some later time on demand.

At its most basic function, processing involves the encoding or repetition of content so that neural pathways are formed and strengthened in memory. This activation and reactivation can occur during obviously active engagement (during instruction), but can also be strengthened during passive behaviors (during sleep or daydreaming). Unfortunately, little is known conclusively about specifics of the actual processes that connect long-term and short-term or working memory stores and produce the strong changes in associations that occur in learning. Theorists agree, however, that deep or extensive processing appears to produce the strongest and most readily retrieved memory traces (Atkinson & Shiffrin, 1968; Brown, Bransford, Ferrara, & Campione, 1983; Craik & Lockhart, 1972). However, some argue that even simple repetition produces long term memory traces—though no one argues that simple repetition produces memory traces as readily as does deeper processing (Atkinson & Shiffrin, 1968).

Descriptions of deep processing differ and researchers and theorists have focused more on strategies that seem to produce deep processing than on what the deep processing actually is ((see, for instance, the response of Lockhart and Craik (1978) to criticism of this type)). During the 1970s, considerable research studied the development of active learning strategies intended to form lasting and readily-available associations in long-term memory stores (see Brown et al., 1983). These strategies included

- rehearsal,
- categorization,
- elaboration,
- mnemonics and other strategies for retrieval and coding for retrieval,
- summarization activities involving deletion of trivia and redundancy, categorization, and paraphrasing new information in one's own words, as well as
- meta-cognitive strategies—strategies for becoming more aware and in control of one's learning strategies.

Ultimately, each of these learning strategies stresses conscious processing of new material in the context of prior knowledge. Except for the extreme case of rehearsal-as-simple-repetition, prior knowledge is required to employ each strategy. Categorization draws on prior knowledge to help group and differentiate information. Elaboration typically requires explanations that draw on prior knowledge. Mnemonics developed by learners to refer to their own prior knowledge tend to be more effective than ready-made mnemonics (Symons & Johnson, 1997). Summarization activities use discriminatory powers that draw on prior knowledge; paraphrasing material draws explicitly on prior knowledge.

What makes these strategies effective is less clear. Researchers typically highlight strategies that are the most cognitively demanding. This may be because cognitively demanding activities produce longer activations of associational networks or more intense activations of the networks or activate larger networks that associate new material with more prior knowledge and strengthen existing associations. It appears that, broadly, the same informational processes apply whether students are expected to be able to show they understand subject matter or simply recall subject matter or whether they are learning skills (procedural knowledge) or factual information (semantic knowledge). The alteration of associational networks should occur during learning in each of these cases. The main processing differences among these situations may primarily be in the depth of processing required.

For instance, learning for understanding, that is, being able to explain why something is the way it is, has been described as differing from learning for recall primarily in terms of the amount of knowledge demand on learners (Brown et al., 1983). Learning for understanding requires students to ask themselves about the relevance of particular elements of new material. To understand why something is the way it is, students need to know about the relative significance of elements of the topic, how the topics fit together, and typically need to draw on prior knowledge about other topics that shed light on the explanatory mechanisms of the current topic. Understanding, then, can require students to draw upon and reactivate large associational networks. However, learning is still about activating and altering associational networks.

Deep processing is not always the best processing. Nor is uninterrupted processing necessarily the best way to learn. Researchers are finding that important consolidation of learning may happen through reactivations of new associations that occur unintentionally during sleep or other “down” times or that occur intentionally but with relatively low intensity during “down” times (Maquet, 2001; Stickgold, Hobson, Fosse, & Fosse, 2001; but see also Siegel, 2001). “Down” time, or time spent not actively engaged with new material, may allow for some essential type of internal rehearsal to occur. This constant running of particular neural pathways seems integral to learning because it permits the reactivation of newly introduced associations, strengthening them. And, it allows this reactivation to occur in the absence of new stimuli that might challenge or interfere with these new associations. Down time may also include explicit reference to recently learned material. For instance, problem solving, review, and rehearsal may qualify as down time activities that support the consolidation of new associations.

Current research shows that REM sleep might be one form of downtime that facilitates learning and the solidification memory tasks (Stickgold, Hobson, Fosse, & Fosse, 2001). Neuroscientists hypothesize that some types of new memory traces may remain tenuous until after the first post-training sleep period where can it be consolidated (Maquet, 2001). Studies have shown that learners who spend less time in REM (i.e., those who are awakened when REM cycles begin) can recall strict memorization facts, but are weaker at logic problems and do not encode complex material (Karni, Tanne, Rubenstien, & Askenasy, 1994).

Repeated exposures to new information over a brief period of time may help form strong and accessible associations. Some research suggests that students benefit from repeated exposures to the same information over a two or three day period (Nuthall & Alton-Lee, 1993; Rovee-Collier, 1995). The authors suggest that three or more interactions with information over a two- or three-day "time window" may help to build strong and stable and re-usable associations in long-term stores.

Experiencing information through multiple senses may provide some of the benefits of re-peated exposures or deep processing. For example, mnemonics that employ visual information (as opposed to auditory information), tend to be retrieved especially readily, perhaps because of the vol-ume of information (and therefore associations) associated with images (Atkinson & Shiffrin, 1968; Brown et al., 1983). Also, research suggests the more sensory inputs a content area shares, the more likely the memory will be retrieved (Schacter, 1996). Information that is encoded through vision, sound, smell, and movement is more likely to be remembered, perhaps through repeated activation of the same neural pathways. New material that is related to personal experience tends to make particu-larly strong impressions on learners. Associations tend to be activated more often and for longer periods of time in learners who have had direct or indirect prior experience with the presented subject matter.

In sum, we describe learning processes in terms of memory processes. Learning, in this for-mulation, results from the interaction of prior knowledge, in the form of associations in long-term memory storage, with new information; learning can also result from the interaction of prior knowl-edge with other prior knowledge in a new way. The processing that induces learning is the activation of new associations or the reactivation of associations that leads to stronger associations. What theo-rists call "deep processing" apparently tends to produce especially strong associations. This might be because deep processing activities (like attempts to understand "why" rather than "what"), such as attempting to understand why a historical event occurred induce new associations in addition to the associations caused by attempts to list historical events. This might also occur, in part, because deep processing activities produce more activations of associations per unit time than do less cognitively demanding activities.

For the purposes of the SCE model, we refer to the *occasion* for processing rather than proc-essing, itself. Because processing is an internal, cognitive endeavor (i.e., the activation and strengthening of neural networks in the brain), its occurrence is largely unseen and its accurate and efficient measurement has not yet been established (Bailey, Karhu, & Ilmoniem, 2001). The student content engagement model therefore focuses on those behaviors that increase the likelihood of processing, or the availability of processing occasions. As mentioned previously, it is impossible to determine the number and nature of opportunities for processing a particular student will require to learn new material. Individual students will vary in their speed of processing and their memory capacities (Fry & Hale, 1996). They will also vary in the amount of prior knowledge they bring to a learning situation, which will necessarily influence their ability to integrate new information into memory.

PHYSIOLOGICAL READINESS

Physiological barriers are a seldom discussed (at least in mainstream education) but important set of impediments to attention and learning in classrooms. At any given moment if a student is not physiologically ready to attend then that student will not learn the content at hand. For this reason, *Physiological Readiness* is an important precursor to engagement.

We define *Physiological Readiness* in terms of students' capacity to pay attention and perform the other cognitive processes necessary for learning subject matter, given the student's physiological state. Both the external environment and the student's internal psychological activity influence this physiological state. When a student is physiologically ready to engage with content, we say that no physical or psychological obstacles stand in the way of the student's attention. In the sections that follow, we discuss briefly our use of attention as a cognitive process and then describe a series of potential impediments to Physiological Readiness, including extreme stress, inadequately address disabilities, and inadequate nutrition and sleep.

Attention

There are various theories on attention, but researchers do not agree on precisely how to define it or explain its exact role in learning. Still, information processing theorists concur that attention is essential for learning to occur (Byrnes, 2001). In the *physiological readiness* component of student content engagement, we likewise refer to a beginning stage of processing where attention is a prerequisite for learning—students cannot learn something to which they do not attend. Students who are free from physical and psychological hindrances to attention are more likely to attend to the content at hand, which can lead to engagement with the material and potentially to learning.

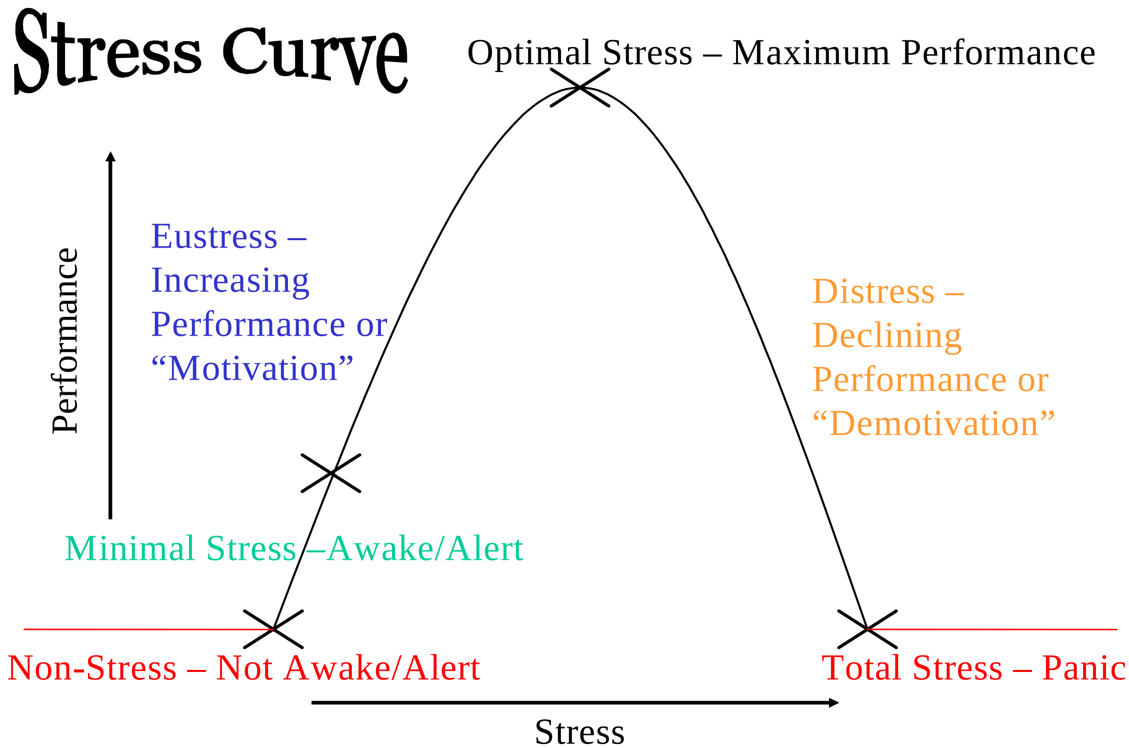
The model presented here is consistent with other theories of attention and memory, which characterize working memory as a limited cognitive resource preventing the processing of all available information. Although long term memory is boundless, working memory is limited in the amount of cognitive work it can perform on information and subsequently transfer to long term memory. An overwhelming amount of information continuously bombards our sensory registers—the initial memory stores that temporarily record a stimulus. In an effort to conserve working memory, sensory registers in the brain only process basic physical characteristics of information such as color, shape, or size simultaneously with (or in parallel with) other features such as sound. After this early, passive (or pre-attentive) processing, the brain moves some information from the sensory register to the working memory by narrowing or dividing attention and focusing on information which is potentially most useful and relevant (see Atkinson & Shiffrin, 1968 or Baddeley, 1996).

The process of allocating attention to a portion of the enormous amount of information that reaches our sensory registers is known as selective attention**.** Psychologists are divided on how and when the actual filtering of information is accomplished (Broadbent, 1958; Kahneman, 1973; Treisman, 1960), but most filter theories recognize that the content to which a student attends often depends on his/her prior knowledge and emotional connections. We concentrate on selective attention in our model because other types of attention discussed in the literature (divided, switching) can be said to fall under this classification, and the majority of the research is in the area of selective attention (for a broader discussion on the role of selective attention in memory systems and informational processing, see Occasions for Processing, above).

Stress

Due in part to studies on the effects of long-term stress, people often think of *stress* as something that is entirely bad for one's health. However, stress can be more neutrally defined "as previous or actual exposure to life events that require adaptation from the individual" (Selye, 1950 as cited in Lupien, King, Meaney, & Meaney, 2001). In psychology literature and throughout this paper, the term *stress* is comparable to arousal and can be good (eustress) or bad (distress) for performance (Yerkes & Dodson, 1908).

Humans are driven to maintain an optimal level of physiological comfort, and learning typically occurs within a moderate range of general arousal (Yerkes & Dodson, 1908). A certain amount of arousal or stress can be a motivator toward change (for our purposes, learning). Too little arousal has an inert effect on the learner, while too much has a hyperactive effect. The optimal level of arousal for any given task is relative (i.e., lower levels are preferable for more difficult cognitive tasks, while higher levels are more effective motivators for tasks requiring endurance and persistence). People are internally and naturally motivated to maintain an optimal level of arousal and physical and psychological equilibrium. Proper nutrition, sleep, lack of emotional upheaval and environmental stress contribute to students maintaining a proper level of arousal suitable for engaging with content during instruction. A deficit in one of these areas will create an obstacle for engagement, and therefore learning.



Note: This curve was adapted from the Yerkes-Dodson construct (see Bourne & Yaroush, 2003; Cohen, Evans, Krantz, & Stokols, 1986)

For our purposes, performance is defined as selectively attending, which is a required process for learning. Too little stress has an inert effect on performance on selective attention tasks, while too much has a hyperactive effect. A state of total stress might result in paralysis of performance or non-action. A certain amount of stress can motivate change thus increasing performance on selective attention tasks. An optimal level of stress often results in maximum selective attention. Humans are driven (or biologically motivated) to maintain an advantageous level of physiological comfort, and optimal performance of selective attention leading to learning occurs within a moderate range of stress. Generally, researchers maintain that lower levels of stress are preferable for more difficult cognitive tasks, while higher levels of stress are more effective motivators for more mundane tasks requiring endurance and persistence (Cohen, Evans, Krantz, & Stokols, 1986).

To describe the effect that stress has on physiological functioning, specifically its effect on cognitive functioning, we reviewed neuroscience and biology literature. A description of those effects and one of the biological mechanisms that relates physiological stress to selective attention follows.

In response to a stressor, the body releases hormones—including adrenaline, epinephrine, and cortisol—to enable the mind and body to respond appropriately to the impending potential emergency. We focus on the effect of cortisol on the body mainly because of the measurement advantages (cortisol can be measured in saliva). Cortisol is considered a reliable indicator of humans' physiological response to stress and stress is indicated by cortisol levels that are elevated above an individual's cortisol baseline (Lupien, King, Meaney, & Meaney, 2001). Cortisol helps regulate blood pressure, cardiovascular functions, and use of proteins, carbohydrates, and fats. The hypothalamic-pituitary-adrenal (HPA) axis is the neuroendocrine system that helps us react and adapt to stress by controlling other hormones that regulate the release of cortisol. The HPA system normalizes cortisol levels via a negative feedback loop (Bremnar, 2002; Nelson & Carter, 1998). Basic functioning of the HPA axis is denoted by cortisol levels that flow in circadian rhythms or diurnal variation, which means cortisol levels are higher in the morning, lower in the afternoon, and continue to decline until sleep (Kirschbaum & Hellhammer, 1989; Lupien, King, Meaney, & Meaney, 2001). Stress is also revealed by a physical manifestation of elevated cortisol, including indicators like increased heart rate or perspiration (Davis & Ekwall, 1976).

Stressors include any number of phenomena that elevate cortisol and depending on the task at hand and the amount they can be good or bad for selective attention. Stressors are often evaluated as positive or negative, such as excitement from winning the lottery or fear of presenting in front of a crowd (for a discussion of types of stressors see Anisman & Merali, 1999). However, from a physiological standpoint, all types of stress influence performance in the same way—an intense amount of eustress elicits the same physiological response as an intense amount of distress. Stressors can be external (e.g., excessive noise, violence, or bullying) or internal (e.g., concern for safety or thoughts about family conflict). Extreme environmental factors such as poverty can also be considered stressors if they regularly increase cortisol levels and hinder selective attention (see for instance Dohrenwend, 1973 as cited in Lupien, King, Meaney, & Meaney, 2001).

Stressors are distinguished from simple distractions by their influence on cortisol levels and degree of impact on selective attention. For instance, hearing a car honk once outside the window might momentarily detract a student from an instructional activity but listening to an unattended car alarm for several minutes might elevate his/her cortisol levels to the point that it becomes a stressor and inhibits selective attention. Keep in mind, however, that moderate stressors can improve attention, for instance, a teacher who loudly claps his/her hands might raise students' cortisol levels just enough that the students are aroused and motivated to attend to the lesson at hand. Although it is true that a distraction effects one's selective attention even if his/her cortisol levels remain unchanged or even increase slightly (i.e., thereby dividing one's attention), a discussion of such interruptions is better left to the SCE component Occasions for Processing – a component which speaks to the role of attention in information processing.

The optimal level of stress for any individual's performance on selective attention tasks is not easily identified. Cortisol baselines vary from person to person and fluctuate over the course of the day. Bremnar (2002) points out that the relationship between cortisol and stress in humans is complex and "highly dependent on psychological factors" (p. 91). The programming of an individual's stress circuits in the central nervous system begins very early in life and develops with the myriad of one's own experiences (Gunnar & Barr, 1998, p. 2). The HPA system adapts over time as it is exposed to stressors (Anisman & Merali, 1999). Accordingly, one can expect stress baselines and the optimal stress level to vary not only by individual but also according to the given task (e.g., some students become stressed when doing math games whereas others only release high levels of cortisol when they have to read out loud to the class).

Optimal stress levels are also difficult to pinpoint because of the nature of its relationship to performance—some stress helps selective attention and yet too much stress is detrimental to attention and ultimately for one's health. Theorists, who agree that working memory is a limited resource, have different ideas on how a person under stress uses the remainder of their resources to attend to stimuli. Some researchers maintain that a person under stress attends to relevant information (Easterbrook, 1959) while others argue that a person under stress attends to irrelevant information (Wegner, 1994). Born, Kern, Fehm-Wolfsdorf, and Fehm (1987) found that increased cortisol excites brain stems in emotionally stable adults and is associated with increased energy and concentration ability (as cited in Gunnar & Barr, 1998). Chajut and Algom (2003) looked at selective attention in flight controllers and found that it improves under high stress. However, Braunstein-Bercovitz (2003) found that stress impairs college students' selective attention by increasing interference from irrelevant information.

It is not possible to determine how much stress is universally too much and will negatively affect an individual's performance on selective attention tasks. However, some researchers affirm that the major limiting variable on performance is inexperience (Matthews & Desmond, 1995; Bourne & Yaroush, 2003). Perhaps it follows that the more experience one has with potential stressors or the more automatic a task becomes for someone, then the less likely that stress will impede his/her performance. Students with prior experience in a subject matter area or with particular curricular tasks are thus less likely to feel stress in the presence of such stimuli with repeated practice.

Another interesting finding in the study of the effect of stress on cognitive function is the notion that long-term stress can directly affect the biological structures that are known to support memory formation (Bremnar, 2002). Recurrent and extended elevated cortisol levels shrink neural cells in the hippocampus—the brain region primarily responsible for short-term memory management (Gunnar & Barr, 1998; Höschl & Hajek, 2001). McEwen and Sapolsky (1995) found a loss of dendrites, synapses, and nerve cells in persons who adapted to stressful life circumstances (as cited in Gunnar & Barr, 1998). Despite hippocampal shrinkage, some researchers recognize that if high cortisol levels begin to decrease over time then the rate of hippocampal cell loss might also slow down. It is not known if these cells will grow again (Höschl & Hajek, 2001). So there is evidence that stress effects memory formation in both the short-term (by interrupting attention) and long-term (through organic damage of brain structures).

Disabilities

Students may be unable to attend to curricular activities for a variety of reasons, including short- or long-term disabilities. We include a discussion of disabilities under the physiological readiness component of student content engagement as many of these conditions stem from a physiological source.

According to the Americans with Disabilities Act (ADA) of 1990, "Anyone with a physical or mental impairment substantially limiting one or more major life activities; who has a record of such impairment; or who is regarded as having such an impairment, is considered a person with a disability" (U.S. Department of Labor, 2004). Passed in 1975, the Individuals with Disabilities Education Act (IDEA) provides the legislative foundation that protects students with disabilities and ensures that they receive free services to meet their special education and related service needs (IDEA, 1997). IDEA specifies that children with disabilities be educated in the least restrictive environment possible, meaning that most students with disabilities must be taught in a general education classroom (National Council on Disability, 2004).

IDEA lists 13 different categories—from specific learning disabilities to speech, language, or orthopedic impairments—under which children ages 3-21 qualify for services through their schools. In order to qualify for special education and related services, a student's disability—whatever the category—must affect his or her educational performance. According to the National Dissemination Center for Children with Disabilities (2002) the IDEA categories are:

- autism,
- deaf-blindness,
- emotional disturbance,
- hearing impairment (including deafness),
- mental retardation,
- multiple disabilities,
- orthopedic impairment,
- other health impairment,
- specific learning disability,
- speech or language impairment,
- traumatic brain injury, or
- visual impairment (including blindness).

In addition to these categories, local education agencies and states can use the term "developmental delay" to describe a child who has a disability that does not fall into on one of IDEA's 13 categories named above. Delays in physical, cognitive, communication, social or emotional, and adaptive development that cause the child to require special education and related services could be considered developmental delays.

To define the term "disability" for the purposes of this paper, we adopt the same criteria that appear in the IDEA legislation. This definition casts a net wide enough to include varied physiological impairments that could stop a student's in-the-moment attention processes, interfere with selective attention, and prevent learning from occurring. Our definition of disability includes a variety of functional, chronic, developmental, compensatory, and service-use disabilities that fall on a continuum from mild to severe.

A description of all disability categories is beyond the scope of this paper. We would, however, like to focus briefly on Attention Deficit Hyperactivity Disorder (ADHD) because this disability clearly hinders an individual student's ability to attend and learn and it is the most common cognitive and behavioral disorder diagnosed in school-age children (American Academy of Pediatrics, 2000).

Attention Deficit Hyperactivity Disorder (ADHD). According to IDEA, Attention Deficit Hyperactivity Disorder (ADHD) is not a federal disability category unto itself, but rather falls under the category of "Other Health Impairment." Other disabilities in this category include asthma, diabetes, a heart condition, lead poisoning, or "any chronic or acute health problem that may affect a child's educational performance."

Recent research suggests that ADHD is a cognitive disorder with a neurobiological basis, rather than a behavioral disorder resulting from food allergies, excess sugar, or poor parenting, as has been hypothesized in the past. Research by Giedd, Blumenthal, Molloy, and Castellanos (2001) found that several regions of the brain are significantly smaller in both boys and girls with ADHD than in those without it. These brain regions, which are rich in the neurotransmitter dopamine, regulate attention, working memory, impulsiveness, and motor control. Whether diagnosed by a psychiatrist, psychologist, social worker, or team of mental health professionals, ADHD is characterized by inattention and/or hyperactivity-impulsivity that inhibit a student's selective attention and his or her capacity to learn a given material (Spencer, 2002). The Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) points to three patterns of behavior that indicate the presence of ADHD: first, the predominantly hyperactive-impulsive type includes signs of restlessness, blurting out answers, and having difficulty waiting in line or to take turns. Secondly, the predominantly inattentive type includes such signs as becoming easily distracted by irrelevant signs and sounds; failure to pay attention to details and/or making careless mistakes; rarely following instructions; and often skipping from one uncompleted activity to another. And third, the combined type, in which the student displays symptoms of both the inattentive and hyperactive-impulsive type. Classification of ADHD is made difficult because the disorder is often co-morbid with a variety of other impairments that negatively affect attention, such as learning disabilities, anxiety/depression, and share symptoms with deficits in other physiological needs, such as adequate nutrition and sleep, to which we now turn.

Nutrition and Sleep

To be physiologically ready, students need adequate nutrition, and providing it is a relatively simple way to maximize the potential for learning. There is strong evidence that nutrition, specifically adequate levels of glucose in the body, is directly related to attention capacity and performance on memory tasks. Benton and Parker (1998) examined the relationship of glucose and memory with college students and found that students who fasted but drank a glucose drink performed comparably to those who ate breakfast. Fasting in the morning without consuming a glucose drink negatively affected students ability to recall a word list, read a story out loud, and remember items as they counted backwards. Smith, Kendrick, Maben, and Salmon (1994) also found that eating breakfast increased college students' performance on recall and recognition memory tasks. Maintaining optimal levels of glucose in the bloodstream, or more specifically, increasing a low level of glucose, increases the chances of cognitive engagement.

Sleep is also essential for cognitive functioning. Although it is not possible to identify the exact physiological function of sleep, many researchers maintain that sleep is necessary for the consolidation of memories (Stickgold et al., 2001) and promotion of insight (Wagner, Gais, Haider, Verleger, & Born, 2004) (see Siegel, 2001 for dissention). In addition to consolidation and insight, sleep primes our cognition so we are ready to attend the next day. Sleep deprivation appears to reduce behavioral control potentially leading to decreased attentional command and increased emotional distress, both of which could interfere with attention and learning (Dahl, 1996). In their meta-analysis of 19 studies on sleep deprivation, Pilcher and Huffcutt (1996) conclude that the effects of sleep deprivation, especially partial sleep deprivation are underestimated. Partial sleep deprivation seems to have a larger effect on performance, specifically on attention span, than does long-term or short-term sleep deprivation. On self-reports of college students, Pilcher and Walters (1997) found that those who stayed up all night before tests involving critical thinking reported they believed they performed better than those who got 8 hours of sleep. However, the students who got no sleep for 24 hours actually perform much worse than the comparison group. Another study showed that losing one night of sleep affected college students' performance on tasks involving selective attention (Linde & Bergström, 1992).

Conclusion: Physiological Readiness

Physiological Readiness refers to the state of the student in the moment of instruction and is essentially dichotomous. In the moment of instruction, students are either able to attend and otherwise participate or they are not, because of some physiological barrier, such as extreme stress or an unaddressed disability, or low blood sugar or sleep deprivation. It is expected that most students are nearly always physiologically ready. However, it is expected that nearly all students are occasionally unready physiologically and that some students are often unready, because of one of these barriers.

MOTIVATION

Motivation is generally defined as that which moves one to act (Guthrie & Wigfield, 1999; Stipek, 1996). As a component of the student content engagement model, *Motivation* is that which moves a student to participate in a given learning activity. This is tied specifically to the instructional activity of the moment. Although students are expected to show relative stability in motivation for schoolwork, the motivation to participate in the task of the moment determines whether students engage in that task or not. Moreover, the willingness of the student to participate in a learning activity may not reflect the student's interest in the activity or the subject matter. We expect students to be motivated by a host of influences, including influences internal to themselves and those from external sources, as well as what might be called positive influences, such as interest and negative influences, such as fear. In the sections that follow, we briefly review the literature on motivation.

Schools of Motivation Theory

General theories of motivation are far-reaching and apply to a variety of human behavior. Most motivation theorists assume that motivation is involved in the performance of all learned responses; that is, a learned behavior will not occur unless it is activated. However, theorists attribute the seeds of motivation to a variety of sources. Some of the earliest theories looked at motivation from a biological perspective (Hull, 1943; Yerkes & Dodson, 1908), believing that people were innately driven to maintain an optimal level of arousal because it is physiologically satisfying. Biological theories gave way to behaviorism or theories of instrumentality (Thorndike, 1910; Watson, 1913; Pavlov, 1927; Skinner, 1953; Eysenck, 1988) and the belief that people act primarily to obtain desired pleasant consequences or avoid undesired unpleasant consequences. Behaviorism did not address the internal workings of the mind and a school of thought based on cognition arose. Motivational theories based on cognitive processes assert that the thoughts and belief systems of an individual motivate behavior (Vroom, 1964; Festinger, 1957; Weiner, 1979) and that people change their behavior to align with what they believe to be true. At the same time, other researchers looked into the influence of the social setting on behavior. These social theorists suggest that people are motivated, at least in part, to mimic positive models to be accepted as part of a group (Adams, 1965; McGregor, 1960; McClellend, 1985; Bandura, 1997). During the 1980s, humanistic theories of behavior emerged. These theories expanded on previous findings and focused on the importance of the individual self-evaluation. Humanistic theories (Maslow, 1943; Anderman & Midgley, 1998; Csikszentmihalyi, 1990; Deci & Ryan, 1985; Brophy, 1983; Dweck, 1986) assert that people are motivated by inner feelings of worth, esteem, efficacy, and control.

Most theories of motivation can be applied across social fields and were designed to address a particular set of behaviors (e.g., maximizing productivity at work, improving physical performance, stopping addictive behavior). This paper deals with those theories that influence the motivation to learn, or academic motivation. In the last twenty years, motivation researchers have moved into the classroom to identify the types of behaviors that produce effective learning. This research is based largely on an integration of cognitive, social, and humanistic views of motivated behavior, and a resulting model of motivation is presented below.

An Expectancy–Value Model of Motivation

Reflecting the research interest in motivation across fields of social science, theories of motivation and the terminology describing those theories have proliferated. For our purpose—developing a perspective for the observation of both the student motivation in classrooms and the classroom instruction that influences motivation—it is not necessary to sort through all the differences among theories and terminology related to student motivation. Instead, we describe a relatively broad theory of motivation drawn from the most robust research findings. We use an *expectancy–value* model of motivation that is consistent with the major theories of motivation, provides a relatively simple framework for observing motivation in classrooms, and has been linked to student achievement (Eccles & Wigfield, 2002).

Manifestations of motivation are visible in the choices students make concerning activities and their behavior, the energy and time they put into activities, and the decisions to persist in the face of difficulty. Our expectancy–value framework for observing motivation looks beyond the outward manifestations at how students form motivations. In this framework, students will not engage in an activity unless they have a reasonable expectation of success and value the activity in some way. How students come to form reasonable expectations of success and how they come to value an activity sufficiently to engage in it have been the subject of considerable research. We discuss each half of the expectancy-value dynamic in more detail below.

Expectancy

Student self-efficacy is the core of the expectation half of the expectancy-value model. Self-efficacy is one's personal judgment of ability to achieve a specified task or implement a certain behavior in a particular situation (Schunk, 1984). The perception of efficacy affects student motivation more than actual efficacy. Once engaged, actual efficacy has a strong influence on achievement. However, the decision to engage depends on self-perceptions of efficacy. The influence of actual efficacy on motivation is through its influence on perceived efficacy.

Students who have high levels of perceived ability perform better on tests of math and English (Eccles & Wigfield, 2002). Success breeds success in expectancy theories of motivation. A student's sense of self-efficacy is postulated to affect performance in part through regulating the effort and persistence the student devotes to a task. Studies have linked feelings of competence to higher levels of self-efficacy (Schunk, 1984) and self-worth (Covington, 1992). Self-efficacy, in turn, has been linked to persistence and performance in school-aged children (Schunk, 1984).

An important component of self-efficacy is its specificity to the particular domain of the task at hand (Schunk, 1991). Although students can hold fairly broad perceptions of their ability—"I'm not good at school" or "I'm not good at new things"—the influence on motivation is through self-perceptions of the specific domain at hand. Thus, a student might think, "I'm generally not good at school, but I know this topic well, so I bet I can read this book."

Context also factors into decisions about self-efficacy. In weighing expectations of success, students consider their ability to manage external resources to complete a task as well as their ability in the domain of the task (Schunk, 1991). For instance, a student might think, "I know I can read my essay in front of the class, but if someone makes fun of me, I think I may wet my pants; so, I don't think I can do this."

This perception of self-efficacy is influenced by several factors that have been the subject of considerable research. Studies have been made of how students vary in their attributions of the sources of personal success and failure (e.g., internal or external locus of control), how students vary in their beliefs about change in ability, how students vary in the goals they have for engagement of the task (this influences, for instance, how the student judges success or failure), and the value of moderate challenge in leveraging expectation for motivation.

Student attributions for success and failure appear to serve as an important bridge between prior experience and current self-efficacy (Weiner, 1985). Students tend to attribute their performance to either external or internal forces. Those students with an external locus of control believe success can be attributed to luck and failure to unfair treatment. Students with an internal locus of control believe success can be attributed to natural ability and failure to personal incompetence. According to Weiner (1985), students who believe that their poor performance is caused by factors out of their control are unlikely to see any reason to hope for an improvement. And students who attribute successful performance to external factors may not convert success effectively into self-efficacy. In contrast, if students attribute their poor performance to a lack of important skills or to poor study habits, they are more likely to persist in the future. And students who attribute success to their own skill or effort may be more likely to try a similar or even more challenging activity in the same domain in the future.

Another important bridge between prior experience and self-efficacy is students' beliefs about the mutability of ability. Some students perceive ability as relatively fixed. They either are or are not talented in a domain and they can do little to change their ability. Research suggests that students who view ability as a fixed entity tend not to expend much effort on tasks in domains in which they believe they are not talented (Dweck, 1986). They interpret the need for effort in a domain as an indication of lack of talent in the domain. Rather than struggle to improve in the domain, they tend to turn to other domains that require less effort for success. They may work hard in these domains, but they avoid domains of difficulty. Students who view ability as mutable tend to interpret the need for effort differently. Believing that ability grows incrementally, they tend to interpret the need for effort as a sign that they are learning. Therefore, students holding this "incremental" view of ability are expected to persevere more than other students on difficult tasks (Dweck, 1986).

Students vary in their goal orientations toward activities and these differences appear to be important for expectations for success in tasks (Ames, 1992; Anderman & Midgley, 1998). This variance is the subject of a major research effort in student motivation, called "goal theory." While different researchers define the goal theory constructs in slightly different ways, they generally agree upon two main goal orientations—task goals and ability goals. A task-goal orientation represents the belief that the purpose of achieving is personal improvement and understanding. Students with a task-goal orientation focus on and define success by their own progress in mastering skills and knowledge. An ability-goal orientation represents the belief that the purpose of achieving is the demonstration of ability (or, alternatively, the concealment of a lack of ability). Students with an ability-goal orientation focus on appearing competent, often in comparison to others, and define success accordingly.

Researchers tend to favor a task-goal orientation for student success in schools. Studies of students' goal orientations generally find that the adoption of task goals is associated with more adaptive patterns of learning than is the adoption of performance goals, including the use of more effective cognitive strategies, a willingness to seek help when it is needed, a greater tendency to engage in challenging tasks, and more positive feelings about school and oneself as a learner (Anderman & Maehr, 1994; Ryan, Hicks, & Midgley, 1997). Students with task goals are also more likely to try activities in which they may not demonstrate prowess, because they define success in terms of their own progress rather than objective success or performance relative to others in the class. In so doing, task-oriented students may have more opportunities for learning than have goal-oriented students. Similarly, researchers favor incremental views of ability over fixed views (Dweck, 1986). Again, students who view ability as mutable may be more likely to try tasks in domains in which they have not demonstrated competence and may persevere more once involved in the tasks.

The difficulty of content affects student expectations of success on tasks. Research suggests that appropriate challenge has motivational characteristics independent of other aspects of the task (Csikszentmihalyi, 1990). Csikszentmihalyi (1990) described a condition under which a person feels optimally motivated by a task, which he termed a state of "flow." A flow-type experience includes one or more of the following features: The task is one that appears possible to complete, concentration is maximized, feedback is immediate, the student feels a sense of control, and the passage of time is altered. To experience flow, individuals' challenges and skills must not only be in balance but also exceed levels that are typical for their daily experiences. High levels of both challenge and ability lead to flow, and an imbalance between the two lead to demotivated and avoidance behavior. When a presented task is too challenging for the student's level of ability, anxiety sets in. When the task is too easy for the student's ability, boredom dominates (Moneta & Csikszentmihalyi, 1996).

In sum, students' perception of self-efficacy on the task at hand is central to the expectations half of the expectancy-value model. Students who do not have a reasonable expectation of succeeding on a task are unlikely to attempt the task. Still, how students make decisions about reasonable expectations and how they develop self-efficacy vary. Students' perceptions of self-efficacy are more important than their actual competence when deciding whether or not to undertake a task. In making decisions about tasks, students define their self-efficacy narrowly, focusing on their perceptions of competence on the specific task at hand. In making these decisions, students attend to all aspects of the task at hand, including their perceptions of their ability to control contextual factors (such as available resources or the actions of others involved). The conversion of prior experience into self-efficacy depend on the attributions students make about their prior experiences, including whether they believe they succeeded or failed based on their actions or through external forces. This conversion of prior experience into perceptions of self-efficacy is also mediated by students' perceptions of the mutability of ability. Students who believe they can improve their ability in an area may be more likely than others to engage in tasks on which they have struggled before and to persevere in the face of difficulty. Students who observe others who they perceive as equal to themselves succeeding at a task tend to expect to succeed at the task as well. Students vary in the goals they have for tasks and these differences have implications for their expectations of success. Some students tend to be performance-oriented while others are task-oriented. While performance-oriented students tend to focus on outward signs of success, task-oriented students tend to set their goals on learning and improvement. Finally, appropriately challenging tasks appear to be motivating. The experience of grasping and succeeding at moderately difficult tasks appears to act as a kind of engine that draws students into a “flow” concentrated engagement.

Value

Expectation for success allows students to think that they can successfully engage in a task if they choose. The value a task holds for a student is what draws the student into action. Value in this sense is more than interest; it is whatever causes the student to want to do the task. This value may spring from interest in the subject of the task or the activity of the task or from a sense of the utility of undertaking the task. Students are thought to vary both in what they value and in how they value. Both what students value and how they tend to place value are the result of socialization at home, at school, and with peers.

A useful way for discussing what students value is to think in terms of identity and relevance. Jere Brophy (1999) wrote a thoughtful piece on the subject of motivation in which he suggested central roles for identity relevance. In Brophy’s formulation, students respond to their perceptions of the relevance of new activities to themselves. Relevance may take the form of links to prior knowledge or links to perceptions of the student about himself or herself. A student may identify as an athlete and this might lead to heightened value placed on tasks related to athletics. A student may identify by gender and place value based on judgments about gender appropriateness. A student may identify by race or ethnicity or social class. A student may identify with school and academics or against school and academics. A student may identify with the subject of a task, the activity of the task, or with the teacher or others in the classroom associated with the task. Self-perceptions of identity may present a stance from which students detect relevance and gauge value.

Many bodies of research have addressed how students value, or the sources of value that drive student motivation. Deci and Ryan (1985) describe a continuum of motivational influences dependent on the amount of autonomy each one allows. Their model includes four types of motivation:

external, introjected, identified, and integrated. Externally regulated behaviors are performed to satisfy an external demand or reward contingency. Introjected behaviors involve taking in a rule or regulation but not fully accepting it as one's own. Behaviors are performed to avoid guilt or anxiety or attain ego enhancement. Identified regulation of behavior reflects a conscious valuing of a goal so much that the action is regarded as personally important. Integrated regulation occurs when identified regulations are fully assimilated to the self, which means they have been "evaluated and brought into congruence with one's other values and needs" (Deci & Ryan, 1985, p.330).

Eccles-Parsons, Adler, Futterman, Goff, Kaczala, Meece, & Midgley (1983) describe how students determine value in terms of their orientations toward tasks. They identify three value orientations: attainment, intrinsic, and utility. The attainment orientation parallels the ability goal orientation that conditions students' expectations for success (see the discussion above and Ames, 1992; Anderman & Midgley, 1998). When students assume an attainment orientation, they value tasks mainly in terms of performance. They value a task to the extent that they want to demonstrate prowess in it. When students take an intrinsic orientation, they value tasks based primarily on their interest in the task or subject matter (see also Schiefele, 1999 on interest). When students approach a task with a utility orientation, they determine value by examining how closely a task relates to a current or recognizable future goal.

Both what and how students value are subject to socialization processes that occur as children grown and mature. If we think in terms of Brophy's discussion of identity, then what one values (or students' perception of the relevance of a given task) would develop as children grow through experience and accumulate knowledge of the world and themselves.

Similarly, the sources of value students draw upon or the typical value orientations they take to new tasks are subject to socializing forces. Deci and Ryan describe a process they call internalization to chart the development of integrated motivations. In the Deci and Ryan (1985; Deci, Vallerand, Pelletier & Ryan, 1991) model, people are thought to have three categories of needs: a need for a sense of competence, a need for relatedness to others, and a need for autonomy. Competence involves understanding how to, and believing that one can, achieve various outcomes. Relatedness involves developing satisfactory connections to others in one's social group. Autonomy involves initiating and regulating one's own actions. These needs drive behavior, in part by determining the value a student places on a task. Through students' interaction with these three needs, they "internalize and integrate the regulation of uninteresting activities that are useful for effective functioning in the social world" (Deci & Ryan, 1985, p. 329). Behaviors (such as studying) that may be considered inconvenient, uninteresting, or that compete with more desirable behaviors (such as talking with friends) at any given time become valuable because students have internalized the importance of future goals (e.g., graduation) through exposure to and reinforcement from friends and family or other models.

Factors that motivate individual behavior necessarily change over time (Eccles & Wigfield, 2002). Motivators for first grade students will not likely motivate the same student in high school, though some forms of extrinsic motivation (i.e., social acceptance) will remain unchanged. Individuals may not be aware of whether they are motivated for purely intrinsic reasons, or for extrinsic, but internalized, reasons. For our purposes, the source of the motivation is inconsequential. Researchers and educators tend to privilege intrinsic motivations. We do not. We recognize that teachers' jobs may be easier, in the long term, if students develop intrinsic motivations for engaging in classwork. Teachers, in this case, are saved having to provide extrinsic motivation. Also, intrinsically motivated students may be more likely to engage in academically beneficial activities outside the teacher's purview. However, in the moment of student engagement with content, it matters not to the mental processing involved whether or not the student is intrinsically or extrinsically motivated—it matters only that the student is sufficiently motivated to engage in the task.

In sum, the value half of the expectancy–value dynamic consists of both what students value and how they determine what they value. Following Brophy (1999), we suggest that in determining what they value, students examine the relevance of offered tasks to their own sense of self. Thus, students connect new material to what they already know. They identify with (or do not identify with) teachers and peers and determine the value of classroom activities accordingly. How they make those connections and which connections predominate in decisions about value is varied. Students may value a task in response to a direct external contingency (promise of reward or threat of punishment). Students may value a task in response to less direct external contingencies. For instance, they may introject the values of others—that is, they may feel the need to act in line with another's values though they do not share the values (e.g., they may act out of guilt). They may also come to identify with a goal so strongly that they put personal stock in a task they see as related. Or, students may respond to a task based on values that are completely internalized. In this case, the offered task is completely in line with a student's values and needs. Students may approach tasks in different ways as well. They may determine value mainly in terms of interest in the subject or activity of a task. They may determine value primarily in terms of a desire to demonstrate prowess. Or, they may determine value based on the task's relation to long- or short-term goals that have connections to the task that may not be readily apparent to an observer. In all cases, what students value and the sources they draw upon to determine value are the subject of socializing forces.

Similarly, expectations for success may condition values. It seems unlikely that expectations for success would directly affect what a student values, because it should not influence the relevance of an activity. However, expectations for success may influence how students make value decisions and, indirectly, what they come to value. For instance, presented with an uninteresting task that the student finds simple to do, the student may be drawn toward an ability orientation by the opportunity to demonstrate prowess or to feel a sense of accomplishment. Thus, a low threshold presented by the expectancy half of the dynamic may influence the value decision. Over time, as students take opportunities to do relatively simple tasks, they may develop interest in the tasks. In that way, expectations may indirectly influence what students value.

The interaction of expectancy and values requires further study. A measurement model attempting to describe student motivation should measure the two halves of the dynamic separately and allow for interaction between the two.

RELATIONSHIPS BETWEEN SCE COMPONENTS

Although the SCE components have been described as four separate conditions that are necessary for learning in classroom, the SCE components are expected to interact. For instance, *Physiological Readiness* and *Motivation* are closely related. The physiological state of a student can impact his or her motivation to learn. As discomfort increases – through an environment of intolerable heat or cold, excessive sleep deprivation or psychological stress (manifested in physiological impairment) – an individual is less likely to value any educational task over the desire for physical or psychological comfort or sleep, nor have a realistic expectation of his or her ability to engage in a competing, intellectually challenging task. So, even if physiological needs meet the threshold required for engagement, physiological impediments can influence motivation. Similarly, the positive influence of a student's motivation may override moderate, or even severe, discomfort.

We also expect *Subject Matter Content Level* to influence students' *Motivation* and *Physiological Readiness*. Difficult content on which a student is performing well may be motivating as success breeds efficacy. On the other hand, difficult content on which a student struggles may be demotivating and may push students' stress beyond an acceptable level.

Finally, *Occasion for Processing*, specifically depth of processing and duration and frequency of processing probably interact with *Physiological Readiness*, *Motivation*, and *Subject Matter Content Level*. The threshold physiological stress and motivation levels may differ according to depth of processing required of a learning activity. A stressed student, for instance, may be able to engage in low-level tasks or to engage in higher demand tasks intermittently. A difficult task may require more motivation of a student than a lower level task. Asking students to engage in an activity for a long time or repeatedly also may place special demands on motivation and may stress students or be difficult for stressed students. In relation to level of content knowledge, the zone of proximal development for students probably depends on the cognitive task asked of the students.

CONTRASTING CONSTRUCTS WITH SCE

Student content engagement shares much in common with other, earlier constructs describing the quality of instruction. This is not surprising, because the student content engagement concept has been developed from the reading of various literatures on learning. Other related constructs include various incarnations of student engagement, time-on-task measures, and opportunity-to-learn measures. In addition, concepts of attention and self-regulated learning have overlaps with SCE. The uniqueness of SCE draws from its emphasis on the memory processes that underlie learning and implications of the variety of these processes for effective instruction, as well as joint recognition of the importance and interdependence of the student and instructional content.

STUDENT ENGAGEMENT

There are many different definitions of student engagement existing in the literature. Tobin and Capie (1980) describe student engagement as attending, recalling, collecting, comprehending, quantifying, planning, generalizing, and non-cognitive goal-directed behaviors (such as collecting equipment). Student classroom behaviors are classified as either engagement behaviors or observable off-task behaviors. Similarly, Lee and Smith (1993) describe students engaged with academic work through student behavior, such as coming to class with appropriate materials, completing homework, and feelings of boredom. The National Survey of Student Engagement (NSSE), a survey directed at college-aged students, includes measures of school- and classroom-level variables: 1) level of academic challenge, 2) active and collaborative learning, 3) student-faculty interaction, 4) enriching educational experiences, and 5) supportive campus environment. While interesting, the constructs measured by the NSSE are not immediately relevant for our interest in classroom content, interactions and their potential achievement effects as they do not emphasis the individual cognitive processing that are central to the notion of student content engagement described here.

Nystrand and Gamoran’s (1989) description of substantive student engagement is perhaps closest to the construct defined here. They describe two types of engagement: procedural and substantive. Procedural engagement involves students’ adherence to classroom rules and regulations.

Students who are not disruptive and appear to be working on an assigned task are procedurally engaged. While not obviously directly related to student content engagement, their description of procedural engagement nonetheless fits into a model of student content engagement that relies heavily on the prior knowledge of students. This prior knowledge, on which students will ultimately build all learning, includes the rules, regulations, and daily interactions in the classroom that students learn through exposure. In this way, procedural engagement can affect overall student learning. Substantive engagement, on the other hand, involves individual student cognitions and more closely mimics the model of student content engagement. Substantive engagement involves sustained mental concentration, focus, and habits of thoughtfulness (Newmann, Onosko, & Stevenson, 1988). It depends on the content with which students are engaged and the students' investment in academic work--if they invest their time and energy in low quality tasks, they will not learn.

Differences remain, however, between Nystrand and Gamoran's substantive engagement and student content engagement. One difference is the emphasis on content. Although substantive engagement does recognize content as an important piece in facilitating student engagement, it does not allow for individual differences in engagement with content. We adhere to the notion that each student constructs knowledge or understandings based on prior experience, changing the content during the process and making engagement unique for each student.

Another difference is that student content engagement is directly dependent upon student motivation (Guthrie, 2002). Although it can be assumed that for students to invest in schoolwork as required by substantive engagement they must be academically motivated, a model that allows for both intrinsic and extrinsic motivators and specifies the role motivation plays in student content engagement is more complete. A third difference is the specification of processing mechanisms in student content engagement. Although the student engagement described by Nystrand and Gamoran (1989) relies on individual student cognitions, it does not detail what those cognitions are. Also, they describe engagement as occurring through student-teacher or peer interactions and discourse. Although student content engagement may be facilitated by a teacher or peer, it can happen outside the presence of the teacher as well. Overall, Nystrand and Garmorn's model appears to address parts of the student content engagement model (e.g., procedural engagement deepens prior knowledge; discourse deepens processing), but does not rely as heavily on motivation, the existence of prior knowledge, and the variety of processing opportunities available to students.

TIME-ON-TASK

Student content engagement differs from previous conceptualizations of time on task or time spent on learning (Gettinger, 1984; Karweit, 1984). Time is a recurring issue for educators and there are various methods for measuring time and learning. The amount of time actually spent on learning is thought to influence the amount learned (Carroll, 1989; Gettinger, 1984). The time spent on learning is influenced by the time allowed for learning, or opportunity to learn, and the amount of time the student is willing to devote to learning.

Notions of time and learning suffer from many of the same shortcomings as traditional conceptions of student engagement. Descriptions of time spent on learning treat content as a separate, self-contained entity, and do not consider student prior knowledge critical for learning. Content plays a more prominent role in student content engagement as students are interacting with and changing the content based on previous exposure and modeling by others. Another difference is the role of motivation: while the various conceptions of time on task recognize that students differ in the amount of time they are motivated to spend on a task, they do not require students to value academic achievement, either intrinsically or extrinsically, nor have an expectation for success, for learning to occur. A third difference is the requirement that students be cognitively active in student content engagement. For example, time on task may include time the student spends in gathering materials needed to complete a task; these actions would not be included in student content engagement, unless the student is consciously processing information during this activity.

OPPORTUNITY-TO-LEARN

Opportunity-to-learn (OTL) measures provide a process-oriented method of examining the schooling that children experience (Brewer & Stasz, 1996). It focuses on curriculum content (topic coverage, time spent, relative teacher emphasis), instructional strategies (methods and pace of instruction, questioning strategies, expectations for students, classroom policies, allocation of class time, etc.), and instructional resources (availability of books, computers, and physical classroom environment) (Brewer & Stasz, 1996), and attempts to measure the enacted curriculum.

OTL is similar to student content engagement in that it stems from a belief that learning happens at the student level and often incorporates many elements of student content engagement, such as content exposure, physical environment, and expectations for students. However, like the aforementioned constructs that contrast with student content engagement, OTL overlooks the critical role of student prior knowledge and measurable motivation variables. And while OTL measures focus on content exposure and cognitive demand level and link to student achievement modestly (Gamoran, Porter, Smithson, & White, 1997), these indicators can be measured at the teacher or classroom level. Student content engagement would need to be, at least partially, measured by student-level indicators.

Self-Regulated Learning

Finally, student content engagement does not require student self-regulation of learning. Self-regulated learning consists of specific cognitive activities, such as deliberate planning and monitoring, that learners use as they encounter tasks (Corno & Mandinach, 1983). Self-regulated learning involves metacognitive strategies for planning, monitoring, and modifying cognitions; management and control of effort on tasks; and the actual cognitive strategies students use (Pintrich & DeGroot, 1990). The absence of self-regulation from the model of student content engagement described above does not indicate that the components are not important for learning. Indeed, many of the components of self-regulation are included in student content engagement. However, some of these elements do not need to be regulated by the student for learning to occur. Teachers can control these elements as well. Furthermore, self-regulation strategies are developed over time (Corno & Mandinach, 1983) and young children may not yet be effective self-regulators, so the construct may not be helpful in an overarching framework for engagement.

The absence of self-regulated learning from student content engagement also does not imply that knowing how to regulate one's learning does not lead to higher student achievement. Students would still benefit if they knew effective self-regulation techniques. Teachers would also benefit, because they would not have to regulate the learning of every student in their class. So while learning may be enhanced long-term if students know self-regulating strategies, it is not necessary for learning to occur.

CONCLUSION

In this paper, we have introduced and provided a first iteration of a description of a framework for developing measures of the characteristics of teaching and teachers that influence student learning. The overall measurement construct is called "Student Content Engagement." The framework is comprised of four conditions that the research on learning suggests are necessary for learning in classrooms. Expressed in a single statement:

Student Content Engagement is the cognitive interaction of the student with appropriately challenging subject matter knowledge (Subject Matter Content Knowledge) through an activity that should produce the mental processing necessary for learning (Occasion for Processing) and that the student is able (Physiological Readiness) and willing (Motivation) to perform.

The Student Content Engagement framework presented here is not specific to subject or grade level. Nor is it specific to how it will be used—in observations of teaching, such as classroom observations or in self-report surveys on instruction, or, in observations of other characteristics of teachers, such as surveys of teacher knowledge.

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